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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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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-

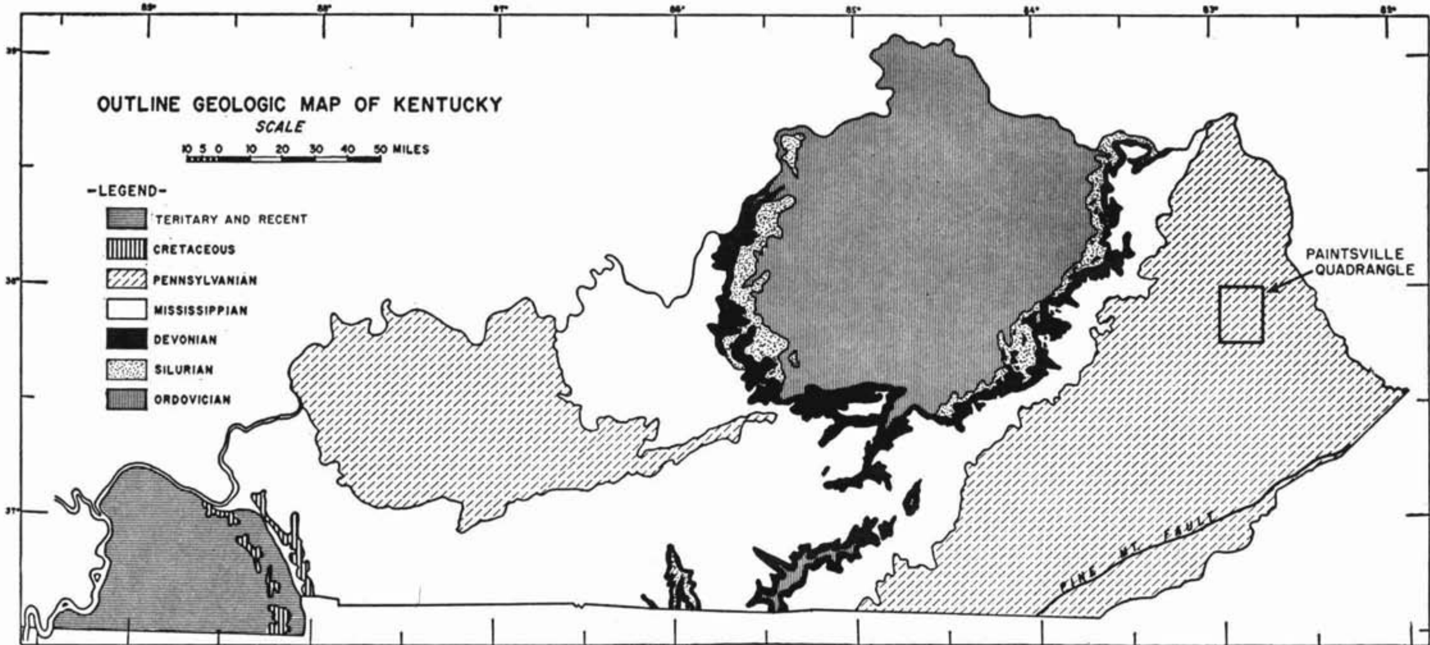


Fig. 1. Generalized geological map of Kentucky showing the location and regional setting of the Paintsville quadrangle.

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.

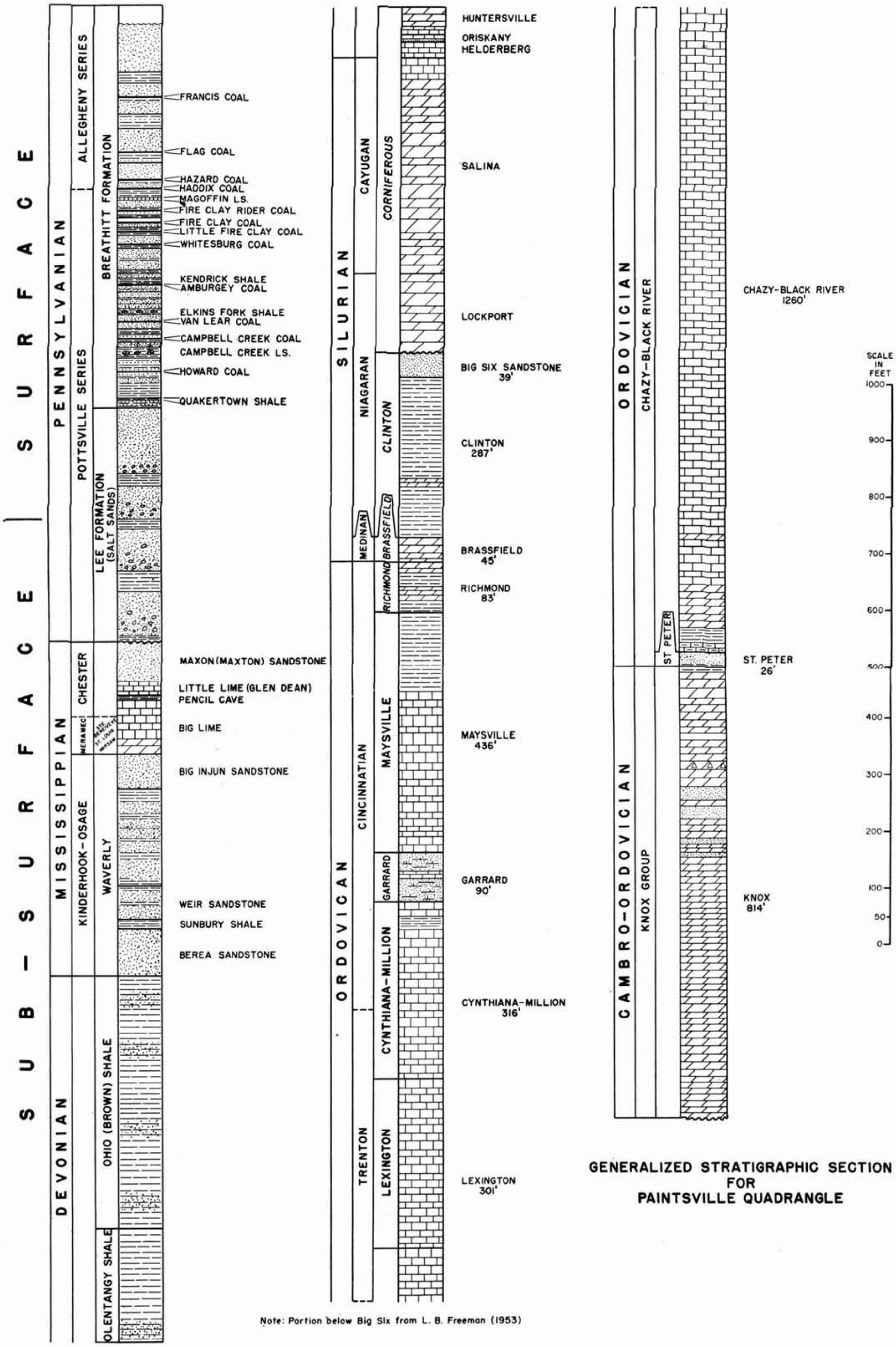
Paintsville (pop. 4,290) is in the approximate center of the southeast quarter and is the seat of Johnson County. Through highways enter Paintsville from the north, south, east, and west, and it is also located on the Chesapeake and Ohio Railroad Company line.

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.



GENERALIZED STRATIGRAPHIC SECTION
FOR
PAINTSVILLE QUADRANGLE

Fig. 2.

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

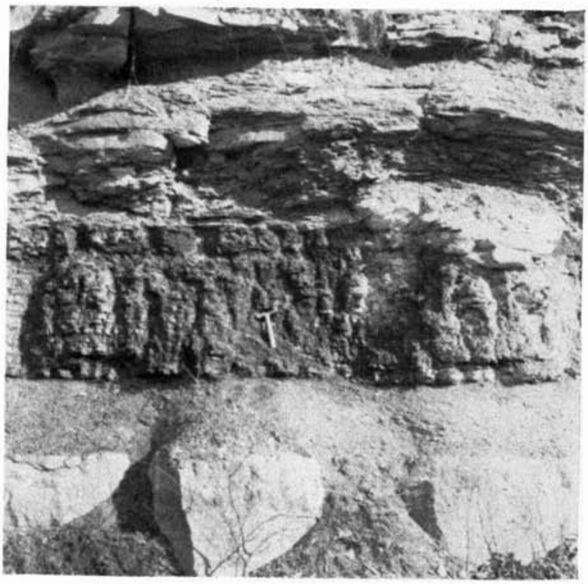


Fig. 6. Van Lear coal, 45 inches thick, near headwaters of Muddy Branch.

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 canneloid 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 ls.		
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	Limestone, very argillaceous, dark-red, trace green, fine-grained.
(St. Peter)	
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.

5387-94	Dolomite, dark-brown, finely crystalline, dense, some slightly argillaceous; trace of dark-brown chert.
5394-5424	Dolomite, dark-brown, very finely crystalline, dense; some stylolite clay.
5424-75	Dolomite, fine- to medium-crystalline, very dense; rare chert and stylolite clay.
5475-83	Dolomite, fine- to medium-crystalline, as above, cream; some finely disseminated pyrite.
5483-5500	Dolomite, medium-grained, brown, dense to slightly vugular, with some black stylolitic clay.
5500-08	Dolomite, as above; trace of chert, small brown oolites in white matrix.
5508-15	Dolomite, medium-crystalline, sucrose, medium-brown; trace of chert, as above.
5515-20	Dolomite, creamy-gray, very finely crystalline, with trace medium-grained; much pyrite.
5520-28	Dolomite, light-tan, densely crystalline, fine-grained; rare chalky-white chert, with dolomolds.
5528-37	Dolomite, cream, medium-crystalline, dense to sucrose.
5537-97	Dolomite, light-tan to brown, fine-medium crystalline, dense to vugular, with coarser dolomite in vugs; trace of stylolitic clay.
5610-13	Dolomite, as above.
5625-57	Dolomite, very slightly argillaceous, fine-grained, dark-brown.
5670-78	Dolomite, finely crystalline, very dense, brown, as above; trace of silt.

Structure

The accompanying structure maps (plates 4a, b, c, and d) were drawn on the Van Lear coal, Fire Clay coal, and the top of the Lee formation. However, some explanation as to how the structural control was obtained for these maps is in order. It should be noted that the Van Lear coal is and has been mined rather extensively in the southeastern part of the Paintsville quadrangle and, thus, can be traced and mapped with considerable certainty. The other coals are mined in comparatively few places and are, therefore, difficult to trace and map.

The top of the Lee formation was used as a datum plane to map the structure in the approximate northwest half of the 15-minute area. Outcrops, well logs, intervals from the Quakertown shale, and intervals from the Howard coal to the top of the Lee formation were all used to determine the position of the top of this formation.

Intervals between known coals, shales, sandstones, and siltstones have been measured in numerous places where there is more than one unit exposed. These intervals are known to vary over considerable distances horizontally, but it has been assumed that they remain approximately the same in an area no larger than that studied for this report. For example, if in one measured section the Magoffin limestone is found to be 40 feet above the Fire Clay coal and in another section the Magoffin limestone is exposed but not the Fire Clay coal, it is assumed that the Fire Clay coal is about 40 feet below the Magoffin limestone.

Structurally, the Paintsville quadrangle encompasses approximately the eastern half of the Paint Creek uplift. Thus, its structure is monoclinal, with the beds dipping off to the east and southeast. This monoclinal feature is interrupted locally by domes, synclines, anticlines, and faults.

Except for small differences the surface structure and the subsurface structure are alike, indicating that folding and faulting took place during post-Pennsylvanian time.

The most prominent structure is the Paintsville anticline, which extends from the head of Pigeon Creek to beyond the eastern edge of the area. The axis of this anticline trends almost due east-west and plunges toward the east. Roughly paralleling and 2 to 3 miles north of the Paintsville anticline is the Toms Creek syncline, which also plunges toward the east and extends to beyond the eastern edge of the area. About 1 mile north of the Toms Creek syncline is the Fishtrap anticline, and still farther north is the Irvine-Paint Creek fault, the latter two paralleling the Toms Creek syncline.

The Irvine-Paint Creek fault has a south dip of approximately 85 degrees (see figure 7) and has its maximum stratigraphic displacement—about 180 feet—near the mouth of Pigeon Creek. The displacement is a few feet less toward the west from the mouth of Pigeon Creek and toward the east it is gradually lessened; the fault apparently dies out about 1 mile almost due east of Volga.

Near the head of Toms Creek, on Strumbo Fork, a small fault can be seen on outcrop and has been reported as present in a coal mine nearby. This fault parallels the Irvine-Paint Creek fault, but its displacement and extent are unknown.

Two prominent domes are recognized, a large ellipse-shaped structure in the north-central portion of the area called the Laurel Creek dome and a second structure in the west-central area, part of the Mine Fork dome. The western portion of the latter is beyond the western edge of the Paintsville quadrangle.

MINERAL RESOURCES

Coal

To date, coal has been the most important mineral resource of the Paintsville quadrangle, and the economic condition of the area is reflected by the production of coal. There are three coal seams of importance in the area—the Van Lear or Millers Creek coal, the Fire Clay coal, and the Haddix coal. Of the three the Van Lear is by far the most important.

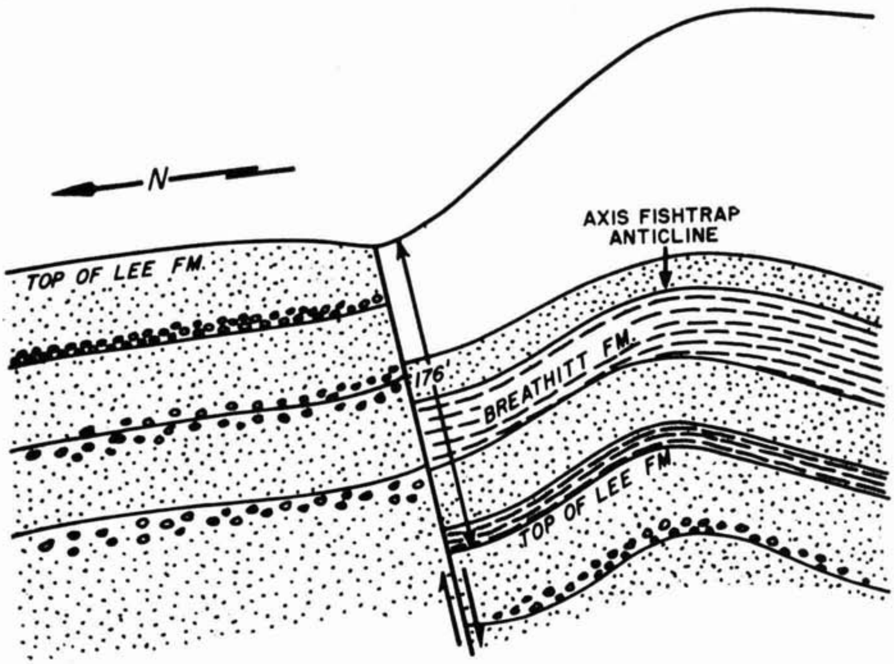


Fig. 7. Diagrammatic sketch of Irvine-Paint Creek fault on the east side of Pigeon Creek.

The remaining coals above drainage are too thin (except perhaps for local pockets) to be of commercial importance at present. If thicknesses great enough for production are found they will undoubtedly occur as lenses or pockets and will not have great areal extent.

Most of the coal being mined is the Van Lear coal, because it is consistently thicker, higher grade, and more accessible than the other coals. The Van Lear is low in ash and sulphur and is a desirable coal on the market. It ranges in thickness from 10 to 60 inches, with an overall average of about 32 inches (see plate 5).

The Consolidation Coal Company mined out most of the Van Lear coal on Millers Creek in the southeastern corner of the quadrangle. This operation was acquired by the Farwest Coal Company in 1949, and in 1951 they had finished taking out the remaining minable coal.

The Northeast Coal Company has mined out (operation ceased in January 1952) a large area of Van Lear coal in the east-central part of the quadrangle, enclosing the area north of Paintsville and Levisa Fork, east of Turner Branch and Rush Fork, and south of Toms Creek.

In the southeast and east-central portions of the area there are many smaller mining operations in the Van Lear coal.

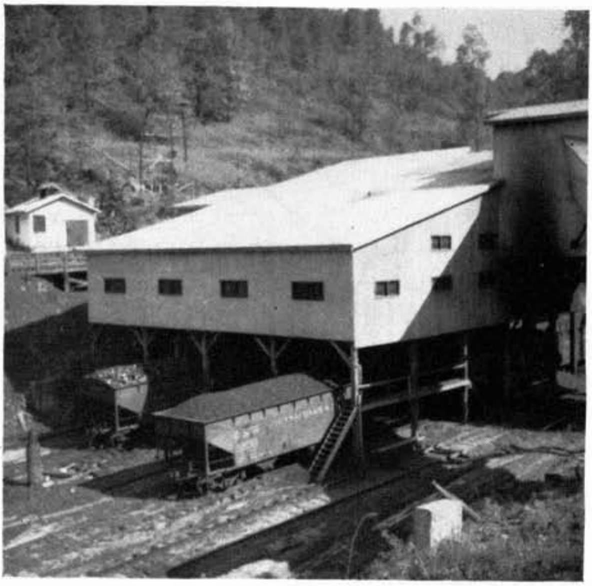


Fig. 8. Northeast Coal Company loading tipple, Thealka, Ky.

The Fire Clay coal (locally known as the "Springville" coal) is about 137 feet higher stratigraphically than the Van Lear coal and is being mined on the headwaters of Hood Creek and Toms Creek, where it is 36 to 44 inches thick. The Fire Clay coal is generally canneloid at the top and contains a 3- to 6-inch parting anywhere from the middle to the bottom of the seam.

The third coal of importance is the Haddix, which is about 50 feet higher stratigraphically than the Fire Clay coal. It has been opened in only a few places and in these areas has only been mined for local domestic use. Because of its high stratigraphic position the Haddix coal is restricted in areal extent to hilltop areas in the southwest, southeast, northeast, and central portions of the quadrangle.

In the hill just east of Hager Hill gap there was a 4- to 11-foot pocket of cannel coal, which was mined out years ago by the Northeast Coal Company. This was probably the Haddix coal.

Future Possibilities

Larger mining operations of the Van Lear coal in the Paintsville area are a thing of the past. The near-drainage and easily accessible coals of greater thickness are mined out. They occurred in the Millers Creek area in the southeastern corner of the quadrangle and in the area just north of Paintsville, where the Consolidation Coal Company

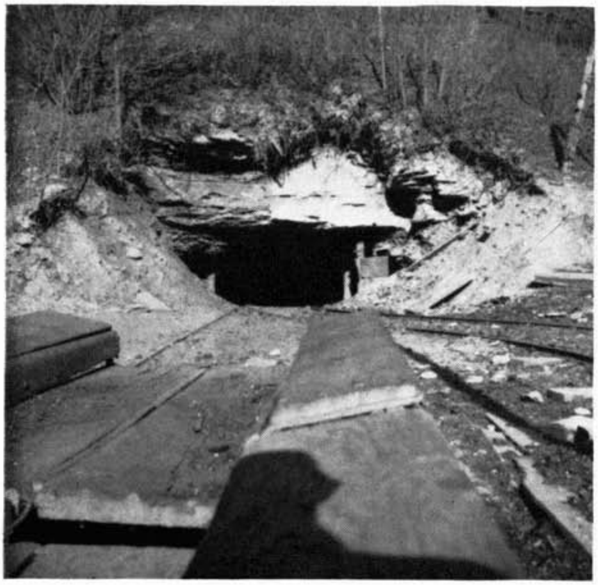


Fig. 9. Typical truck mine in Fire Clay coal near headwaters of Toms Creek. Coal is 38 inches thick.

and the Northeast Coal Company, respectively, have only recently ceased mining operations.

Smaller areas of coal suitable for limited operations are still present. Some of these areas depend upon road improvement before the coal can be moved.

Less than one acre of Van Lear coal was stripped between Stave Branch and Turner Branch. Stripping operation of the higher coals (Fire Clay and Haddix) is possible, but only of small boundaries. The small limits of stripping are due to the steepness of the slopes, requiring the removal of excessive overburden.

Drift mining of the Fire Clay coal and Haddix coal remains a possibility, because little exploration has been done on these two coals. As has been pointed out, the areal extent of these two coals is much smaller than that of the Van Lear coal because of their higher stratigraphic positions which limit their outcrops to the higher hills. Future demands for coal will undoubtedly control the production of the Fire Clay and Haddix coals. Thickness requirements necessary for coals to be minable have decreased in the past few years because of exhaustion of thicker, more accessible coals and because of improved mining methods.

Present mining is restricted to small operations, two of which use cutting machines and the others use powder to shoot the coal down. The coal is loaded into trucks at the mines and hauled to railroad sidings for shipment.

Analyses of the Kendrick shale show that when mixed properly with other clay it will make sewer tile, thus inviting the possibility that this shale along with the immediately underlying Amburgey coal (6″ thick at point of sampling) may be mined together.

Analyses show that the ash and sulphur content was lower in the mined out areas of Van Lear coal than it is in the coal that remains.

The Fire Clay coal varies greatly in ash and sulphur content. It is as high as 22.3 percent ash and 6.8 percent sulphur in the southeast corner and 7.4 percent ash and 1.2 percent sulphur in the south-central area where sampled. Thus, careful analyses should be made before exploiting the Fire Clay coal.

The Haddix coal was sampled in only one mine and showed 5.2 percent ash and 1.2 percent sulphur.

Seventeen coal samples were collected in conjunction with field work for this report and were submitted to the U. S. Bureau of Mines for analyses. The results of these analyses appear in table 1 and give a more complete picture of the general characteristics and variations of the minable coals. In the table the numbers 1, 2, 3, and 4 under the heading *Condition* have the following meanings: 1 is the coal as received in the laboratory; 2 is moisture free coal; 3 is coal both moisture and ash free; and 4 is air dried. *Hvab* is high-volatile A bituminous coal; *Hvbb* is high-volatile B bituminous coal; *Hvb* is high-volatile bituminous coal.

TABLE 1

CHEMICAL ANALYSES* OF COAL SAMPLES
Norton Field, Johnson County, Kentucky

Location and source	Bed	Rank	Condition	Sample no.	Lab. no.	Air-drying loss	Calorific value (B.T.U.)	Fusibility of Ash °F. Initial deformation	Softening temp.	Fluid temp.	Moisture	Proximate Analysis % Volatile matter	Fixed carbon	Ash	Ultimate Analysis % Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen
Adams Coal Co.	Van Lear	Hvbb	1	1	D39544	2.6	13510	2180	2260	2470	5.8	39.2	52.2	2.8	1.7	5.7	74.9	1.4	13.5
4 Mi. NE of Paints-			2				14350					41.6	55.4	3.0	1.8	5.4	79.6	1.5	8.7
ville. Drift. 30′			3				14790					42.9	57.1		1.9	5.6	82.0	1.6	8.9
from entry			4				13870				3.4	40.3	53.4	2.9	1.7	5.6	76.9	1.5	11.4
Mountain Coal Co.	Van Lear	Hvab	1	2	D39545	1.9	13730	2710	2760	2870	5.6	37.7	54.6	2.1	.5	5.7	76.7	1.4	13.6
3 Mi. E of			2				14550					39.9	57.9	2.2	.6	5.4	81.2	1.5	9.1
Paintsville. Drift.			3				14880					40.8	59.2		.6	5.5	83.1	1.6	9.2
200′ from entry			4				13990				3.9	38.4	55.6	2.1	.6	5.6	78.1	1.5	12.1
Northeast Coal Co.	Van Lear	Hvbb	1	3	D39546	2.7	13400	2570	2620	2710	6.9	36.3	54.5	2.3	.5	5.6	76.0	1.5	14.1
1½ Mi. N of Paints-			2				14400					39.0	58.5	2.5	.5	5.2	81.7	1.6	8.5
ville. Drift.			3				14770					40.0	60.0		.5	5.4	83.8	1.7	8.6
200′ from entry			4				13780				4.3	37.3	56.0	2.4	.5	5.5	78.2	1.6	11.8
Witten Coal Co.	Van Lear	Hvbb	1	4	D39547	2.2	13360	2030	2080	2440	5.9	38.9	51.4	3.8	1.4	5.6	74.3	1.2	13.7
3½ Mi. N of Paints-			2				14200					41.3	54.6	4.1	1.5	5.3	79.0	1.3	8.3
ville. Drift.			3				14800					43.0	57.0		1.5	5.5	82.3	1.4	9.3
100′ from entry			4				13660				3.8	39.7	52.6	3.9	1.4	5.5	76.0	1.3	11.9
H. L. Riff	Van Lear	Hvbb	1	5	D39548	4.7	13130	2090	2240	2370	7.0	39.7	48.6	4.7	2.4	5.8	72.0	1.4	13.7
3 Mi. SE of Paints-			2				14110					42.7	52.2	5.1	2.6	5.4	77.4	1.5	8.0
ville. Drift.			3				14870					45.0	55.0		2.8	5.7	81.5	1.5	8.5
40′ from entry			4				13780				2.4	41.7	50.9	5.0	2.6	5.5	75.6	1.4	9.9
Albert Blanton	Van Lear	Hvb	1	6	D39549	1.4	12750	2080	2180	2440	4.3	39.6	47.1	9.0	2.7	5.5	69.9	1.5	11.4
3 Mi. SW of Paints-			2				13320					41.4	49.2	9.4	2.9	5.2	73.1	1.5	7.9
ville. Drift.			3				14710					45.7	54.3		3.2	5.7	80.7	1.7	8.7
300′ from entry			4				12930				2.9	40.2	47.7	9.2	2.8	5.4	70.9	1.5	10.2

* U.S. Bureau of Mines analyses.

TABLE 1—Continued

Chemical Analyses of Coal Samples
Norton Field, Johnson County, Kentucky

Location and source	Bed	Rank	Condition	Sample no.	Lab. no.	Air-drying loss	Calorific value (B.T.U.)	Fusibility of Ash °F. Initial deformation	Softening temp.	Fluid temp.	Proximate Analysis % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate Analysis % Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen
Albert Blanton	Fire Clay	Hvab	1	7	D39550	1.8	12960	2470	2550	2780	4.8	39.4	48.5	7.3	1.1	5.6	71.8	1.5	12.7
3 Mi. SW of Paints-			2				13620					41.4	51.0	7.6	1.2	5.3	75.4	1.6	8.9
ville. Drift.			3				14750					44.8	55.2		1.3	5.7	81.6	1.7	9.7
50′ from entry			4				13210				3.0	40.2	49.4	7.4	1.2	5.5	73.1	1.5	11.3
Mahan Bros.	Van Lear	Hvbb	1	8	D39551	5.8	12910	2570	2650	2710	9.2	36.1	51.0	2.9	.6	5.8	72.7	1.4	16.6
5 Mi. NW of Paints-			2				14220					39.7	57.1	3.2	.6	5.2	80.0	1.5	9.5
ville. Drift.			3				14690					41.1	58.9		.7	5.4	82.6	1.6	9.7
100′ from entry			4				13710				3.6	38.3	55.0	3.1	.6	5.4	77.1	1.5	12.3
Davy Daniels	Haddix	Hvbb	1	9	D39552	2.8	13010	2680	2730	2840	6.1	37.7	51.1	5.1	1.1	5.6	72.3	1.5	14.4
½ Mi. S of Paints-			2				13870					40.1	54.5	5.4	1.2	5.3	77.0	1.6	9.6
ville. Drift.			3				14660					42.4	57.6		1.3	5.6	81.4	1.7	10.0
50′ from entry			4				13390				3.5	38.7	52.6	5.2	1.2	5.5	74.4	1.6	12.1
John Crum, 4½	Fire Clay	Hvab	1	10	D39553	2.7	10680	1970	2000	2360	4.6	35.7	38.0	21.7	6.6	4.7	57.0	1.1	8.9
Mi. SE of Paints-			2				11200					37.4	39.9	22.7	7.0	4.4	59.8	1.2	4.9
ville. Drift.			3				14490					48.4	51.6		9.0	5.7	77.3	1.6	6.4
20′ from entry			4				10980				2.0	36.7	39.0	22.3	6.8	4.5	58.6	1.2	6.6
Alfred Johnson	Van Lear	Hvbb	1	11	D39554	1.7	13190	2030	2100	2420	5.6	36.9	53.0	4.5	1.1	5.5	74.0	1.3	13.6
2½ Mi. W of Paints-			2				13970					39.1	56.1	4.8	1.1	5.1	78.4	1.3	9.3
ville. Drift.			3				14670					41.1	58.9		1.2	5.4	82.4	1.4	9.6
100′ from entry			4				13420				4.0	37.6	53.8	4.6	1.1	5.4	75.3	1.3	12.3
Ed Salyers, 3½	Van Lear	Hvbb	1	12	D39555	3.3	12680	1940	2000	2390	6.2	38.3	48.1	7.4	5.2	5.3	69.2	1.3	11.6
Mi. SW of Paints-			2				13520					40.8	51.3	7.9	5.5	4.9	73.8	1.4	6.5
ville. Drift.			3				14680					44.3	55.7		6.0	5.4	80.1	1.5	7.0
30′ from entry			4				13110				3.0	39.6	49.7	7.7	5.4	5.1	71.6	1.3	8.9

TABLE 1—Continued

Chemical Analyses of Coal Samples
Norton Field, Johnson County, Kentucky

Location and source	Bed	Rank	Condition	Sample no.	Lab. no.	Air-drying loss	Calorific value (B.T.U.)	Fusibility of Ash °F. Initial deformation	Softening temp.	Fluid temp.	Proximate Analysis % Moisture	Volatile matter	Fixed carbon	Ash	Ultimate Analysis % Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen
Wade McKenzie, 1 Mi.	Fire Clay	Hvab	1	13	D85249	....	13690	2650	2750	2850	5.8	39.6	52.4	2.2	.6	5.8	76.0	1.6	13.8
E of Redbush. Drift.			2				14520					42.0	55.6	2.4	.6	5.4	80.7	1.7	9.2
250′ from entry			3				14880					43.0	57.0		.7	5.6	82.6	1.7	9.4
Jess Fairchild, 6 Mi.	Van Lear	Hvab	1	14	D85247	....	12640	2080	2330	2530	5.1	38.4	47.8	8.7	2.6	5.4	70.0	1.4	11.9
W of Paintsville. Drift.			2				13310					40.5	50.3	9.2	2.7	5.1	73.7	1.5	7.8
20′ from entry			3				14660					44.6	55.4		3.0	5.6	81.2	1.6	8.6
Paris Fairchild, 6 Mi.	Van Lear	Hvab	1	15	D85250	....	13720	2000	2100	2520	4.4	42.5	50.1	3.0	1.5	5.9	76.1	1.6	11.9
SW of Paintsville. Drift.			2				14350					44.4	52.5	3.1	1.6	5.6	79.6	1.6	8.5
250′ from entry			3				14820					45.9	54.1		1.7	5.8	82.2	1.7	8.6
B. B. Short, 5½ Mi.	Van Lear	Hvab	1	16	D85248	....	13530	2510	2660	2760	4.6	37.4	54.7	3.3	.7	5.6	76.1	1.6	12.7
N of Paintsville. Drift.			2				14180					39.2	57.3	3.5	.8	5.3	79.8	1.6	9.0
150′ from entry			3				14690					40.7	59.3		.8	5.5	82.7	1.7	9.3
Crate Rice, 6½ Mi.	Fire Clay	Hvbb	1	17	D85251	....	11770	2470	2660	2820	5.5	34.5	46.2	13.8	1.3	5.2	66.1	1.4	12.2
N of Paintsville. Drift.			2				12470					36.5	48.9	14.6	1.3	4.8	69.9	1.5	7.9
1000′ from entry			3				14600					42.8	57.2		1.6	5.6	81.9	1.8	9.1

Table 2 gives the annual coal production for Johnson County from 1892 to 1951. Inasmuch as the Paintsville quadrangle is largely confined to this county and includes virtually all of the coal producing portion of the county, the figures are essentially production figures for the quadrangle.

TABLE 2

COAL PRODUCTION, JOHNSON COUNTY, KENTUCKY
1892-1951

(Data furnished by the Kentucky Department of Mines and Minerals)

Year	*Short Tons*	*Year*	*Short Tons*
1892	27,450	1923	693,409
1893	24,859	1924	1,021,576
1894	16,902	1925	1,173,040
1895	10,679	1926	1,223,396
1896	6,762	1927	1,219,185
1897	4,005	1928	1,183,075
1898	10,964	1929	1,535,802
1899	11,380	1930	1,220,602
1900	15,635	1931	859,393
1901	39,034	1932	711,083
1902	59,407	1933	702,524
1903	53,745	1934	887,211
1904	98,193	1935	628,659
1905	69,024	1936	806,166
1906	26,339	1937	858,447
1907	131,649	1938	753,885
1908	154,459	1939	614,925
1909	206,326	1940	831,181
1910	466,901	1941	737,295
1911	800,416	1942	695,345
1912	911,087	1943	821,887
1913	841,356	1944	850,734
1914	940,340	1945	695,957
1915	950,453	1946	797,579
1916	1,061,481	1947	2,208,792
1917	957,958	1948	828,742
1918	791,241	1949	802,181
1919	824,229	1950	857,005
1920	772,286	1951	846,319
1921	713,347		
1922	307,299	Total Short Tons	38,370,601

Coal Reserves

Coal reserves in this quadrangle have been broken down into three categories—measured, indicated, and inferred. Furthermore, reserve estimates have been made separately for coal thicknesses of 14 to 22 inches, 22 to 36 inches, and over 36 inches.

Measured reserves are calculated on an acre-ton (1 acre of coal 1 inch thick equals 147.5 tons of coal) basis from a point of known thickness of the coal. All coal within ½-mile radius of this known point of thickness is considered measured coal.

Indicated coal is all the coal outside the ½-mile radius of a point of known thickness and inside a 1½-mile radius from this same point.

Inferred coal is all the coal outside the 1½-mile radius of a point of known thickness of coal and for conservative estimate is included in the 14- to 22-inch thickness.

The Van Lear coal attains a maximum thickness of 60 inches, the Fire Clay 46 inches, and the Haddix 32 inches.

Van Lear coal reserves in the 14- to 22-inch thickness class include coal that is under drainage in the extreme southwest corner and in the northeast corner of the area. However, this is only a small part of the reserve figure.

Table 3 summarizes the coal reserves of the Paintsville 15-minute quadrangle.

TABLE 3

COAL RESERVES

Paintsville Quadrangle

Van Lear	Inches	Short Tons
Measured	14 to 22	12,493,914
Indicated	14 to 22	23,533,533
Inferred	14 to 22	84,216,738
Measured	22 to 36	96,758,555
Indicated	22 to 36	48,160,188
Measured	Over 36	5,096,456
Indicated	Over 36	13,118,482
	Total	283,377,866

Fire Clay	Inches	Short Tons
Measured	14 to 22	3,585,601
Indicated	14 to 22	7,446,162
Inferred	14 to 22	92,817,434
Measured	22 to 36	9,136,124
Indicated	22 to 36	16,260,388
Measured	Over 36	7,119,805
Indicated	Over 36	6,094,949
	Total	142,460,463

Haddix	Inches	Short Tons
Measured	22 to 36	6,281,730
Indicated	22 to 36	11,744,235
Inferred	14 to 22	49,287,640
	Total	67,313,605

Total Van Lear reserves	283,377,866
Total Fire Clay reserves	142,460,463
Total Haddix reserves	67,313,605
Total	493,151,934

OIL AND GAS

Introduction

Commercial production of oil and gas in the Paintsville area dates back to the beginning of World War I (1917), when a wildcat well was drilled in a large open flow of gas on the Mine Fork dome. This well initiated interest in a large structure—the Paint Creek uplift—as a petroleum producer. A rich oil strike was made a short time later, starting a boom which lasted nearly a decade.

Recent secondary recovery operations by both air-gas injection and water flooding, such as the 1948 project in the Oil Springs area (Jones, 1952, p. 8), have revived interest in the declining production. Depletion of the shallow producing horizons along with future demands for oil and gas will very probably bring about exploration in the deeper oil and gas sands.

Present Production

The oil production in the area is generally discussed under two separate pools, the Oil Springs pool and the Martha pool. Although these two oil pools and their associated gas fields extend beyond the limits of the Paintsville quadrangle, they will be discussed in their entirety.

The Oil Springs pool is located in northeastern Magoffin County, 1 mile west of Oil Springs (see figure 10). The Mine Fork pool, which is located 1 mile north of the Oil Springs pool, is considered an extension of the latter. The producing formation is the Weir of Lower Mississippian Age. The Oil Springs pool is producing approximately 1,100 barrels per day from about 6,000 acres.

Secondary recovery by water flooding is being carried out on two different leases, the L. C. Bailey (265 acres) operated by the Cumberland Petroleum Company and the Green Rice (186 acres) operated by the Brundred Oil Company. Production on the Bailey lease has been increased over 1,000 percent since flooding operations began in 1948.

The Martha oil pool, sometimes referred to as the Blaine-Martha pool, is located in northwestern Johnson County and southwestern Lawrence County (see figure 10). Here, as in the Oil Springs pool, the producing formation is the Weir sandstone.

The Martha pool is producing approximately 1,500 barrels per day from 850 wells covering about 7,000 acres. The entire pool is owned and operated by the Ashland Oil and Refining Company.

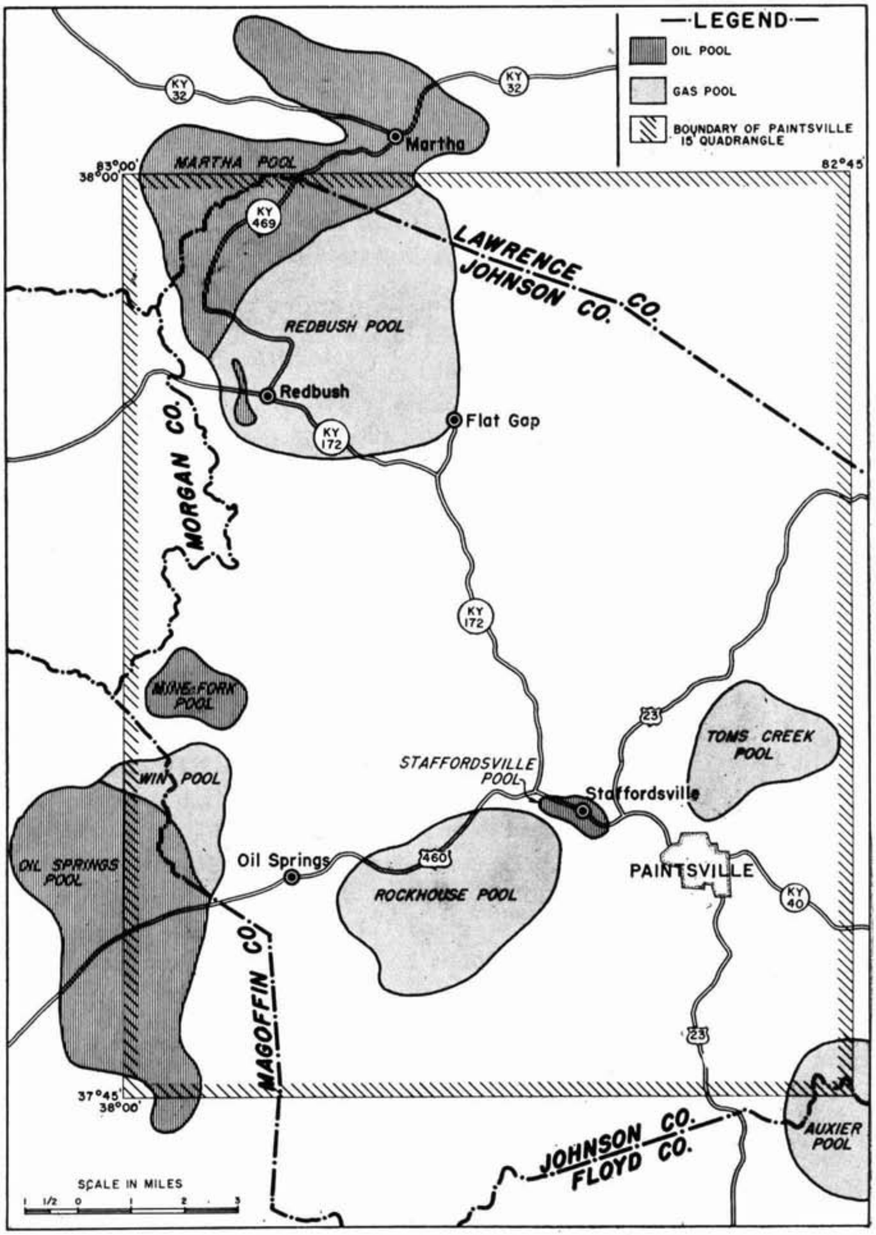


Fig. 10. Map of oil pools and gas fields of Paintsville area.

Secondary recovery by air-gas repressuring was begun in 1929 with 8 pressure wells. Today Ashland Oil and Refining Company is operating a total of 55 pressure wells which have accounted for 435,843 barrels of additional oil as of January 1, 1952.

The natural gas production in the area is approximately 250 million cubic feet per year from 110 wells and 7 different producing horizons. Gas has been found in small quantities throughout the area, but 5 distinct fields are recognized. They are, in order of their size, Redbush, Rockhouse, Toms Creek, Win, and Auxier fields.

The producing horizons are as follows:

Redbush—Weir, Berea, Ohio shale, Corniferous, and Big Six.
Rockhouse—Corniferous and Big Six.
Toms Creek—Ohio shale and Big Six.
Win—Corniferous and Big Six.
Auxier—Big Lime, Ohio shale, Corniferous, and Big Six.

Past Production and Reserve Estimates

In the following discussion reserve estimates are based on past production in this area and total production of comparable areas in Eastern Kentucky.

Staffordsville (Paint Creek) pool.—The first oil pool discovered in the Paintsville quadrangle was a small, now depleted pool located on Paint Creek 2 miles northwest of Paintsville and known as the Staffordsville or Paint Creek pool. The discovery well was drilled on the Stafford tract in 1916 with initial production of 4 barrels per day from the Berea sandstone at a depth of 850 feet. Eighteen wells were drilled along Paint Creek both north and south of the discovery well. The average initial production was from 3 to 4 barrels per day and lasted for nearly 30 years. Recently several of these wells have been pumped, but the recovery has not been sufficient to be classed as commercial. The Staffordsville oil pool total production is approximately 100,000 barrels.

Oil Springs pool.—The Oil Springs pool was discovered in June 1919, by a well drilled on the Milt Wheeler farm on Litteral Fork of Mine Fork in Magoffin County. The operator was the Bedrock Petroleum Company. Oil was encountered in the Weir sandstone at a depth of 902 feet. Active drilling was carried on by more than a score of small companies and individuals, with the result that the pool was well outlined by 1925. Initial production varied from 10 to 150 barrels per day and averaged 30 barrels.

The total cumulative production in the Oil Springs pool is approximately 10 million barrels.

Martha pool.—The Martha pool was discovered in August 1919, the result of a well drilled by the Union Oil Company on the Skaggs farm on Blaine Creek, Lawrence County. This well encountered 50 barrels of oil per day in the Weir sandstone. It started a boom which brought numerous drilling rigs to the area along the drainage of Blaine Creek. For four years active drilling was carried on, and by 1923 the pool was fairly well outlined. The total cumulative production in the Martha pool is approximately 17 million barrels.

Redbush field.—The Redbush gas field is located in northwestern Johnson County, extending from the community of Redbush north and east for about 5 miles across the headwaters of Upper Laurel Creek. The discovery well was drilled in September 1918, on the C. N. Williams farm on Upper Laurel Creek, behind the Redbush Post Office. The open flow was estimated at 500,000 cubic feet, with a rock pressure of 235 pounds. Production came from the Berea sandstone at a depth of 832 feet. Subsequent drilling encountered gas in the Weir sandstone, which lies about 100 feet above the Berea sandstone. The average initial production was as follows: Weir open flow—275,000 cubic feet, rock pressure 215 pounds; Berea open flow—275,000 cubic feet, rock pressure 285 pounds.

The Redbush field has produced approximately 15 billion cubic feet of gas. At present the field is near depletion, with a total reserve of about 3 billion cubic feet.

Rockhouse field.—The Rockhouse gas field is located 4 miles west of Paintsville on the tributaries of Paint Creek and on both sides of U. S. Highway 460. The discovery well was drilled on the Albert Horne farm on Rockhouse Branch of Paint Creek by Sam Allen and Crate Rice. The Big Six sandstone was drilled in at a depth of 2,315 feet on December 27, 1940. The open flow was gauged at 440,000 cubic feet, with a rock pressure of 690 pounds. The field was largely drilled up within the next two years. At present there are 22 Big Six and 5 Corniferous wells dispersed over an area of approximately 8 square miles. All of the production is either owned or bought by the Inland Gas Corporation. The estimated total cumulative production is 1 billion cubic feet, and the total reserve is approximately 350 million cubic feet.

Toms Creek field.—The Toms Creek gas field is located 2 miles northeast of Paintsville on Whippoorwill Branch and Road Fork of Toms Creek. The discovery well was drilled on the Henry Howes tract on Boyd Branch by the Evans Oil and Gas Company. The open flow measured 213,000 cubic feet, with a rock pressure of 800 pounds from the Big Six sandstone at a depth of 2,474 feet. This is the only Big Six well in the field. The wells drilled thereafter encountered gas in the Ohio shale and were not deepened. At present there are 8 wells producing from the Ohio shale and one shut-in in the Big Six.[1] The average well had an initial open flow of 150,000 cubic feet and a rock pressure of 300 pounds.

The Toms Creek field has produced approximately 250 million cubic feet of gas from the Ohio shale. The total estimated reserve is approximately 150 million cubic feet, and the entire production is sold to the city of Paintsville.

Win field.—The Win gas field is located in western Johnson County near the community of Win and on the headwaters of Pigeon and Hargis Creeks. The discovery well was drilled in November 1917, on the W. H. Conley farm by the Bedrock Petroleum Company. The open flow was estimated at 1 million cubic feet, with a rock pressure of 285 pounds from the Weir formation at a depth of 850 feet. Deeper drilling encountered gas in the Berea sandstone and the Corniferous limestone.

The field has produced approximately 800 million cubic feet of gas from about 40 wells covering about 2,000 acres. The estimated reserve is approximately 150 million cubic feet.

Auxier field.—The Auxier gas field is located in south-central Johnson County and north-central Floyd County along Levisa Fork of the Big Sandy River. The field was discovered in January 1931, by a well drilled on the Auxier Coal Company farm by the Piney Oil and Gas Company. The open flow was gauged at 521,000 cubic feet, with a rock pressure of 475 pounds, from the Corniferous formation.

The Kentucky West Virginia Gas Company at present has 8 wells turned into the line. There are about 12 depleted wells in the field.

The estimated cumulative production is 4 billion cubic feet of gas, and the estimated reserve is 1 billion cubic feet.

Analysis of Oil and Gas Accumulation and Future Possibilities

The greater portion of natural gas and oil from the shallower pay "sands" of the Paintsville quadrangle has probably been found. Since exploration began, about the time of World War I, over half of the reserves of the proven areas have been consumed. The above statement refers to production from Big Six and younger horizons, but exploration in pre-Big Six beds may open new fields.

Oil and gas production in the area is controlled by several factors. Structure plays an important part, inasmuch as most of the oil and gas

[1] Well has too much sulphur gas and therefore has not been turned into the line.

found is on the structural highs. This is demonstrated by noting the positions of the various oil and gas pools (see plate 6; also see plates 7, 8, and 9 for more detailed study of structure). The Oil Springs pool is located on the southern nose of the Paint Creek uplift; the Barnetts Creek and Rockhouse gas fields are on the south flank of the Paintsville anticline; the Win gas field is on the eastern, southeastern, and southern flanks of the Mine Fork dome; the Redbush gas field is on top and on the northern and southern flanks of the Laurel Creek dome; and the Martha pool is on the northern, northwestern, and western flanks of the Laurel Creek dome. However, this relationship to structure alone does not completely explain the distribution of the production, for in all cases the pool boundaries disregard the structure contours, cutting across them sharply. Furthermore, although the pools are in general structurally high, they are not necessarily at the highest points of the local structures. This indicates that other factors are equally important in the localization of the production. These are lithology, degree of cementation, degree of sorting, and localization of fracture zones. Thus, areas of favorable stratigraphic conditions variously located on the major structural highs are the loci of production.

It is possible that the location of structural highs was influenced partially by the original distribution of sediments. Sediments near shore or in other areas favorable for wave action may have been washed cleaner and better sorted. These could have suffered less compaction and initiated the high structures. Later folding could then accentuate these initial highs.

Since the boundaries of the pools are presumably permeability barriers, the pools can have no water drive. The production process is chiefly a depletion drive, and as a result the primary production recovers only a small proportion of the oil in place. This fact, plus the relatively low permeability and shallow depth, make these pools excellent prospects for water flooding.

Regarding production of gas from the Big Lime, D. M. Young (1950) has stated that production is believed to be controlled by porosity and permeability conditions. Most production is from oolitic beds in the Ste. Genevieve, where porosity is determined by the degree of cementation and the amount of solution. The size and degree of sorting of the oolites and the amount and coarseness of quartz sand present may also be factors.

Faulting could also be responsible for the localization of some of the oil and gas. Areas in close proximity to faults may be riddled with minor subsidiary fractures, producing porosity and permeability in otherwise impervious zones.

Fig. 11. Location of No. 2 clay sample at Volga, on Kentucky Route 172. This shale lies immediately above the Lee formation and is an excellent brick and tile shale.

Clay

Five clay shale samples collected by the writer from within the quadrangle have been analyzed (Walker, 1951, pp. 8-10; 1953, pp. 20-22). All the samples were taken from the Breathitt formation and were given preliminary tests. Samples 2, 3, and 5 were subjected to more complete examination.

Sample No. 1 was taken from the Kendrick shale, and it requires other clay additions in order to be suitable for the manufacturing of sewer pipes. This clay shale is the least desirable of the five clays tested. Place of sampling was at the head of Whippoorwill Branch of Toms Creek. Here the shale is 12 feet thick and lies immediately above the Amburgey coal, which in turn is 35 feet above the Van Lear coal.

The Kendrick shale has a large areal extent in this region, as only along the northern half of the eastern edge of the quadrangle does it go under drainage. From east to west it rises with the structure, so that it would be above the hilltops in the west-central area.

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).

Sample No. 5 is a different type of clay from the others, and it would be useful in the production of a wide variety of vitrified stoneware shapes, as well as wall or glazed brick. This clay was sampled at a point on a hill above and about 1000 feet northwest of the confluence of Pigeon Creek and Little Paint Creek, ½ mile from an improved gravel road and 6 miles west of U. S. Highway 460.

The sample was taken with a post-hole digger from a rain-washed ditch on a covered hillside. The clay is 6 to 8 feet thick here. The bottom of the clay is about 12 feet above the top of the Lee formation. This clay is creamy-white on outcrop, and when dry it is chalky-white, rather hard, and brittle. It slakes easily and is very plastic. It is believed by the writer to be in the same stratigraphic position as sample No. 2. Evidently it changes from a dark-blue shale, as seen in the road cuts between Paintsville and Volga, to this white clay at the mouth of Pigeon Creek.

Analyses

Samples No. 1 and 2 were analyzed by Dr. T. N. McVay, of the University of Alabama, and the following information is taken from his reports.

Sample No. 1 (Preliminary test)

The shale is pink in color, slakes well, and did not give a test for calcium carbonate or soluble sulfates. The working properties are satisfactory and its drying characteristics appear to be good.

Water of plasticity	25.2%
Linear drying shrinkage	3.9%
Linear firing shrinkage 1850° F	2.6%
Linear firing shrinkage 2100° F	8.5%
Color after 1850° F	Pinkish-buff
Color after 2100° F	Brownish-buff (not pleasing)

This clay may be useful with other clay additions for the manufacture of sewer pipes. The firing shrinkage at 2100° F. is rather high. It would require a complete test to determine its usefulness.

Sample No. 2

This is a mixture of pink and gray shale. It slakes well in water, works well, and is more plastic than number 1. The shale did not give a test for carbonates, and there was only a trace of soluble sulfates present. When the clay was mixed with the amount of water which the writer thought would be satisfactory, the clay column was too hard. When more water was added, it worked satisfactorily through the die.

Drying behavior

Linear drying shrinkage[1]	4.4%
Volume drying shrinkage	12.7%
Water of plasticity	24.5%
Drying defects	None noted
Tranverse strength	356 pounds per square inch

Cone	Porosity	Volume shrinkage	Linear shrinkage	Color
		%[1]	%	
08	29.3	1.6	0.5	Light salmon
06	25.8	5.5	.18	Light salmon
04	15.2	16.0	5.7	Salmon
02	0.6	27.4	10.3	Light brownish-red
1	0.0	27.2	10.2	Brownish-red
3	0.3	27.6	10.4	Brownish-red
5	0.0	26.6	10.0	Chocolate
7	2.9	17.8	6.4	Chocolate
9	7.5	12.6	4.4	Chocolate

Conclusions

This is a good shale, as it fired to a pleasing color and had a long firing range as shown by the porosity and firing shrinkage data.

Clays for use in making vitrified products should maintain a relatively constant low porosity and a constant volume over a considerable temperature interval. It may be noted that there was a drop in porosity and increase in shrinkage between cone 02 and cone 1. However, there is a temperature interval of about 80° F. between these cones.

The colors of the fired pieces may be different in commercial firing because of the longer heat treatment and slower cooling. However, they should be good, clear colors and entirely satisfactory.

It will not be necessary to fire to as high a temperature in kilns as in the laboratory to reach the same state of maturity in the shale, because of the difference in firing schedules. This also depends upon the type of kiln, because the maximum temperature in a periodic kiln for the same material is likely to be lower than tunnel kiln firing. It is estimated that the firing temperature in commercial kilns will be in the range 1900-2000° F.

[1] All shrinkages were calculated on the dimensions of the plastic test pieces in order to make calculations of die sizes easier. To obtain the total, add the drying and firing shrinkages.

Insofar as could be determined this shale should work well in processing and drying and has sufficient strength in the dry state so that ware can be handled.

In a letter to the Survey Dr. McVay states:

"Paintsville number 2 shale would be satisfactory for making common brick, drain tile and hollow block which need not be vitrified. It would also be suitable for high grade face brick, roofing and quarry tile. Quarry tile must be and the best grades of face brick are vitrified. Roofing tile may or may not be vitrified but I believe the latter are preferred on account of color."

The following three shale samples—Nos. 3, 4, and 5— were analyzed by J. H. Handwerk, University of Alabama. These analyses are quoted from reports received from Mr. Handwerk.

Sample No. 3

This is a dark, gray-colored shale which did not give a test for calcium carbonate or any soluble sulfates. It was slow to slake in water and is rather hard to grind. The shale when ground is plastic and will mold readily.

The sample as received was dried for 24 hours at 110° C. and then crushed to all pass 20 mesh. The proper amount of water was added and bars were extruded by means of the laboratory de-airing extrusion machine using full vacuum.

These bars were allowed to air dry and were then placed in an electric dryer where they were dried at 110° C. for 24 hours.

Transverse strength tests were made on 15 six-inch bars.

A draw trial firing was made. The furnace temperature was raised to 1500° F. overnight and then at the rate of 50° per hour. Three bars were withdrawn from the furnace at each of the following cones: 08, 06, 04, 02, 1, 3, 5, 7, and 8. These bars were then placed in a sagger, covered with sand, and allowed to cool to room temperature.

This shale is a dark-gray color and rather hard to crush. It is fairly plastic and worked well in the extrusion machine. The drying characteristics of the shale are as follows:

Water of plasticity	24.7%
Linear drying shrinkage	3.9%
Volume drying shrinkage	13.5%
Transverse strength	377 psi.
Drying defects	None noted

The firing characteristics are:

Cone	Porosity	Volume Shrinkage	Linear Shrinkage	Color
08	33.5%	2.7%	0.9%	Salmon
06	30.6%	7.5%	2.2%	Salmon
04	18.5%	19.5%	7.2%	Salmon
02	0.3%	31.6%	12.3%	Red
1	0.0%	31.7%	12.3%	Red
3	0.3%	31.5%	12.3%	Red
5	0.0%	31.5%	12.3%	Dark-brown
7	0.0%	30.8%	11.7%	Dark-brown
8	0.0%	27.9%	10.4%	Dark-brown
9	Bars fused together			

All shrinkages were calculated from the dimensions of the dry bars. To get the total shrinkage add the drying and firing shrinkages.

The drying characteristics of this shale are good. It has a low drying shrinkage and as no defects were noticed even when a 6-inch plastic bar was placed in a hot (110° C.) dryer, it is thought that this shale would be easy to dry. The tranverse strength of the dry bars was well within the limits for brick and tile shales.

The firing characteristics indicate that this shale will be a fast shrinking shale which will reach vitrification at moderate temperatures. The shale started shrinking at cone 06, and had reached vitrification at cone 02.

After vitrification the shale maintained its volume and low porosity over a long range of cones.

The fired colors of the bars were a range of reds and browns. These colors were pleasing to the eye.

This shale should be useful in the production of vitrified clay products such as sewer pipe and should also be suitable for brick and tile or other structural clay products.

Sample No. 4 (Preliminary test)

This shale is a dark, gray-colored shale which is slow to slake in water. It did not give a test for calcium carbonate or any soluble sulphates. The ground shale was plastic and could be readily molded into bars.

Water of plasticity	24.5%
Linear drying shrinkage	3.6%
Linear firing shrinkage	11.1%
Drying defects	None noted
Color (2000° F.)	Dark red

The drying shrinkage of this shale is low and as a 6-inch plastic bar did not warp or crack when placed in a hot (110° C.) dryer, this shale would be easy to dry. The color at 2000° F. is a good dark red. The firing shrinkage is rather high and the bars fired at 2000° F. had a vitreous appearance. This shale might be suitable for heavy vitrified clay products as well as for brick and tile.

Sample No. 5

This sample is a fine-grained clay which is soft enough to be crushed between the fingers. The color was an off-shade white with a light-cream cast. It did not give a test for calcium carbonate or any soluble sulphates. When crushed it was very plastic and would mold easily into bars.

The clay as received was dried at 110° C. for 24 hours, and then crushed to all pass 20 mesh. The proper amount of water was added, and bars were formed by means of the laboratory de-airing extrusion machine using full vacuum.

Transverse strength tests were made on 15 six-inch bars.

A draw trial firing was made. The furnace temperature was raised to 1500° F. overnight and then at the rate of 50° per hour. Three bars were withdrawn from the kiln at each of the following cones: 08, 06, 04, 02, 1, 3, 5, 7, and 9. These bars were placed in a sagger, covered with sand, and allowed to cool to room temperature.

This clay is a light cream-colored clay, and is similar to some of the stoneware clays. It is easy to crush and was very plastic. No difficulty was encountered in extruding the clay. The drying characteristics are:

Water of plasticity	34.5%
Linear drying shrinkage	6.6%
Volume drying shrinkage	20.1%
Tranverse strength	311 psi.
Drying defects	None noted

The firing characteristics are:

Cone	Porosity	Volume Shrinkage	Linear Shrinkage	Color
08	40.5%	0.5%	0.2%	Light-cream
06	39.4%	2.5%	0.9%	Light-cream
04	33.8%	10.9%	3.7%	Light-cream
02	12.3%	29.4%	11.1%	Buff
1	11.2%	29.9%	11.2%	Buff
3	8.7%	31.3%	12.1%	Dark-buff
5	0.0%	35.3%	13.5%	Brown
7	0.0%	35.6%	13.6%	Brown
9	0.3%	36.4%	14.1%	Brown

All shrinkages were calculated from the dimensions of the dry bars. To get the total shrinkage add the drying and firing shrinkages.

Conclusions

The drying shrinkage of this clay is moderate and as a 6-inch plastic bar did not warp or crack when placed in a hot (110° C.) drver, it was thought that this clay would cause no trouble in drying.

The transverse strength of the dry clay is high enough to enable ware formed from the clay to be handled in the dry state with little danger of breaking the ware.

The firing characteristics show that the clay has a moderate firing shrinkage up to cone 9 and that it will vitrify at cone 5. The firing range of the clay would be estimated from cone 5 to cone 9 and during this range the clay has a constant volume and low porosity.

The color of the fired bars in this range is a dark grayish-brown.

This clay would be useful in the production of a wide variety of vitrified stoneware shapes. The fired color is not too good, but this could be covered by glazes or engobes. Other ware which could be produced from this clay would be products such as wall tile or glazed brick.

TABLE 4

FUSING POINTS OF SEGER CONES
(Crider, 1913, pp. 709-711)

The following is a table of fusing points of Seger Cones so that the reader may better interpret the firing tests as given in the preceding pages.

Number of Cone	Fusing Point Degrees F.	Fusing Point Degrees C.	Number of Cone	Fusing Point Degrees F.	Fusing Point Degrees C.
0.012	1,634	890	3	2,174	1,190
0.011	1,688	920	4	2,210	1,210
0.010	1,742	950	5	2,246	1,230
0.09	1,778	970	6	2,282	1,250
0.08	1,814	990	7	2,318	1,270
0.07	1,850	1,010	8	2,354	1,290
0.06	1,886	1,030	9	2,390	1,310
0.05	1,922	1,050	10	2,426	1,330
0.04	1,950	1,070	11	2,462	1,350
0.03	1,994	1,090	12	2,498	1,370
0.02	2,030	1,110	13	2,534	1,390
0.01	2,066	1,130	14	2,570	1,410
1	2,102	1,150	15	2,606	1,430
2	2,138	1,170			

Future Possibilities

From these five clay analyses it is apparent that there are abundant clay shales of high quality within the Paintsville quadrangle. Other clay shales in this area that have not been sampled are undoubtedly of usable quality.

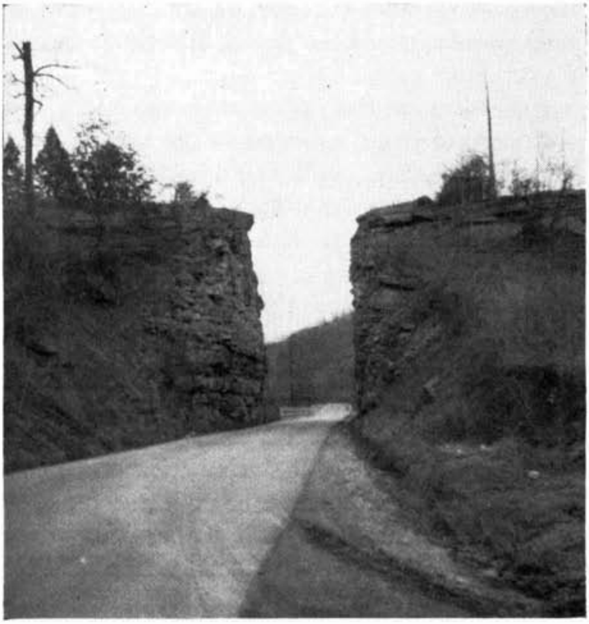


Fig. 12. Road cut through top 54 feet of sandstone at the top of the Lee formation one-fourth mile north of Staffordsville on Kentucky Route 172.

To date the clay shales have not been exploited, and there are no clay-manufacturing plants within a radius of approximately 70 miles. The abundant natural gas close at hand would be useful in clay products manufacturing.

The widespread areal extent of the clays and the several stratigraphic levels at which they occur makes it possible to locate clay sources where strip mining is feasible.

Sandstone

The Lee formation is probably the only sandstone in the area which may prove to be of commercial importance. It crops out in over half of the area and has a total thickness of about 450 feet. However, at its greatest exposure only about 200 feet of this sandstone is above drainage. One of the more favorable localities for possible exploitation of the sandstone as a glass sand or a building sandstone is one-quarter of a mile north of Staffordsville (see figure 12). Here a road cut on Kentucky Route 172 exposes 54 feet of sandstone at the top of the Lee formation. At this locality it is white, medium-grained, fairly clean, and medium-bedded.

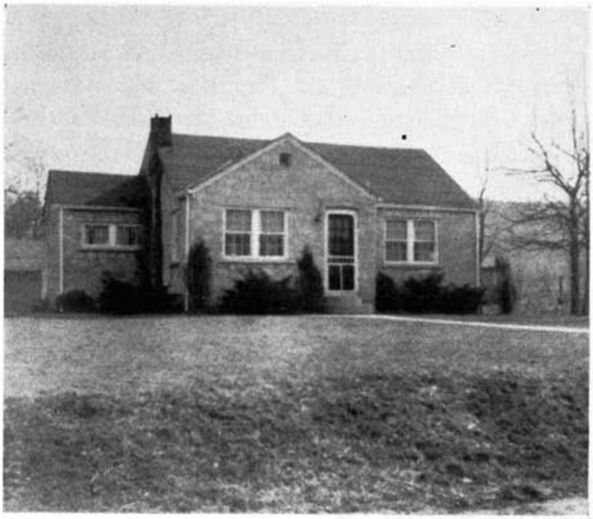


Fig. 13. House constructed from hewn Lee sandstone on Kentucky Route 172 about one-fourth mile north of Staffordsville.

This sandstone has been used locally as a building stone for domestic dwellings (figure 13).

A sample of the sandstone taken at the road cut just mentioned was analyzed by the Corning Glass Works, Corning, New York. Following are the results of the analysis: 0.11 percent Fe_2O_3 and 3.1 percent nonsilica remained in the sand after washing. This would allow the sand to be used in making seventh quality, or green glass, and ninth quality, or amber glass (McGrain, 1952, p. 8).

The top of the Lee formation in places consists of a series of alternating sandstones and shales. The sandstones range in thickness from about 3 to 12 inches and are flat and smooth on top and bottom. These sandstones could be readily quarried, because of the soft shales between them, and used for building stones and flagstones.

The Lee sandstone may also be used as an aggregate for road building. In places it meets qualifications as an aggregate, and it is thick and consistent and does not pinch out like many of the other sandstones in the area.

There are also two other fairly persistent sandstones in the area which will meet qualifications as an aggregate. These two sandstones are found just above and below the Van Lear coal.

Limestone

There is a good possibility that limestone could be profitably mined within the Paintsville quadrangle. The most likely formation which could serve as a source of commercial limestone is the Big Lime. This Mississippian limestone ranges in thickness from about 20 to 190 feet (see plate 3a, b, and c). Nowhere in the Paintsville quadrangle does the limestone crop out at the surface, but in the west-central part of the area, just north of the Irvine-Paint Creek fault, well logs show it to be little more than 100 feet below the surface. It is about 50 feet thick in this area. From this structural high the limestone dips down in all directions. At Staffordsville it is 335 feet below the surface and at Paintsville it is about 550 feet underground.

The structure and isopach maps (plates 7a, b, and c, 8a, b, and c, and 3a, b, and c) indicate the most favorable places for possible limestone mining. Cores of the limestone have not been analyzed, but in many other parts of the state this horizon is known to contain limestone of chemical grade (Stokley, 1949, p. 49, fig. IV, V). Certainly the stone would be useful for road ballast, mine dusting, and agricultural lime.

Brines

Five brines from wells in the area have been sampled and analyzed. Three were taken from the Pennsylvanian sandstones and one each from the Corniferous and Knox dolomite. Table 5 gives the results of these analyses, and table 6 indicates the location and geologic horizon of each sample.

Throughout Eastern Kentucky, brine samples are being collected and analyzed, and some of the results have been included in a preliminary report of the natural brines of Eastern Kentucky (McGrain and Thomas, 1951).

"The older the formation, the better the brine" is a simple rule that has general application to the brines. For example, Corniferous brines are better, Salt sand brines are poorer. However, there are exceptions to this rule. Some Knox brines have lower densities than some of the Corniferous brines.

Studies to date show that the Corniferous brines of five northeastern counties—Boyd, Greenup, Carter, Elliott, and Lawrence—have the best commercial promise. The brines south of these counties, however, show less commercial promise. However, complete information on the brines will not be known until the brine survey of Eastern Kentucky is terminated.

TABLE 5

Analyses of Brine Samples[*]

Brine Sample No.		13	35	44	7-E	10-B
Density at 25° C.		1.025	1.127	1.025		
Density at 20° C.					1.0156	1.104
Total solids (%)		4.11	16.62	5.00		
Calcium chloride (%)		0.52	6.25	0.38		
Strontium chloride	(%)	0.000	0.21	0.01		
Barium chloride	(%)	0.004	ND	ND		
Magnesium chloride	(%)	0.20	0.51	0.11		
Potassium chloride	(%)	0.018	0.26	0.04		
Sodium chloride	(%)	3.23	9.27	3.30		
Bicarbonate	(ppm)	34	108	280	120	140
Bromide	(ppm)	127	735	110	92	
Iodine	(ppm)	5	41	13	.4	18
Sulfate	(ppm)	3	128	ND	0	1,060
Iron	(ppm)	0	7	ND	4.4	0.71
Boron	(ppm)		6.5	7.3		
pH					7.3	
Silica	(ppm)				5.9	8.00
Aluminum	(ppm)				8.6	
Calcium	(ppm)				1,337	12,700
Magnesium	(ppm)				368	3,390
Strontium	(ppm)				41	
Barium	(ppm)				66	
Sodium	(ppm)				8,009	34,140
Potassium	(ppm)				96	958
Carbonate	(ppm)				0.0	0.0
Chloride	(ppm)				15,520	85,430
Bromide	(ppm)				92	914
Borate	(ppm)				0.0	
Phosphate	(ppm)				0.0	
Manganese	(ppm)					0.0
Dissolved solids	(ppm)				25,310	142,400
Specific conductance at 25° C. (micromhos)					34,450	123,000
Total hardness as $CaCO_3$	(ppm)					45,630

(ND—No determination made)
(*ppm—Parts per million*)

[*] Data for samples 13, 35, and 44 taken from Preliminary Report on the Natural Brines of Eastern Kentucky, by Preston McGrain and George R. Thomas (1951).

[*] Data for samples 7-E and 10-B obtained from U. S. Geological Survey, Water Resources Branch, Paintsville office.

TABLE 6

LOCATION AND SOURCE OF BRINE SAMPLES

Brine Sample Number	Operator and Company No.	Location	Source of Brine Geological Formation	Depth	Elevation at Surface	Indicated Yield
13	Kentucky West Virginia Gas Co. 5789	½ mi. S. of Van Lear	Salt Sand	600	651	Hole full of salt water
35	Ashland Oil & Refining Co.	¼ mi. S. of Redbush	Knox	±5300	843	ND
44	Simon Daniels	2 mi. SE of Paintsville	Salt Sand	520	670	Hole full of salt water
7-E	City of Paintsville	Preston St., Paintsville	Penn. sandstone	ND	ND	2 GM, flow estimated
10-B	Inland Gas Corp. 356	Barnetts Creek, Ky.	Corniferous	2000-2187	ND	ND

(ND–No Data)

(GM–gallons per minute)

Natural Rock Asphalt

Oil saturated sandstone is found within the Lee formation in the western part of the Paintsville quadrangle along Paint Creek and its tributaries. This natural asphalt is found 50 to 75 feet below the top of the Lee formation and ranges in thickness from 4 to 12 feet at outcrop. Thicknesses as great as 90 feet have been reported from oil and gas well tests, but the writer has not been able to confirm these reports.

The asphalt was sampled on Mine Fork just below the mouth of Little Mine Fork (plate 2) and sent to the Kentucky Department of Highways, Frankfort, Kentucky, for analysis.

The following section was seen at the sample location:

75′ (estimated)	sandstone, massive
6′	asphaltic sandstone, very coarse grained
2′ (estimated)	Mine Fork coal (being mined for local use only)

Following are the results of tests of the asphalt sample as received from Division of Materials, Kentucky Department of Highways, Frankfort, Kentucky.

	Percent passing			% Bitumen	
	¾″	½″	#4 sieve	by ignition	% SiO_2
Crushed	100.0	100.0	100.0	4.23	89.3
Uncrushed		No test		9.87	92.4

In order to evaluate the results of the sample the following information regarding requirements of asphalt used by the Kentucky Department of Highways is included.

The rock asphalt shall be composed of sharp angular quartz sand which by natural process has been thoroughly impregnated with bitumen. The sand in the rock asphalt shall contain not less than 93.0% of silica (SiO_2).

The rock asphalt shall be free of dirt, vegetable matter or an appreciable quantity of uncoated sand, and any rock asphalt which becomes contaminated with foreign material shall not be used. The bitumen must be an asphalt that is native to the rock and one that has proven satisfactory for pavement. The rock asphalt shall contain not less than 6.2% nor more than 8.5% bitumen by extraction. The completely dehydrated rock asphalt shall sustain a loss upon ignition of not less than 7.2% nor more than 9.0% bitumen. The ignition test shall be made but in case of failure by this method then the extraction test shall govern. The natural rock asphalt shall be used as quarried or mined with no preparation other than blending, crushing and grinding. No rock asphalt containing less than 6.0% bitumen by ignition shall be used in blending this material. A natural material shall be furnished which will meet all the requirements of these specifications, and no bitumen, sand or other material shall be added to, taken from, or mechanically mixed with the natural rock asphalt.

This material shall be so crushed and ground that when tested by means of laboratory sieves having square openings, it shall comply with the following requirements:

Passing ¾″ sieve		100%
Passing ½″ sieve	not less than	99%
Passing #4 sieve	not less than	80%

(Kentucky Department of Highways, 1945, pp. 494-495)

Ground Water

A study of the ground water resources of the southeast quarter of the Paintsville quadrangle has recently been completed by John A. Baker of the U. S. Geological Survey. A similar project is being undertaken by William E. Price, Jr., of the U. S. Geological Survey for the northeast quarter of the Prestonsburg quadrangle. Since these reports should be published in the near future, no attempt is made here to discuss this resource. The reports will make available information regarding yields from domestic wells, availability of water, and chemical quality analyses of waters of the region.

GEOLOGIC CONDITIONS AFFECTING HIGHWAYS

Roads built in areas of sandstone outcrop are more durable than those built on underclays, shales, and alluvium. The clays and shales slake readily with water, causing disintegration of the pavement and frequently producing slides.

In most places where present, the Lee formation provides an excellent base fcr highway construction because the sandstones are massive, thick-bedded, and disintegrate slowly. Plates 1a, b, c, and d indicate the areas where the Lee is the surface rock. These areas should present no great difficulty in highway construction, insofar as a good base is concerned. However, most of the quadrangle is underlain by the Breathitt formation. A description of its variable characteristics has already been given. It includes many thick shaly zones with several sand horizons. The sandstones are discontinuous, pinching and swelling laterally, making it virtually impossible to follow one of them in road construction, or to predict the characteristics of the bedrock accurately for any great distance along a proposed highway without detailed core drilling.

An undesirable condition for highway maintenance may be seen along a two-mile stretch of U. S. Highways 23 and 460 west of Paints-

Fig. 14. Rock fall, caused by erosional undermining, blocking road one-fourth mile east of Thealka Post Office.

ville, where the road is built on the thick shale section that lies immediately above the Lee formation. Here the shale disintegrates rapidly, resulting in small but frequent slides which fill the drainage ditch along the highway.

Frequently highway cuts have been made in the Breathitt formation where sandstone beds well above road level are underlain by shales. In such cases the shales are likely to be undermined by water seeping down through joints from above. This causes the dislodgment and subsequent sliding of large sandstone blocks (see figure 14.)

Because of the narrow valleys, the narrow, discontinuous divides, and steep slopes most roads must be built in cuts, with the resulting disturbance of equilibrium and production of slides, or the roads must follow the poorly indurated and porous alluvial bottoms of the valleys. Where the alluviated bottoms must be used, it would be well to place the roads as far away from the steep valley sides as possible, because drainage from the hillsides works its way into the alluvium at the contact between the bedrock of the hillslopes and the alluvium of the valley bottom.

Rock of suitable aggregate within the area has long been a problem in road construction in this region. A new source of such aggregate might be developed by the opening of a limestone mine, as already suggested in this report.

Recently the State Highway Department has been conducting tests on sandstone that might be suitable as aggregate. Should these tests give favorable results, there are several localities within the area where sandstone is present in thick enough benches for quarrying operations. A few such areas are as follows. There are three old quarry pits along Levisa Fork just below the mouth of Buffalo Creek where sandstone underlies the Van Lear coal. Sandstone is exposed in a 54 foot cut on State Highway 172 about one-fourth mile north of U. S. Route 460 at Staffordsville (see figure 12). There is an abandoned quarry in the top of the Lee conglomerate about one-half mile north of Flat Gap. The upper portion of the Lee is exposed along the paved road about one-fourth mile north of Redbush and the Lee is again well exposed in the vicinity of the mouth of Barnetts Creek. Sandstone which lies above the Van Lear coal is well exposed along U. S. Highway 23 just south of the railroad yards at Paintsville.

TABLE 7

INDEX TO OIL AND GAS WELLS AND TESTS IN PAINTSVILLE QUADRANGLE

The following table lists the numbers assigned to oil and gas wells and tests by the various operating companies. A second number has been assigned each well by the writer to avoid duplication. All numbers used on the maps of this report are the author's numbers.

SOUTHEAST RECTANGLE

Kentucky West Virginia Gas Co. No.	Author's No.
189	1
347	2
546	3
707	4
709	5
717	6
834	7
835	8
836	9
837	10
838	11
839	12
840	13
8083	14
3422	15
3429	16
3570	17
3909	18
3910	19
4360	20
4453	21
4462	22
4467	23
4490	24
4503	25
4508	26
4535	27
4540	28
4567	29
4568	30
4579	31
4580	32
4595	33
4596	34
4597	35
4625	36
4673	37
4727	38
5028	39
5046	40
5433	41
5465	42
5556	43
5587	44
5609	45
5615	46
5627	47
5658	48
5769	49
5789	50
5452	51
2122	52
6164	53
5345	54
6304	55

Inland Gas Corp. No.	Author's No.
371	56

Southwest Rectangle

Kentucky West Virginia Gas Co. No.	Author's No.
625	1000
631	1001
632	1002
634	1003
635	1004
636	1005
637	1006
638	1007
639	1008
640	1009
645	1010
648	1011
689	1012
723	1013
724	1014
738	1015
777	1016
782	1017
843	1018
857	1019
858	1020
865	1021
569	1022
570	1023
626	1024
627	1025
628	1026
629	1027
641	1028
644	1029
646	1030
642	1031
643	1032
649	1033
650	1034
651	1035
652	1036
653	1037
654	1038
655	1039
656	1040
657	1041
658	1042
659	1043
660	1044
661	1045
662	1046
663	1047
664	1048
665	1049
666	1050
667	1051
668	1052
669	1053
670	1054
671	1055
672	1056
673	1057
674	1058
675	1059
676	1060
677	1061
678	1062
680	1063
681	1064
682	1065
683	1066
684	1067
685	1068
686	1069
687	1070
688	1071
690	1072
691	1073
693	1074
706	1075
707	1076
708	1077
709	1078
711	1079
712	1080
714	1081
710	1082
713	1083
715	1084
716	1085
717	1086
718	1087
719	1088
720	1089
721	1090
722	1091
737	1092
736	1093
771	1094
741	1095
774	1096
775	1097

Southwest Rectangle—Continued

Kentucky West Virginia Gas Co. No.	Author's No.	Kentucky West Virginia Gas Co. No.	Author's No.
776	1098	857	1147
779	1099	858	1148
780	1100	859	1149
781	1101	862	1150
785	1102	863	1151
786	1103	1054	1152
789	1104	1058	1153
790	1105	2091	1154
791	1106	2120	1155
793	1107	2196	1156
794	1108	2222	1157
795	1109	2281	1158
796	1110	2367	1159
797	1111	2762	1160
798	1112	2772	1161
799	1113	2773	1162
800	1114	3479	1163
801	1115	4475	1164
802	1116	4500	1165
803	1117	4536	1166
804	1118	4581	1167
805	1119	4594	1168
806	1120	4631	1169
807	1121	4639	1170
808	1122	4680	1171
809	1123	4732	1172
814	1124	4797	1173
815	1125	4869	1174
816	1126	4890	1175
817	1127	4891	1176
818	1128	4934	1177
819	1129	5192	1178
820	1130	5385	1179
821	1131	5386	1180
822	1132	5460	1181
823	1133	5494	1182
824	1134	5495	1183
825	1135	5507	1184
826	1136	5508	1185
827	1137	5738	1187
828	1138	5780	1188
829	1139	5871	1189
830	1140	6076	1190
841	1141	6092	1191
843	1142	6145	1192
846	1143	6213	1193
854	1144	6250	1194
855	1145	6326	1195
856	1146		

Ashland Oil and Refining Co. Farm	No.	Kentucky West Virginia Gas Co. No.	Author's No.
J. M. Fyffe	14	1442	2000
J. M. Fyffe	4	4	2001
J. M. Fyffe	7	1446	2002
J. M. Fyffe	12	1451	2003
J. M. Fyffe	23	1458	2004
J. C. Gillem	10	10	2005
J. C. Gillem	4	4	2006
Geo. N. Evans	1	1164	2007
Geo. N. Evans	4	1214	2008
Geo. N. Evans	10	1132	2009
Geo. N. Evans	21	21	2010
Sherman Lyon	5	5	2011
Sherman Lyon	6	6	2012
Sherman Lyon	7	1295	2013
P. P. Holbrook	5	225	2014
P. P. Holbrook	15	1880	2015
P. P. Holbrook	25	1891	2016
Proctor Sparks	25	1944	2017
Proctor Sparks	11	1955	2018
Proctor Sparks	7	7	2019
Proctor Sparks	6	6	2020
Proctor Sparks	20	1937	2021
Felix Fyffe	2	1372	2022
Felix Fyffe	5	1375	2023
Jesse Lyon	8	8	2024
Jesse Lyon	18	18	2025
Martha Kelley	1	1318	2026
Martha Kelley	3	1320	2027
Martha Kelley	5	1321	2028
W. L. Gillem	1	1	2029
Proctor Lyon	2	1255	2030
Proctor Lyon	5	5	2031
J. J. Gambill	7	7	2032
J. J. Gambill	36	1864	2033
J. J. Gambill	15	1868	2034
D. V. Skaggs	7	7	2035
D. W. Skaggs	5	1496	2036
D. W. Skaggs	9	1543	2037
Oscar Skaggs	2	1385	2038
J. A. Dials	5	5	2039
J. A. Dials	7	1581	2040
Alfred Skaggs	1	1355	2041
Alfred Skaggs	2	1356	2042
James Skaggs	6		2043
James Skaggs	7		2044
James Skaggs	8		2045
James Skaggs	9		2046
James Skaggs	10		2047
James Skaggs	11		2048
James Skaggs	13		2049
Andrew Skaggs	8		2050
J. J. Cantrill	46		2051
J. J. Cantrill	45		2052
J. J. Cantrill	42		2053
J. J. Cantrill	44		2054
J. J. Cantrill	43		2055
W. C. Cantrill	1	1588	2056

Ashland Oil and Refining Co. Farm	No.	Author's No.	Ashland Oil and Refining Co. Farm	No.	Author's No.
J. J. Cantrill	41	2057	Wm. Lester	8	2104
J. J. Cantrill	40	2058	Wm. Lester	9	2105
J. J. Cantrill	38	2059	Wm. Lester	10	2106
J. J. Cantrill	39	2060	J. L. Skaggs	1	2107
J. J. Cantrill	37	2061	J. L. Skaggs	2	2108
J. J. Cantrill	36	2062	James C. Skaggs	1	2109
J. J. Cantrill	35	2063	James C. Skaggs	2	2110
J. J. Cantrill	34	2064	E. H. Skaggs	3	2111
J. J. Cantrill	32	2065	E. H. Skaggs	4	2112
J. J. Cantrill	33	2066	E. H. Skaggs	5	2113
J. J. Cantrill	31	2067	Levisa Skaggs	1	2114
J. J. Cantrill	29	2068	Levisa Skaggs	6	2115
J. C. Holbrook	9	2069	Levisa Skaggs	7	2116
J. C. Holbrook	10	2070	Levisa Skaggs	10	2117
J. C. Holbrook	8	2071	Levisa Skaggs	12	2118
J. C. Holbrook	12	2072	Levisa Skaggs	17	2119
Jean Holbrook	2	2073	Parish Sparks	2	2120
J. C. Holbrook	14	2074	Parish Sparks	4	2121
L. D. & P. P. Holbrook	1	2075	Parish Sparks	9	2122
L. D. & P. P. Holbrook	3	2076	Geo. Kelley	1	2123
L. D. & P. P. Holbrook	2	2077	Geo. Kelley	2	2124
J. C. Holbrook	5	2078	Geo. Kelley	4	2125
J. C. Holbrook	11	2079	Geo. Kelley	11	2126
Wright Bros.	2	2080	Geo. Kelley	14	2127
C. C. & S. Wright	1	2081	Laura Skaggs	1	2128
W. H. Ferguson	1	2082	Laura Skaggs	2	2129
M. E. & Ben Ferguson	11	2083	Laura Skaggs	3	2130
L. F. Skaggs	1	2084	Laura Skaggs	4	2131
L. F. Skaggs	2	2085	Jim Diles	1	2132
L. H. Skaggs	1	2086	Jim Diles	3	2133
L. H. Skaggs	2	2087	Jim Diles	4	2134
L. H. Skaggs	3	2088	Annie Rose	2	2135
L. H. Skaggs	4	2089	Annie Rose	3	2136
L. H. Skaggs	5	2090	Annie Rose	4	2137
L. H. Skaggs	6	2091	John Rose	1	2138
L. H. Skaggs	7	2092	John Rose	4	2139
L. H. Skaggs	8	2093	C. C. Rose	1	2140
L. H. Skaggs	9	2094	D. H. Ferguson	1	2141
L. H. Skaggs	10	2095	D. H. Ferguson	4	2142
L. H. Skaggs	11	2096	D. H. Ferguson	5	2143
Wm. Lester	1	2097	D. H. Ferguson	6	2144
Wm. Lester	2	2098	J. T. Bailey	1	2145
Wm. Lester	3	2099	J. T. Bailey	2	2146
Wm. Lester	4	2100	J. T. Bailey	3	2147
Wm. Lester	5	2101	Anderson Kelley	1	2148
Wm. Lester	6	2102	Anderson Kelley	2	2149
Wm. Lester	7	2103	Harrison Bailey	2	2150

NORTHWEST RECTANGLE—Continued

Ashland Oil and Refining Co. Farm	No.	Author's No.
Harrison Bailey	3	2151
Harrison Bailey	4	2152
Harrison Bailey	5	2153
Luke Ferguson	1	2154
Luke Ferguson	5	2155
Luke Ferguson	8	2156
Luke Ferguson	9	2157
Hardy Skaggs	1	2158
Hardy Skaggs	2	2159
Andrew Skaggs	2	2160
Andrew Skaggs	3	2161
Andrew Skaggs	4	2162
Andrew Skaggs	13	2163
Andrew Skaggs	14	2164
Andrew Skaggs	15	2165
Lewis Skaggs	2	2166
Lewis Skaggs	5	2167
Lewis Skaggs	6	2168
Lewis Skaggs	7	2169
Lewis Skaggs	12	2170
J. H. Holbrook	1	2171
J. H. Holbrook	9	2172
Sanford Lyon	6	2173
Sanford Lyon	9	2174
Sanford Lyon	11	2175
Sanford Lyon	13	2176
Sanford Lyon	15	2177
Sanford Lyon	16	2178
Sanford Lyon	19	2179
Sanford Lyon	26	2180
James Skaggs	2	2181
James Skaggs	4	2182
James Skaggs	5	2183
James Skaggs	18	2184
James Skaggs	6	2185
James Skaggs	8	2186
James Skaggs	11	2187
Henry McKinzie	2	2188
Henry McKinzie	3	2189
Henry McKinzie	7	2190
Henry McKinzie	11	2191
Herbert Skaggs	1	2192
Herbert Skaggs	2	2193
Herbert Skaggs	4	2194
Herbert Skaggs	1	2195
Ben Ferguson	1	2196
Ben Ferguson	7	2197
Ben Ferguson	5	2198
Ben Ferguson	8	2199
Ben Ferguson	9	2200
Ben Ferguson	13	2201
John C. Gillem	4	2202
John C. Gillem	5	2203
Joel Kelley	1	2204
Joel Kelley	3	2205
Joel Kelley	4	2206
Joel Kelley	5	2207
John McKinzie	1	2208
John McKinzie	2	2209
John McKinzie	5	2210
Keaton School Lot	1	2211
Keaton School Lot	2	2212
L. P. Ferguson	10	2213
L. P. Ferguson	9	2214
Jesse Rose	2	2215
Geo. Kelley	1(2?)	2216
A. M. Lyon	3	2217
A. M. Lyon	4	2218
Proctor Sparks	108	2219
M. E. Ferguson	13	2220
Sanford Lyon	7	2221
J. M. Gibson	1	2222
Sanford Lyon	28	2223
Sanford Lyon	6	2224
Sanford Bailey	1	2225
D. B. Bailey	1	2226
John McKinzie	2	2227
John McKinzie	3	2228
John McKinzie	5	2229
John McKinzie	4	2230
John McKinzie	1	2231
John McKinzie	6	2232
W. R. Bailey	1	2233
W. H. Bailey	1	2234
J. T. Bailey	3	2235
J. T. Bailey	2	2236
W. F. Skaggs	2	2237
M. L. Skaggs	2	2238
H. Skaggs	1	2239
H. T. Hamilton	1	2240
W. F. Skaggs	1	2241

NORTHWEST RECTANGLE—Continued

Kentucky West Virginia Gas Co. No.	Author's No.
2784	2242
239	2243
272	2244
815	2245
1023	2246
1035	2247
1133	2248
1201	2249
1218	2250
1259	2251
1295	2252
2160	2253
2010	2254
2011	2255
1031	2256
243	2257
1296	2258
2163	2259
2736	2260
2820	2261
2783	2262
1033	2263
1024	2264
1297	2265
1298	2266
1351	2267
1352	2268
1353	2269
1354	2270
1355	2271
1357	2272
1370	2273
1371	2274
1377	2275
1378	2276
1382	2277
1384	2278
1450	2279
1489	2280
1491	2281
1460	2282
1461	2283
1462	2284
1482	2285
1483	2286
1530	2287
1570	2288
1571	2289
1572	2290
1574	2291
1575	2292
1581	2293
1601	2294
1602	2295
1603	2296
1856	2297
1903	2298
1937	2299
2158	2300
2162	2301
2164	2302
869	2303
872	2304
873	2305
874	2306
875	2307
876	2308
877	2309
878	2310
879	2311
880	2312
881	2313
882	2314
883	2315
884	2316
885	2317
886	2318
888	2319
889	2320
890	2321
891	2322
894	2323
895	2324
896	2325
897	2326
898	2327
900	2328
1009	2329
1010	2330
1011	2331
1012	2332
1013	2333
1018	2334
1020	2335
2955	2336
5557	2337
6090	2338
1032	2350

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