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ECONOMIC GEOLOGY

OF THE

KENOVA QUADRANGLE

KENTUCKY, OHIO, AND WEST VIRGINIA

BY

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ECONOMIC GEOLOGY OF THE KENOVA QUADRANGLE, KENTUCKY, OHIO, AND WEST VIRGINIA.

By WILLIAM CLIFTON PHALEN.

INTRODUCTION.

Importance of the area.—The Kenova quadrangle is of interest on account of its valuable deposits of coal and fire clay. Of less value are its iron ores, limestones, and building stones. It forms part of a much larger area in which during the last three or four decades there has been much activity in the mining of coal and in the mining and smelting of iron ores. The latter industry has been discontinued, but coal is still being mined. The clay industry in this region is small at present, but should have an important future on account of the amount of available raw material. (See Pl. I, in pocket.)

Location and area.—The Kenova quadrangle includes parts of Kentucky, Ohio, and West Virginia, the name Kenova being coined by combining abbreviations of these State names. Its exact position is shown on the accompanying key map (Pl. II). Far the greater part of its 938 square miles is within Kentucky, including the whole of Boyd County, the larger part of Lawrence, and parts of Carter, Greenup, and Elliott counties, Ky. A small part of Wayne County, W. Va., and the south end of Lawrence County, Ohio, make up the remainder. The quadrangle takes its name from a small town, Kenova, lying at the confluence of Big Sandy and Ohio rivers.

The portions of Kentucky and Ohio in this locality are sometimes known as the "Hanging Rock" region, from an outcrop of massive sandstone at Hanging Rock on Ohio River, a few miles below the city of Ashland.

From a geographic as well as a physiographic point of view, this area is a part of the western Appalachian Plateau province. It lies along the western edge and just north of the center of the great coal field comprised within this province, which extends from north-central Alabama to the southern boundary of New York.

Previous field work.—This area was studied by the geologists of the Kentucky Geological Survey during the latter half of the past

century. Most of the work on the coals and general geology in this particular area was done by Prof. A. R. Crandall. Mr. P. N. Moore examined more particularly the geology, distribution, and technology of the iron ores. Dr. I. C. White, director of the West Virginia Geological Survey, has measured sections in that part of the quadrangle which lies in Wayne County, W. Va., and the State Survey of Ohio has worked on the Ohio portion.

In addition to the work of these men special areas have been examined for private parties by geologists and mining engineers.

Literature.—The publications containing the most information on this area are the following:

Crandall, A. R., and Moore, P. N., Report on the eastern coal field: Geol. Survey Kentucky, vol. C, 1884, 77 pp.

The chapter on coals in this publication is also contained in Geol. Survey Kentucky, vol. 2, pt. 1, new ser., 1877, pp. 1–77; the discussion relating to the iron ores of Greenup, Boyd, and Carter counties, or the Kentucky division of the Hanging Rock iron district, is found in the same report, pt. 3, vol. 1, 1876, pp. 59–136.

Shaler, N. S., and Crandall, A. R., Report on the timber growth of Greenup, Carter, Boyd, and Lawrence counties: Kentucky Geol. Survey, new ser., vol. 1, pt. 1, 1876, pp. 1–58.

Survey of Big Sandy River, West Virginia and Kentucky, including Levisa and Tug Forks; House Doc. No. 326, 56th Cong., 1st sess., 1900, 62 pp.

Hoeing, J. B., Oil and gas: Kentucky Geol. Survey, Bull. No. 1, 1905, 233 pp.

White, I. C., Coal report: West Virginia Geol. Survey, vol. 2, 1903, 725 pp.

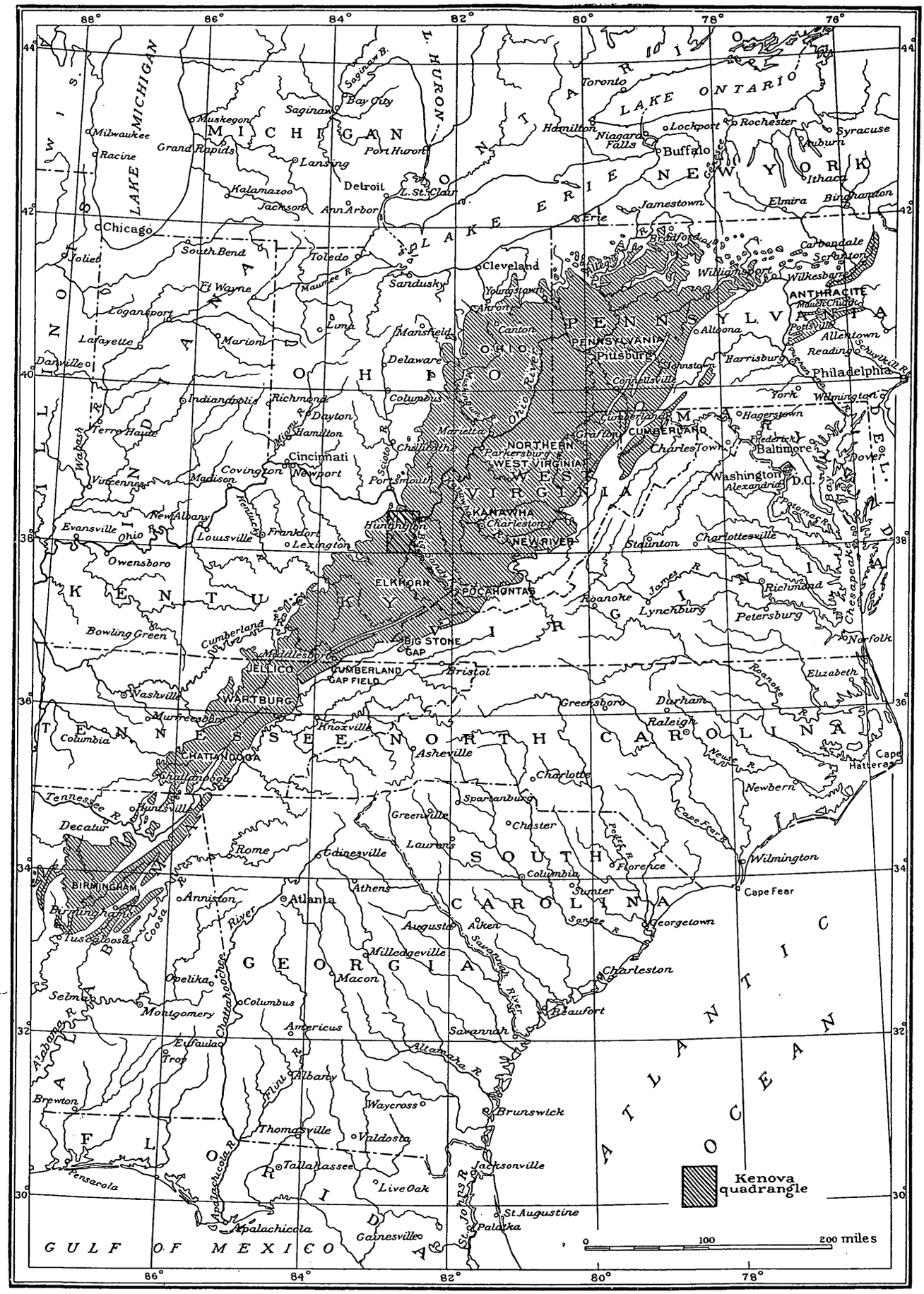
Stevenson, J. J., Lower Carboniferous of the Appalachian Basin: Bull. Geol. Soc. America, vol. 14, 1903, pp. 36 et seq., 80 et seq.

Stevenson, J. J., Carboniferous of the Appalachian Basin: Bull. Geol. Soc. America, vol. 15, 1904, pp. 92–114.

Ohio Geol. Survey, vol. 3, p. 1; vols. 5 and 7.

The reader will also get much information from the four volumes of reports of the first Kentucky Geological Survey, made by Dr. David Dale Owen in the years 1854 to 1860, inclusive. These early reports are somewhat discursive, and the information can most easily be found by reference to the indexes under the names of the various counties.

Present field work.—The field work on which this paper is based was done by W. C. Phalen in 1905, from the last of May to the first of November. George H. Ashley spent about two months in the field, visiting with the writer most of the critical areas and doing some independent mapping. David White also visited the field and spent somewhat less time making numerous careful and complete collections, which have furnished in part the basis for the separation of the formations chosen in geologic mapping. Numerous references to the work of Doctors Ashley and White will be found scattered through the text, and an expression of thanks is herewith extended to these geologists for courtesies both in the office and in the field.



KEY MAP SHOWING LOCATION OF KENOVA QUADRANGLE WITH REFERENCE TO THE ENTIRE APPALACHIAN COAL FIELD.

TOPOGRAPHY.

Relief.—The part of the Appalachian Plateau included in this region has been greatly dissected, until there is now scarcely any level land within the quadrangle, except the flood plains of the larger streams, like Ohio, Big Sandy, and Little Sandy rivers. This extensive erosion has resulted in sharp ridges, in many cases barely wide enough for wagon roads, and rather narrow valleys with small flood plains reaching well up to their heads. From the tops of the highest hills the remnants of the Appalachian Plateau may still be recognized in the even sky line (Pl. III, *A*). In a general way this ancient surface, or rather what remains of it, is highest at the south edge of the area, where the highest knobs reach an elevation of 1,200 feet. It slopes gradually northwest, and in the divide between the waters of Tygarts Creek and Little Sandy River only a few of the knobs rise above 1,000 feet. The lowest points in the area are those farthest downstream on Ohio and Little Sandy rivers and on Tygarts Creek. The flood plain of the Ohio ranges from about 530 feet above sea level where it leaves the quadrangle to about 560 feet where it enters it from the east. The flood plain of Big Sandy has an elevation of about 597 feet at the south edge of the quadrangle and 550 feet at the mouth of the stream, showing a gradient of about 1.1 feet per mile. This is slightly less than the gradient of Little Sandy. On Big Sandy the flood plain, though it may in places reach a mile in width, averages between one-half and three-quarters of a mile. The plain of Little Sandy from Grayson to Argillite has a greater average width, but in the upper portion of the river flood plains are wanting, the stream flowing through a gorge formed in the Sharon conglomerate.

The badly dissected character of the region has an important bearing on the exploitation of the natural resources. The railroads were confined during the early part of their history to the main river valleys and had to leave untouched for some time the more remote workable coal and clay beds; on the other hand, the flood plains, which are almost everywhere developed along the streams, are favorable to the construction of spur tracks that will materially lessen the haulage from mine breast to tipple.

Points of equal elevation are represented on the map by contour lines in buff, which are really the intersections of hypothetical plains with the surface of the country. These contour lines are placed 100 feet apart and, when carefully studied, enable the mind to grasp fairly well the general "lay of the land."

Drainage.—The drainage of this quadrangle is either directly or indirectly into Ohio River, which crosses its northeastern corner. The chief tributaries of Ohio River are Big and Little Sandy rivers

and Twelvepole and Tygarts creeks, the last named flowing across the extreme northwestern corner. Twelvepole Creek, entering from the Huntington quadrangle on the east, flows about 10 miles in a circuitous course in West Virginia and empties into Ohio River at Kellogg. Practically all the smaller streams flow into Big and Little Sandy rivers. Of these streams Big Blaine, a tributary of Big Sandy with an estimated length of about 70 miles almost wholly included within this quadrangle, and East Fork of Little Sandy are the most important. The Big Sandy, which in conjunction with Ohio River is the main drainage course of the area, is formed by the confluence at Louisa of Levisa and Tug forks. After flowing northward for 27 miles, it empties into Ohio River at Catlettsburg. Levisa Fork is often called Big Sandy.

CULTURE.

Roads and farming.—Though from the farmer's point of view this area is rough, it is completely intersected by fairly good country roads, the construction of which is facilitated by the fairly soft character of the rocks. The roads of Boyd County are notably well kept.

Notwithstanding the comparatively rugged character of the country, it is under general cultivation. The flood plains of the streams, which are subject to periodical overflow, are on this account very fertile. Along the valleys of the larger streams some wheat is grown, but corn is the principal crop. In Carter County many of the hillsides are given to the cultivation of tobacco. These crops, with the usual garden truck, constitute the principal products of the soil. The timber resources of this area are of little or no importance. Most of the big timber was removed during the days of the old charcoal iron furnaces, which flourished during the seventies and early eighties.

Railroads.—Most of the railroads are confined to the larger stream valleys. The main line of the Chesapeake and Ohio Railway enters the area from Huntington, W. Va., and crosses Big Sandy River at Hampton, keeping along the south bank of Ohio River. The Big Sandy division of this line, formerly known as the Chatteroi Railroad, follows the west bank of Big Sandy River. During the summer of 1905 the old wooden railroad bridges were being replaced by substantial stone culverts, curves were being straightened, and general improvements were under way in preparation for an expected increase in the freight traffic from the Elkhorn and other coal areas near the headwaters of Levisa Fork. The Louisville and Lexington division of this railroad crosses the area diagonally from northeast to southwest, leaving the main line at Ashland. The coal mined at Straight Creek, Grant, Rush, Princess, and Winslow is carried by

this line or by the Ashland Coal and Iron Railway, which is that portion of it between Rush and Ashland. The Norfolk and Western Railway has recently built a line down the eastern bank of Big Sandy connecting with its Twelvepole division and crossing Ohio River at Kenova. The new line is so much superior to the old in grade and general character that much of the coal from the headwaters of Tug Fork is now hauled over the new division. The Baltimore and Ohio Railroad has a terminus at Kenova. The Eastern Kentucky Railway, a short line constructed several years ago, has its southern terminus at Webbville, Lawrence County, and its northern terminus at Riverton, Greenup County, where it joins the Chesapeake and Ohio Railway. It carries staves, ties, etc., from the Blaine country and coal from its mines at Partloe, Boghead, and Hunnewell, as well as clay from the mines at Willard.

Locks and dams.—Big Sandy River has been under improvement by the United States Government since 1878. The plan of improvement adopted by Congress in March, 1899, contemplates carrying slack water as far as Pikeville on Levisa Fork, and to the mouth of Pond Creek on Tug Fork by the construction of 22 locks and dams. Within the limits of the Kenova quadrangle there have been built already three locks on Big Sandy below Louisa, one on Tug Fork at Saltpeter, and one on Levisa Fork at Chapman. By the aid of the dams the river will be navigable the whole year, instead of only about eight months, and the present commerce, chiefly in saw logs, cross-ties, staves, etc., will be largely augmented as a result of the cheaper water transportation. The development of the thinner coals within the Kenova area and in larger measure the thicker beds near the headwaters of the river will be aided. The navigable season of the smaller streams is so short that it will probably not aid materially in the development of the mineral wealth of this area. These streams are used chiefly in transporting logs and ties.

GENERAL GEOLOGY OF SURFACE ROCKS.

STRATIGRAPHY.

INTRODUCTORY STATEMENT.

All the rocks appearing at the surface within the limits of this quadrangle, with but a single exception, are of sedimentary origin and were laid down in or by water. They consist of sandstones, shales, limestones, coal beds, and iron-ore deposits, and have a total thickness of between 1,100 and 1,200 feet. All of these sedimentary rocks belong to the Carboniferous system, except the imperfectly consolidated gravels of the river terraces, which are of Pleistocene age, and the alluvium of the flood plains. The subdivision of the Carboniferous in the northwest portion of the Appalachian coal field,

which was proposed by Henry D. Rogers in the reports of the First Geological Survey of Pennsylvania,[a] has been accepted and followed, at least in its main features, by all the geologists who have subsequently worked in the territory to which this subdivision applies. The coal-bearing rocks have been followed from Pennsylvania into Ohio, and then southward in Ohio to Jackson County, and from this county into Scioto and Gallia counties, and through them into and across Lawrence County to Ohio River. Thus the stratigraphy of the "Coal Measures" of western Pennsylvania is brought into the northeastern corner of the Kenova quadrangle. The Carboniferous system, as developed in this quadrangle, consists of parts of the Pennsylvania and Mississippian series. The former contains the workable coals of this area. The rocks will be described in descending order, beginning with the youngest.

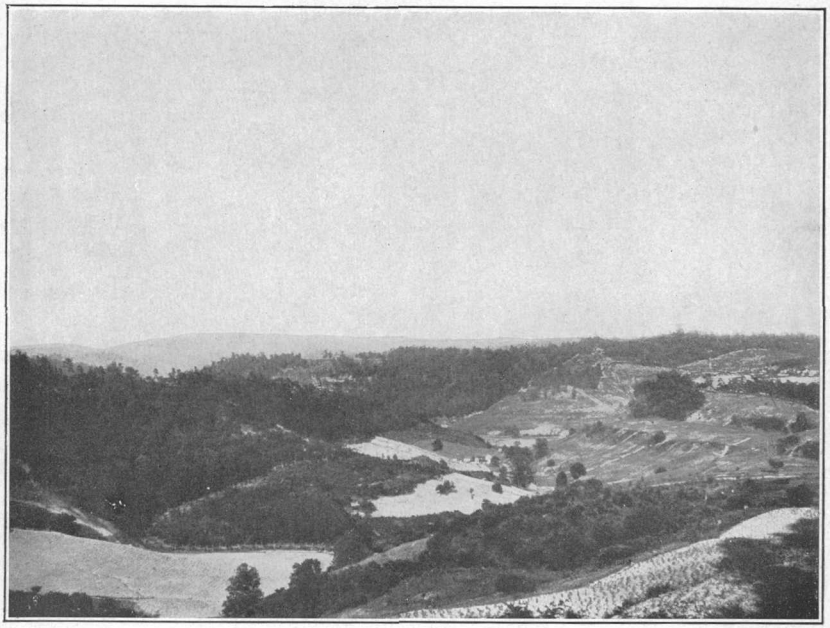
SEDIMENTARY ROCKS.

QUATERNARY SYSTEM.

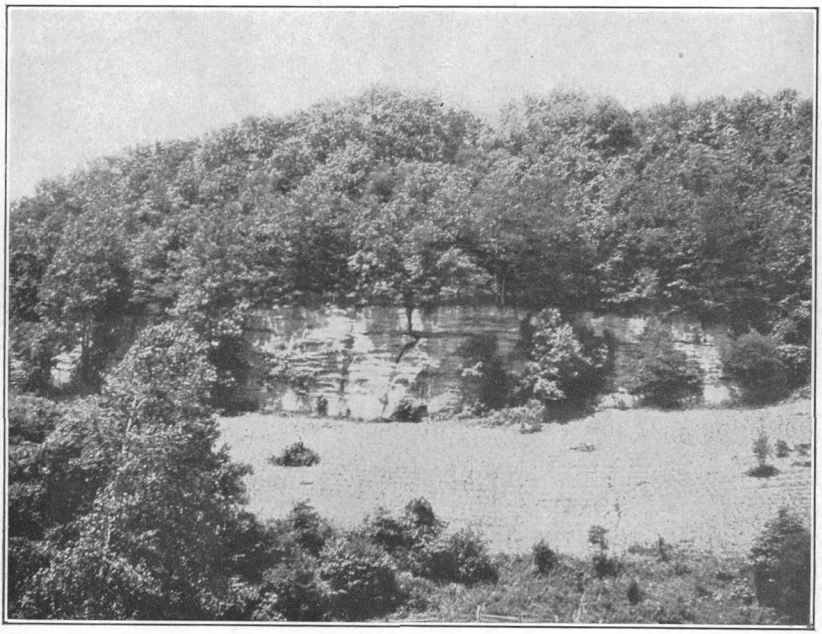
Recent deposits.—The alluvium of the streams of this area is the youngest bedded deposit and has considerable commercial importance. It makes up the flood plains of both the large and the small streams, extending well up to their heads. The larger streams, like Ohio, Big Sandy and Little Sandy rivers, have deposits of this material fully 50 feet thick. Along Ohio River the width of this flood-plain deposit ranges from three-fourths of a mile to a mile, but on Big Sandy and Little Sandy rivers these deposits are not quite so wide. The material is being constantly cut out and redeposited by variations in the currents at each period of high water. The mode of utilization of these flood-plain deposits will be indicated in connection with the description of the clays (p. 120).

Pleistocene deposits.—None of this region lies within the glacial boundary, but there are deposits within the area which are considered of Pleistocene age. Just back of the city of Ashland is a district known as the Flatwoods, where the hills are flat and do not rise to an altitude of over 700 feet. These flat lands are covered with deposits of sand, gravel, quartz, and chert bowlders, some of which are 12 inches in diameter. These represent residual material from the remains of older crystalline rocks of the Blue Ridge to the east. This deposit may be traced fairly distinctly up Big Sandy River to the south of Louisa, maintaining its general elevation of about 150 feet above the present flood plain of the stream. These gravel deposits may, and do in places, represent the valleys of streams which long ago ceased to flow through them. The proof of this statement lies in the rounded character of the bowlders and in

[a] Vol. 2, pt. 1, 1858, p. 16 et seq.



A. OHIO TOPOGRAPHY, SHOWING LEVEL SKY LINE.



B. MAHONING SANDSTONE, LITTLE ICE CREEK, LAWRENCE COUNTY, OHIO.

certain topographic features usually associated with streams. Among the more conspicuous features of the remnants of these old, high-level valleys are their well-graded walls and the maturity indicated by their flat-bottomed floors. This floor in the Flatwoods area is nearly a mile wide. The old drainage channel represented by the Flatwoods is regarded by W. G. Tight[a] as a continuation of the preglacial Teays River.

Similar deposits have been found on the Little Sandy at elevations closely approximating those of the Big Sandy, and though the correlation of the two deposits has not been attempted, it is probable that the benches and their associated gravels on Little Sandy, when traced up Ohio River, will merge into those on Big Sandy. Silt associated with quartz pebbles has been discovered at lower elevations on Little Sandy, indicating a quiescent condition of the water with periods of deposition while these ancient streams were probably subsiding. Since these deposits, as developed in the Kenova quadrangle, have no economic significance, they will not be considered further.

CARBONIFEROUS SYSTEM.

PENNSYLVANIAN SERIES.

Monongahela formation.—The Monongahela in Pennsylvania was first termed the "Upper Productive Measures," since it marks an epoch in which several workable beds of coal were deposited. The base of the formation is marked by the Pittsburg coal. In accordance with Dr. I. C. White's correlation, the coal at the top of the hills east of Lett, near the mouth of Gragston Creek, West Virginia, is accepted for the time being as the Pittsburg coal and as marking the base of the Monongahela formation.[b] The area underlain by the coal does not exceed a few acres, and the formation is represented by 100 feet of shales with a massive sandstone at its base. No important coals are found in it except the Pittsburg bed.

Conemaugh formation.—The Conemaugh includes the rocks lying below the Pittsburg coal and above the Upper Freeport coal. What is regarded as the Upper Freeport coal with its overlying massive Mahoning sandstone is well exposed below Louisa in the vicinity of Zelda, and on Blaine Creek near Fallsburg. Above the sandstone which forms the roof of the Upper Freeport coal, and which varies in thickness from 20 to 30 or more feet, the rocks are in marked contrast with the rocks below, both in character and in the number and importance of the coal beds.[c] The massive sandstone is probably the

[a] Prof. Paper U. S. Geol. Survey No. 13, 1903. For a very complete description of Teays River to the east of this area see M. R. Campbell, Description of Huntington quadrangle; Geologic Atlas U. S., folio 69, U. S. Geol. Survey, 1900, pp. 2–3.

[b] West Virginia Geol. Survey, vol. 2, 1903, pp. 191–192. See also pp. 16–17 of this bulletin.

[c] Kentucky Geol. Survey, vol. C, 1884, p. 60.

same as that which overlies the Waterloo, Bayleys Run, No. 7, or Upper Freeport coal of the Ohio geologists, and which makes such a striking appearance along the banks of Big Sandy River near its mouth. The coal at its base in Lawrence County, Ohio, is regarded by the geologists of that State as higher than the Hatcher or No. 8 coal of the Kentucky reports.[a]

The position of the coal under consideration, which north of Louisa is immediately below a massive sandstone, the Mahoning of Owen, is strong evidence that it corresponds more probably with the coal above the Hatcher bed. Crandall, however, in his report on the geology of Greenup, Carter, and Boyd counties, explicitly states that coal No. 8 of the Kentucky survey is the first coal below the Mahoning sandstone of Owen, and follows the statement with the words that this coal is commonly known as the Hatcher seam.[b] In another place[c] he states that above the shales containing coals Nos. 7 and 8 occurs a coarse ferruginous sandstone, the Mahoning of Owen and Lesquereux. In this sandstone and its overlying rocks are found coals Nos. 9, 10, 11, 12, etc. However, J. J. Stevenson, in his description of the Allegheny formation in Kentucky,[d] interprets Crandall's generalized section of Greenup, Boyd, and Carter counties as placing coal bed No. 9 below the Mahoning sandstone.

In view of the evidence outlined above, the coal which has been opened below the massive sandstone exposed near Zelda and Fallsburg is regarded as the Upper Freeport and as the first bed above the Hatcher coal or No. 8 of the Kentucky reports. Normally, therefore, it would be No. 9 of the Kentucky series, and instead of coming within the Mahoning sandstone would occur just below it, as in Pennsylvania.

The minimum thickness of the Conemaugh formation is between 300 and 400 feet. It is almost entirely exposed only in a small area near the center of the basin in the hills east of Lett, W. Va. This may be due to a possible local thinning of the formation, for at other points near the center of the basin, west of Big Sandy River, where the hills rise as high, nothing is apparently known of the existence of the Pittsburg coal. If the thickness of the Conemaugh formation, 300 to 400 feet, obtained under the assumption that the coal in the hilltops near the mouth of Gragston Creek, West Virginia, is the Pittsburg bed, is compared with the thickness of that formation at Charleston and Huntington given by I. C. White, some question may be raised as to the correctness of the identification of the Pittsburg bed. White makes the Conemaugh 800 feet thick at Charleston and

[a] See section by E. McMillan, Ohio Geol. Survey, vol. 5, 1884, p. 122.
[b] Kentucky Geol. Survey, vol. C, 1884, p. 24.
[c] Idem, pp. 9, 10.
[d] Bull. Geol. Soc. America, vol. 17, 1906, p. 128.

660 feet at Huntington. However, the correctness of his identification of the Upper Freeport coal at Charleston has been questioned, both David White and J. J. Stevenson placing the Upper Freeport well above the black flint, thus reducing the thickness of the Conemaugh formation to a little over 600 feet. G. H. Ashley has been inclined to reduce it to 530 feet or less. The section of the Conemaugh formation obtained by the Ohio geologists in Lawrence County, Ohio, is only 420 feet thick, suggesting a westward thinning of the formation, which is in full accordance with the westward thinning known to take place in going from Pennsylvania across the panhandle of West Virginia into Ohio. If the coal in the Kenova quadrangle is the Pittsburg bed, the thickness of the Conemaugh is much less than it is to the northeast at Huntington and slightly less than the Ohio geologists make it.

The rocks of the Conemaugh are mainly red or greenish shales, with beds of limestone and iron ore and in some localities important beds of sandstone. The fact that it contains no workable beds of coal, together with the sharply defined character of its rocks as contrasted with those of the formations above and below, serve in part as a basis for making it a separate formation. The members of the formation in this area are generally irregular in their development, and are on this account poor guides in unraveling the stratigraphy. The basal member, however, which is the Mahoning sandstone, is very persistent and hence a valuable guide in tracing this formation. (See Pl. III, *B*.) Above this sandstone at variable intervals occurs a rather persistent limestone, one of the Cambridge limestones, which is usually capped by a cliff-making sandstone. These two massive sandstone members occurring near the base of the Conemaugh serve to clearly demark it in most localities from the underlying rocks, the more so because the succeeding higher rocks are usually red shale. In some parts of the quadrangle, notably near the mouth of Big Sandy River, the basal sandstone is unusually thick and massive, attaining near Kenova a thickness of 70 feet, and is continuous, with but a few irregular intercalations of shale, east to Ceredo, south of which it becomes even more massive and attains a thickness of 100 feet. Above this sandstone there is usually a small coal, which may be the Brush Creek coal of Pennsylvania. This is an unimportant bed, though it has been worked in the hills opposite Louisa. It will probably not be of any great commercial importance in the near future. The Cambridge limestone overlying the Brush Creek coal is a very persistent member and is a most valuable guide in tracing the rocks of the Conemaugh. In many places it consists of two members, an upper and a lower, as shown by the section obtained near the bed of Whites Creek, about 1 mile west of Potomac (p. 131).

In the western part of the quadrangle, near Willard, this limestone usually occurs as a single layer. At Willard it is found near the hilltops 180 feet above coal No. 7, but the interval above this coal is in some places slightly less than that. This limestone has a very characteristic appearance, and, owing to the fact that it is highly siliceous, it withstands weathering, and can usually be found at its proper horizon. Almost directly above it occurs a small bed of coal, locally workable. Overlying this coal at a varying interval is a massive sandstone. The distance between the base of this sandstone and the limestone ranges from 10 to 40 feet, but averages about 35 feet. This sandstone is rarely more than 25 to 30 feet thick, but is usually massive and coarse grained, and makes prominent outcrops. Capping this sandstone is a mass of red shale, near the base of which occurs a small bed of coal. The remainder of the Conemaugh is prevailingly red, and for the most part the rocks are shales or shaly sandstones with a few bands of massive sandstone. (See Pl. III, *B*.) The formation contains practically no workable coal.

Allegheny formation.—The Allegheny formation underlies the Conemaugh and is about 180 feet thick in the northern part of the quadrangle, but in places it varies considerably from this thickness, as in the southern part of the area, where the thickening of the Homewood sandstone seems to have interfered with the normal development of the Allegheny. The top of this formation is the top of the Zelda coal, which is believed to correspond to the first bed above the true Hatcher coal of Ohio, and hence to be the Upper Freeport coal of Ohio and normally No. 9 of the Kentucky series. The base of the formation is demarked from the underlying rocks both on paleontologic and lithologic grounds. It is the base of coal No. 5 of the Kentucky series, which according to Stevenson [a] corresponds to the Brookville coal of Pennsylvania. This coal lies practically at the top of a massive sandstone in the Kenova quadrangle, which is regarded as the equivalent of the Homewood sandstone at the top of the next lower (Pottsville) formation. In the western part of the quadrangle, though all the more constant members of the Allegheny are present, the formation seems to be thinner than in the region around Ohio River and to show considerable variation. On one side of the hill west of Willard it is about 130 feet thick, but on the other side it is less than 100 feet. It should be noted that in this district the Homewood sandstone thickens to 100 feet, and in general it may be said that throughout the area the Allegheny formation tends to become thin as the underlying Homewood sandstone thickens. This formation was known in Pennsylvania as the "Lower Productive Measures," from the fact that it is the lower of the two groups of rocks containing valuable coals. It also contains a valuable clay deposit in this part of

[a] Bull. Geol. Soc. America, vol. 17, 1906, p. 128.

Kentucky. In addition it contains beds of sandstone, shale, iron ore, and limestone. Unlike the formation on which it rests, it is, as a rule, not decidedly sandy, and the character of its fossil plants is so distinct from that of the plants in the Pottsville as to warrant its separation as an independent formation.

The number of coals present in the Allegheny formation is usually not more than six, and in many places not more than four. The lowest coal, No. 5 of the Kentucky Survey, lies directly on the Homewood sandstone. It is locally of workable thickness.

An important member in this formation has been called the "Ferriferous" limestone by Andrews in the reports of the Ohio Geological Survey, and the "Hanging Rock" limestone by Orton.[a] It is the equivalent of the Vanport ("Ferriferous") limestone of western Pennsylvania, and that name will be used in this report.

Its relationships in the Kenova quadrangle may easily be made out at Coalgrove, opposite Ashland. (See section on pages 30–31.)

It usually lies from 10 to 20 feet above the top of the Homewood sandstone, and is found at its top in many places where coal No. 5 is absent. It is generally associated with an important clay bed, and on this account has an economic interest. This clay ranges in thickness from 4 to 6 feet. The next higher economic member in this formation is the No. 6 coal of the Kentucky section, known in the region about Ashland as the "Limestone coal" and in Ohio as the "Newcastle coal." It is commonly found 20 feet above the Vanport ("Hanging Rock") limestone.

The next higher coal is the Coalton, or the No. 7 of the Kentucky Geological Survey, or the No. 6 or Sheridan coal of Ohio. This is the celebrated Nelsonville coal of the Hocking Valley. It is the most important bed in this area at present and is found from 25 to 45 feet above coal No. 6 and from 40 to 50 feet below coal No. 8, the next higher bed in the formation. This coal No. 8 is workable in parts of the quadrangle, but is as yet comparatively unimportant. From 40 to 50 feet higher in the scale is coal No. 9, which, like the coal below it, is generally a thin bed and only locally workable.

Besides the coals and fire clays of economic importance in this formation, various beds of iron ore occur. These formerly had considerable importance, but at present have little or no value, as the cheaper ores of Lake Superior and Alabama have entirely replaced them in the market. The general sections (Pl. IV and fig. 20) show the beds of economic interest and the intervals between them.

Pottsville formation.—The Pottsville formation is the lowest in the Pennsylvanian series. Its base is the top of the Mississippian series, on which it rests unconformably, and it comprises all the rocks

[a] Ohio Geol. Survey, vol. 3, pt. 1, 1878, pp. 885 et seq., 892 et seq.

to the top of the Homewood sandstone. This formation is separated from that lying below and from that above on both lithologic and fossil evidence. The entire formation is exposed in the northwestern part of the quadrangle, where it has a thickness of between 350 and 400 feet. In the southeastern part of the area it has a thickness of at least 600 feet, and along the southern edge it must be fully as thick. General sections showing the character of the rocks of this formation, as exposed at different points of the area, are given in Pl. IV. The rocks of this formation are decidedly sandy, but contain occasional beds of shale, iron ore, limestone, and coal. Owing to its thickening in the southeastern part of the area and the introduction of coal beds not represented in the section in the western part of the field, the lowest coals in the area are believed to appear in the section along Levisa Fork near Gallup. There are three or four of these beds, and the thickest of them is not over 2 feet at any point. The higher coals in this formation are all locally workable and have been numbered by Prof. A. R. Crandall (Pl. IV). There are usually four fairly thick coal beds in this formation, but at some points this number may be increased to five and even six. Detailed descriptions of these coals, together with the intervals which separate them, are given under the headings of the various districts.

The Pottsville formation also contains some very valuable beds of fire clay. Most noteworthy of all is the bed occurring only a few feet above the top of the Maxville limestone. This is the celebrated Sciotoville fire clay of Ohio. Though it outcrops over a very small area in this particular quadrangle, it has considerable economic importance to the west, and it is being mined at present on a large scale in the vicinity of Olive Hill. Other beds of fire clay in this formation are locally workable, notably the bed associated with coal No. 4, which has been worked in the eastern part of Ashland and on Catletts Creek. Nearly one-half of the entire surface of this quadrangle is covered by rocks belonging to the Pottsville.

MISSISSIPPIAN SERIES.

The Mississippian series is represented by a massive limestone, called in the Kentucky reports "Sub-Carboniferous limestone," and in those of Ohio the Maxville limestone. About 100 feet of the Waverly group is also present. The outcrops of the limestone are confined to the western part of the area and are limited in extent. West of Tygarts Creek, in Greenup County, this rock is present in the hills. Here it does not exceed a thickness of 25 feet, being underlain by 100 feet of sandstone and shale belonging to the Waverly. A small outcrop of limestone is found at the bend in Everman Creek, Carter County, just above the mouth of Wolfpen Branch, and again farther up the creek, just at the edge of the quadrangle. The lime-

stone in this part of the field does not exceed 15 or 20 feet in thickness. It is usually overlain by a thin band of iron ore. This limestone is encountered in all the deeper borings for oil, in both the eastern and western parts of the quadrangle, and reaches in places a thickness of several hundred feet. The total thickness of the Mississippian rocks outcropping in the western part of the area does not exceed 150 feet.

IGNEOUS ROCKS.

Occurrence.—Igneous rocks in this quadrangle were noted by Professor Crandall many years ago. They are found in the hills on each side of Ison Creek west of Stephens, Elliott County, and about 8 miles southwest of Willard. The region was visited by J. S. Diller, of the United States Geological Survey, in 1884, and as a result of this trip a very detailed account of the occurrence and petrography of these rocks was published.[a] The rock is peridotite, and owing to this fact is of more than usual interest, first, because it bears a resemblance to the peridotite of South Africa, the mother rock of the diamond, in the Kimberley district; and second, owing to the relative scarcity of this type of igneous rock and to a possible relationship to the mica peridotite of western Kentucky.[b] In another publication Mr. Diller has applied the name of kimberlite to this rock from its resemblance to the South African rock.[c]

Extent.—The area covered by the rock is very small, not more than a few acres. The outcrops of the solid ledge are not numerous, but their original extent is not difficult to trace, owing to the characteristic minerals resulting from weathering. There is no apparent reason why the various isolated masses should not be considered parts of a single intrusion, as all appear identical in mineral composition.

Character of rock.—The groundmass of this rock is compact, grayish black in color, and porphyritic. It is plentifully specked with phenocrysts of olivine, which appear to be very fresh and unaltered and give a grayish tinge to the rock. Garnet (pyrope) and titanic iron ore (ilmenite) are also easily detected and in the field were found to be of great assistance in tracing the boundaries of the decayed ledges. Sections of biotite are not uncommon. Besides these constituents, which are readily detected in the hand specimens, the chief remaining minerals are enstatite and a small amount of apatite. In places the olivine has been altered to serpentine, which may be readily seen in hand specimens, and which in thin section is associated with magnetite and some carbonate, presumably dolomite resulting from the alteration of the olivine. This rock has been so thoroughly described by Diller, and its peculiar characteristics are

[a] Bull. U. S. Geol. Survey No. 38, 1887.
[b] Williams, G. H., Am. Jour. Sci., 3d ser., vol. 34, Aug., 1887, p. 137.
[c] Bull. U. S. Geol. Survey No. 150, 1898, pp. 290–294.

so well pointed out in his publication, that it will not be further considered here.

Age and relationships.—The sedimentary rocks through which the igneous rock has forced its way are traceable practically up to the contact and strangely enough do not appear to have been even flexed upward along this zone. Though the igneous rock has broken off masses of shale, which are now found embedded in it, this is surprisingly fresh and unaltered, like the ordinary black shale of the Pennsylvanian series. Only in a few cases are metamorphic effects markedly visible. In some of the baked shale secondary mica was seen in considerable quantity. The color of the shale had been somewhat reddened and the sandstone and limestone fragments, which were inclosed by the igneous rock, had been baked and the latter converted to quicklime.

The sedimentary rocks in which the bulk of the igneous rock is found belong to the Pottsville formation, but as some of the igneous rock is found in the Allegheny, the intrusion is Allegheny or post-Allegheny in age. It was forced into the carbonaceous shale and coal beds found in this formation, and, owing to the fact that the Kimberley diamonds occur in peridotite penetrating carbonaceous shale, more than ordinary interest attaches to the Elliott County occurrence of peridotite. This interest has led to the prospecting of streams in the neighborhood, and also to the sinking of a shaft 70 feet deep, which at the time of the writer's visit (October, 1905) was filled with débris. During the spring of 1906 it was reported that another prospect shaft was being sunk. As to the presence of diamonds the writer has no authentic information.

STRUCTURE.

MODE OF REPRESENTING STRUCTURE.

The inclination of the beds to a horizontal plane, or the dip of the beds, as it is commonly called, is measured in the field by means of a clinometer when the inclination is great enough to be susceptible to this method. In but few localities, however, in the Kenova quadrangle are the dips sufficient to allow this mode of measurement. Where this method is not applicable continuous road sections are run and the beds are correlated from hillside to hillside. When the elevation above mean sea level of a given sandstone, coal, or limestone on one hill and its elevation a mile or so away have been found, the rise or fall of this particular bed in feet per mile is at once obtained. By connecting points of equal elevation on any selected bed the contour lines for that bed are drawn. On the map, Pl. I, the contour interval is 50 feet and all points having altitudes

that are multiples of 50 were connected by black lines. For instance, in drawing the 600-foot contour line those points in the area where the datum selected (the top of the Homewood sandstone) reached this elevation were connected, and likewise for the other contour lines.

The top of the Homewood sandstone was selected in this area, on account of the ease with which this bed may be followed, owing to its persistence and relations to other well-known horizons. Where it failed to appear above drainage, its distance below other known beds was used, assuming, of course, that the distance was constant within the limited area where this means was employed. Conversely, when the dips were such as to carry the top of the Homewood above the hilltops its distance above known beds was applied. However, great precision was not obtainable, as such intervals are subject to variation all over the region, and especially in the areas covered by the formations above the Homewood. Furthermore the elevations were obtained by means of aneroid barometers, which are liable to sudden variations and have to be constantly checked against spirit-level elevations. In spite of these sources of error, it has been thought advisable to draw structure contour lines. These show the generalized surface formed by the top of the Homewood sandstone, and, less precisely, the lay of the overlying and underlying beds. The limit of error may generally be considered a contour interval, but where the beds vary in thickness as they do in this area it may be more. This mode of presentation, in addition to showing the structure of the beds, enables us to estimate the elevation of the top of the Homewood sandstone when it is below drainage. For instance, near Zelda the 400-foot contour line was drawn. The elevation of Zelda is 580 feet above mean sea level; therefore, the top of the Homewood sandstone should be at a depth of 180 feet. The distances of the various coal beds above or below the top of this sandstone being known, their depth below the surface may in turn be estimated at this point.

DETAILED DESCRIPTION OF STRUCTURE.

This quadrangle lies at the southwest end of the great trough formed by the coal-bearing rocks of the Appalachian field. The axis of the trough extends southwest from near Pittsburg, Pa., and the trough reaches its maximum development near central West Virginia. From this point southwestward the axis slowly rises, crossing Ohio River a little east of the quadrangle and reaching Big Sandy River from 8 to 10 miles above its confluence with the Ohio. The axial line follows Big Sandy River southward for 2 miles and gradually curves to the west, pitching upward along a line practically coincident with the boundary between Carter County and Elliott

and Lawrence counties. The beds south of the axial line dip north and northwest, and those on the northern side dip southeast. The dips over most of the area are not very steep. In the northern two-thirds of the quadrangle the dips, with a few exceptions, do not average as high as 50 feet per mile. Near Catlettsburg the upper part of the Pottsville formation is exposed at railroad level, but across Big Sandy River the lowest rocks exposed in the cliffs along the Norfolk and Western Railway are the lower sandstone members of the Conemaugh formation; thus a dip of more than 50 feet per mile is involved between these points. Near Willard and southwest of this town in Carter County the dips are above the average, being close to 100 feet per mile. The steepest dips are confined to the southern third of the area. This belt of sharp dips is about 6 miles broad south of Louisa, but it narrows westward until at Blaine it is not more than a mile in width. West of this town the beds curve gently northwestward around the head of the basin. The dips in the ridge south of Louisa are fully 100 feet per mile. Near Adams and on Right Fork of Blaine Creek the rocks in places dip 300 feet per mile. The steepest dips in the area are near the mouth of Hood Creek in the eastern part of the town of Blaine. At the bridge over Hood creek the beds are inclined 11 degrees, and near this point two small faults were discovered by Mr. Ashley, but their throws are probably not great enough to materially affect the structure contours.

A few minor flexures are involved in the main syncline. In the region near Irad and Osie, Lawrence County, the Homewood sandstone thickens toward the west very rapidly, causing a slight arch in the overlying beds, but west of this district the sandstone is somewhat thinner and causes a slight depression. West of Cherokee Creek, approaching Elliott County, the structure seems to be rather irregular. This may be more apparent than real, and the irregularity in the contours may be due to the fact that they are based on but few outcrops and that the underlying sandstones, which might serve as a guide, thicken and cut out the coal beds. The flattening of the beds to the west is due to the dying out of the Appalachian folds as the Cincinnati arch is approached. West of this quadrangle the beds gradually rise to the apex of this arch, and this gradual rise is indicated in the contours west of Little Sandy River.

MINERAL RESOURCES.

GENERAL STATEMENT.

In an area of sedimentary rocks, like the Kenova quadrangle, in which the chief deposits are sandy or clayey, it is useless to attempt to find such metals as gold, silver, and lead in paying quantities.

Small amounts of lead, zinc, and iron sulphides do occur in the clay-limestone concretions in the shales of the Carboniferous system, but the amount of such material is so small as to be entirely negligible, and time devoted to the search for the precious and base metals will be fruitlessly spent. On the other hand, the coal and fire-clay beds may repay more careful prospecting than has heretofore been given them, and perhaps to a less extent this is also true of the alluvium of the stream beds, the shale, the limestone, and the sandstone beds.

COAL.

Workable beds of coal are scattered through nearly the entire geologic column, as developed in this area, up to and including the celebrated Pittsburg coal at the base of the Monongahela formation. The names, positions, and relationships of these coals are given in the general columnar sections (Pl. IV) and also in the local sections.

These coal beds vary somewhat in character but include most varieties of the bituminous class. The bulk belong to the harder, bituminous variety, and in many places have a splinty aspect. The coals, as a rule, break into rather thin slabs along charcoal layers, and hence may be classed as semiblock coals. As a rule they are unsuitable for coking, but after washing some of them give fair satisfaction. Coal No. 6, or the Winslow coal, which has been mined for several years at Winslow, has been washed and coked by the Ashland Iron and Mining Company for use in the company's furnaces at Ashland, and has always proved fairly satisfactory when mixed with a small amount of some standard coke or when coked with a small amount of some standard coking coal. All the coals give excellent results when used for ordinary steam and domestic purposes. Nearly all bear well transportation and stocking. Coal No. 7, or the Coalton coal, which ranks with and is stratigraphically equivalent to the famous Nelsonville coal of Ohio, has been and is still used by the Ashland Iron and Mining Company in its blast furnaces at Ashland.

Ordinary bituminous coal is frequently associated with the splinty variety in most of the coal beds. It is finely interlaminated with a dull splint in many of the benches, and in other places it forms complete benches by itself. This is sometimes the case with the Winslow coal, the bottom bench of which is usually of the soft bituminous variety and contrasts with the harder splinty type of the two upper benches. Certain beds in restricted areas contain benches of cannel coal, for example, the coals now being worked by the Kentucky Cannel Coal Company at Boghead and Hunnewell. Sections obtained at Boghead show the character of these two coals at this point.

Relations of coal and other important beds in the Kenova quad-

System.	Series.	Formation.	Names used in this report.
Carboniferous.	Pennsylvanian.	Monongahela.	Pittsburg sandstone Pittsburg coal
		Conemaugh.	Ames limestone Cambridge limestone Brush Creek coal Mahoning sandstone
		Allegheny.	Zelda coal Hatcher coal Red kidney ore Coalton coal Yellow kidney ore Winslow coal Iron ore Flint and plastic clay Vanport ("Ferriferous") limestone Flint and plastic clay Cat Creek coal
		Pottsville.	Homewood sandstone Lick Creek, Catletts Creek, or Upper Stinson coal Iron ore Torchlight or Lower Stinson coal Danleyton coal "Little Cannel" or Barrett Creek coal Massive sandstone Sharon coal Sharon conglomerate Salt sand Sciotoville fire clay
	Mississippian.	.....	Iron ore Maxville limestone Waverly group Big Injun sand Sunbury shale Berea sandstone Bedford shale
Devonian.	.....	.....	Ragland sand Ohio shale

rangle, with names used in Pennsylvania, Ohio, and Kentucky.

Pennsylvania names.	Ohio names.	Kentucky names.
Pittsburg sandstone		
Pittsburg coal	Pittsburg coal	
Ames limestone	Ames limestone	
Pine Creek or Coleman limestone.	Upper Cambridge limestone	Upper Cambridge limestone.
Brush Creek limestone	Lower Cambridge limestone	Lower Cambridge limestone.
Brush Creek coal		
Mahoning sandstone	Mahoning sandstone	Mahoning sandstone.
Upper Freeport coal	Bayleys Run, Waterloo, or No. 7 coal.	No. 9 coal.
Lower Freeport coal	Hatcher or No. 6 A coal	No. 8 coal.
Middle Kittanning coal	Sheridan, Nelsonville, Straitsville, Lower Waterloo, Ashland, Mineral City, or No. 6 coal.	No. 7 coal.
Lower Kittanning coal	Newcastle or No. 5 coal	No. 6, Keyes Creek, River Hill, or Limestone coal.
Vanport or Ferriferous limestone.	Hanging Rock or Ferriferous limestone.	
Brookville coal	No. 4 coal	No. 5 coal.
Homewood sandstone		
Upper Mercer coal	No. 3 A coal	No. 4 coal.
Lower Mercer coal	Lower Mercer coal	No. 3, McHenry's, or Torchlight coal.
Quakertown coal	Quakertown coal	No. 2 coal.
		No. 1 or Barrett Creek coal.[a]
Sharon coal	Jackson Shaft coal	
Sharon conglomerate	Sharon conglomerate	Maxton sand.
	Sciotoville or Logan fire clay	
Greenbrier limestone or Big lime.	Maxville limestone	Subcarboniferous limestone.
	Waverly group	Waverly series.
Burgoon sandstone or Big Injun sand.	Logan formation (?), Blackhand formation, or Cuyahoga formation.	Big Injun sand.
	Sunbury shale	
	Berea sandstone	
	Bedford shale	
		Ragland sand.
	Ohio shale	Ohio or Chattanooga shale.

[a] See p. 93.

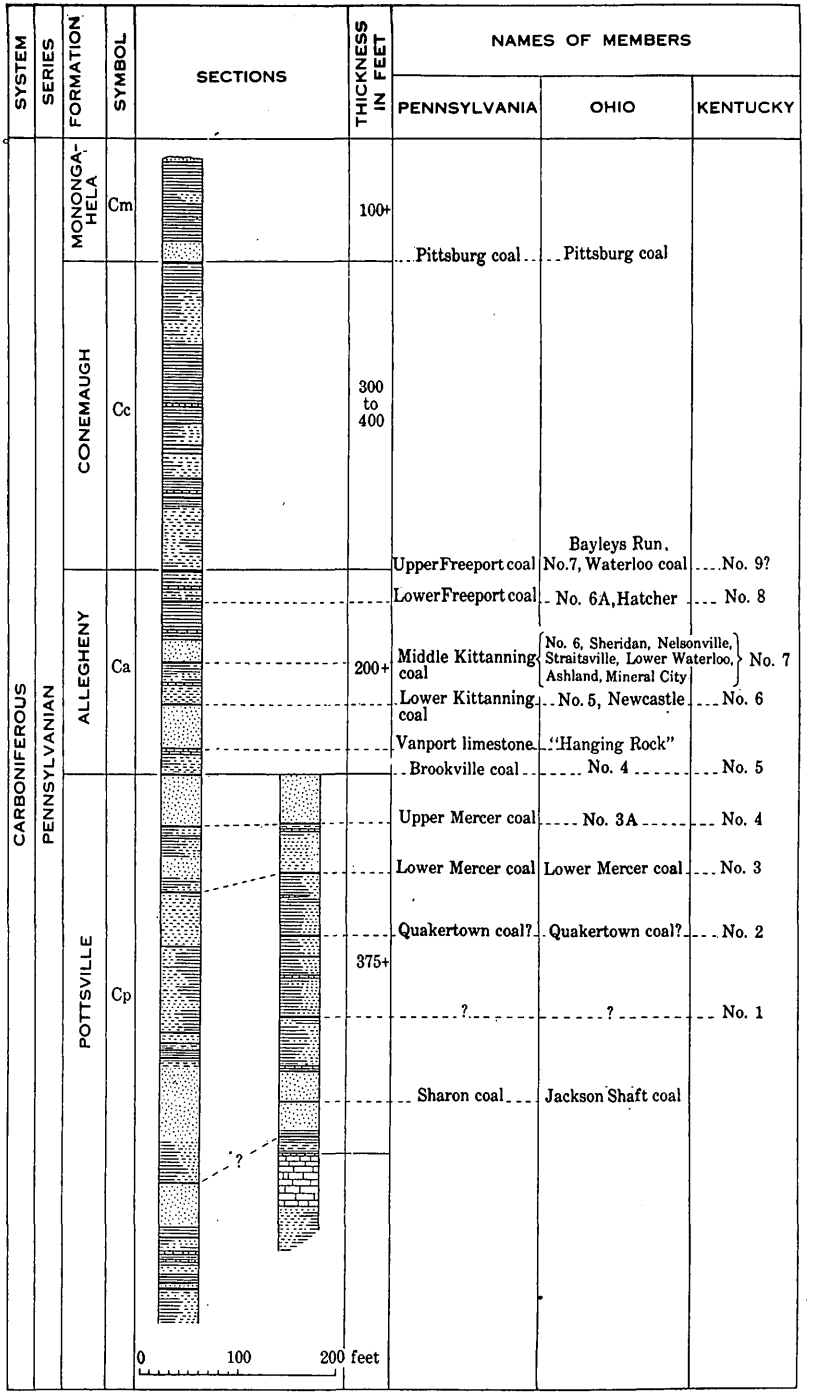
Section of No. 4 coal bed at Boghead.

Shale roof.	Inches.
Coal, bituminous	7½
Bone	½
Coal, bituminous	11
Fire clay	7¾
Bone	6½
Coal, cannel	9
	42¼

Section of No. 3 coal bed at Boghead.

Shale roof.	Inches.
Coal, bituminous	5
Bone	2
Coal, cannel	15
Fire clay	15
Coal, bituminous	14½
	51½

It is reported that the cannel layers are erratic in their occurrence, being as liable in No. 3 bed to occur in the top as in the middle bench. In the hill southeast of Hunnewell the middle bench is cannel coal. In Elliott County, near the western edge of the quadrangle, in the hills west of Stephens and north of Fielden, there is an important cannel bed well up in the top of the hill. Old openings were observed by the writer, but there was no opportunity to measure the coal. G. H. Ashley found the cannel layer 4 feet thick in places in the hills south of Critches Creek. This coal bed lies about 50 to 60 feet above the top of the Homewood sandstone and is tentatively correlated with the Winslow or No. 6 coal of the country to the east. On Hilton Branch, southwest of Willard, a rather thick bed of cannel has been worked in a small way. The seam was opened on the land of William Corey and Elijah Sturgill. At the opening on Mr. Corey's property the coal measured 29 inches of cannel with more lying below unseen on account of the water which nearly filled the opening. Mr. Sturgill, jr., reports 36 inches of cannel overlain by 8 inches of bituminous coal, capped by a sandstone roof. The Brush Creek coal of Lawrence County also contains a cannel layer. Besides these beds of cannel coal there are others containing sufficient volatile hydrocarbons to class them with the cannel coals. This is the case with certain layers in the Torchlight or No. 3 coal of Levisa Fork, Lawrence County, while the "Little Cannel" bed lying 140 feet below No. 3 at Torchlight contains a band whose analysis shows 55 per cent of volatile matter. Pl. IV and the table on pages 26–27 show the relations of the various coals and their equivalents in Pennsylvania, Ohio, and Kentucky.



GENERAL SECTIONS SHOWING RELATION BETWEEN THE COALS IN THE KENOVA QUADRANGLE AND THEIR EQUIVALENTS IN PENNSYLVANIA, OHIO, AND KENTUCKY.

CLAY.

The clays of the Kenova quadrangle are all sedimentary in origin and have reached their present position through the agency of water. They may be divided as regards both age and adaptability into two classes. First, the bedded clays, and, second, the recent unconsolidated silts or clays of the stream valleys. Of the former class two beds are prominent.

The higher of the bedded clays is that occurring near the horizon of the Vanport ("Hanging Rock") limestone, about 10 to 40 feet above the top of the Homewood sandstone. Though not so important as the lower fire clay at Olive Hill (the Sciotoville clay of Ohio) in the northeastern part of Kentucky, yet, when taken as a whole, it is of far greater importance in the Kenova quadrangle. On the economic map the red line, except along Tygarts and Everman creeks, Carter County, may be taken as the outcrop of the Vanport ("Hanging Rock") limestone with its associated clay. Detailed descriptions of the characteristics of this clay, as noted at different localities, are given on pages 113–117.

The lower of the two important clays occurs a few feet above the Maxville limestone and is one of the most important fire clays of northeastern Kentucky and southern Ohio. This is the celebrated Sciotoville clay of the Ohio Geological Survey reports, less widely known as the Logan clay. It has been extensively mined at Sciotoville and in the region around Portsmouth, Ohio, and is also mined on a large scale at Olive Hill, Ky., and in the valley of Tygarts Creek, which cuts across the northwestern corner of this quadrangle. In this area the fire clay appears at a few points near the western boundary and these occurrences are described in detail on page 118.

The recent clays of the flood plains of the rivers and small streams are widespread, even the smallest streams having in places extensive deposits. Those which are worked at present are confined to the Ohio Valley, where there is a local market, cheap coal, and convenient transportation facilities. This flood-plain clay is suitable chiefly for ordinary building brick, tile, shingles, etc.

Other important clays are found, but they are not so persistent as those noted above. Among those of less importance is the fire clay associated with coal No. 4 at Ashland and Catlettsburg and in the hills northwest of Willard, near the headwaters of Johns Creek.

Besides clays proper there is in the Carboniferous rocks over the entire quadrangle an abundance of raw material, such as ganister (siliceous clay) and numerous shale beds, which thus far has not even been prospected. This no doubt would make brick of fair grade.

MISCELLANEOUS ECONOMIC PRODUCTS.

The less important resources of this area are limestone and iron ore, sandstone, oil, gas, glass sand, and salt. These commodities will be considered in detail in a subsequent part of this bulletin.

DESCRIPTION OF COAL RESOURCES BY DISTRICTS.

For convenience in reference and from a commercial rather than a scientific point of view the coal resources of this area are described by districts whose boundaries have been chosen so that each district may coincide as closely as possible with the country naturally tributary to a certain railway line or other highway of communication. These districts are as follows:

1. Ohio district.
2. Big Sandy Valley.
3. District tributary to the Louisville and Lexington Railroad, or Chesapeake and Ohio Railway district.
4. Little Sandy Valley, or main Eastern Kentucky Railway district.
5. District tributary to the southern terminus of the Eastern Kentucky Railway.

OHIO DISTRICT.

EXTENT.

Only the southern part of Lawrence County, Ohio, including parts of Fayette, Perry, and Upper townships, is included in the Kenova quadrangle.

STRATIGRAPHY.

The rocks exposed in Ohio comprise the whole of the Allegheny and parts of the Conemaugh and Pottsville formations. The total thickness represented is in round numbers about 600 or 700 feet. The following section, obtained near Coalgrove depot, gives an excellent idea of the Allegheny formation and the lower part of the Conemaugh as developed at this point. The numbers of the coals are those of the Kentucky series.

Section near Coalgrove depot.

	Feet.
Conemaugh formation:	
Sandstone, laminated	25
Shale, red and green	25
Limestone, fossiliferous (Cambridge)	1
Sandstone, laminated	20
Shale	10±
Sandstone, laminated	36
Allegheny formation:	
Coal bloom (*position of coal No. 9*).	
Concealed	50
Position of coal No. 8.	

Allegheny formation—Continued.	Feet.
Concealed and shaly sandstone	44
Coal No. 7.	
Sandstone, massive	33
Coal No. 6.	
Sandstone, massive	40
Clay, massive flint	1½–1⅞
Clay, plastic	5
Limestone ("Hanging Rock")	4
Fire clay	1⅔
Concealed	5
Probable position of coal No. 4.	

The Conemaugh formation in the Coalgrove section is typical so far as it goes, with the exception of the basal sandstone. This is not usually laminated, but is very massive near the eastern edge of the quadrangle (Pl. III, *B*, p. 14). The massive character of this basal member is well shown near the Norfolk and Western Railway bridge near North Kenova and on the county road joining the river pike west of Burlington. This sandstone forms prominent cliffs nearly all along Ohio River in this area and in West Virginia as well. The higher beds of the Conemaugh, not shown in the section at Coalgrove, are well exposed in the hills back of Burlington and Sybene and in general away from Ohio River, and consist chiefly of red shale and sandstone, occasional limestones, which are more or less persistent, and small coal beds, rarely of workable thickness. In the eastern part of the Ohio district, in Fayette Township, the surface of the country is made up chiefly of shales of the Conemaugh, with local sandstones and small and unimportant coal beds. This region, though very hilly, is fertile and well adapted to the growing of fruits and farm products, and is under general cultivation (Pl. III, *A*, p. 14). Since this formation is of little economic interest, it will not be considered further.

The Allegheny is fairly developed, with the exception of coal No. 4[a] (Ohio nomenclature, Pl. IV). This coal was not seen in the section at Coalgrove, but the higher coals were all seen at one point or another in this State. The Allegheny formation is present in all the hills in Upper and Perry townships, but the eastern dips cause it to disappear near North Kenova, just east of the Norfolk and Western Railway bridge. The thickness of the Allegheny is about 180 feet. The highest coal bed present in this formation is the Upper Freeport, which lies either immediately or at a small distance below the Mahoning sandstone. Its bloom is fairly widespread, though it does not seem to have been worked to any extent. This coal is the Waterloo or No. 7 of the Ohio Geological Survey. Thirty to fifty feet below it occurs the Hatcher of the Ohio and Kentucky geological surveys.

[a] No. 5 in the Kentucky series.

In Ohio it is No. 6A and in Kentucky No. 8. E. McMillan[a] has correlated it with the Lower Freeport of Pennsylvania. The most important coal in this part of Ohio is found 100 feet below the base of the Mahoning sandstone. It is known as the Sheridan or No. 6 coal in Ohio. In Kentucky it is also important and is known as the No. 7 or Coalton coal. The Ohio geologists[a] have correlated it with the Middle Kittanning coal. Between these three coals are two beds of limestone, in many places associated with iron ore. The massive sandstone overlying the Coalton coal serves as a means for locating and following it. About 30 to 40 feet below the Coalton coal another persistent bed is found, known as the Newcastle coal, or No. 5 bed (No. 6 of Kentucky). It is best seen at Coalgrove, where it lies 33 feet below the Coalton coal, the interval being occupied by a very massive sandstone.

The lowest stratum of economic importance in the Allegheny is the clay associated with the Vanport ("Hanging Rock") limestone. The bed is about 75 feet below the Coalton coal and is capped by a very massive sandstone. No other beds of economic value were seen above drainage level in this area.

Only a very small part of the Pottsville formation is shown, probably not more than 20 to 25 feet, and this is in the vicinity of the Coalgrove section. The Homewood sandstone outcrops near Coalgrove depot, and although No. 4 coal of the Ohio Survey, or that resting directly on the Homewood sandstone, is not known in this immediate neighborhood, it has been recognized in the vicinity of Ironton, not more than a mile to the west, by the Ohio geologists.[b]

THE COALS.

UPPER COALS.

The upper coals in the Allegheny formation and the coals in the Conemaugh have little or no importance in this part of Ohio. The Hatcher coal, No. 8 of the Kentucky Survey, and the Upper Freeport have been opened in a few places on Lick Creek, about 1½ miles east of Sheridan, and near the residence of R. H. Henshaw on Little Ice Creek. In the summer of 1905 openings on these upper coals were fallen shut and no measurements could be obtained. According to the Ohio State reports the Upper Freeport coal, which is known as the Bayleys Run or Waterloo coal, is 4 feet thick near Ironton,[b] and in the general section given by McMillan[a] it is represented as averaging 6 feet. In quality these coals are inferior to the

[a] Ohio Geol. Survey, vol. 5, 1884, p. 122.
[b] Ohio Geol. Survey, vol. 3, pt. 1, 1878, section opposite p. 928.

Coalton coal, and under present conditions probably could not be marketed. They have furnished up to the present time a small amount of fuel for local consumption and will probably continue to do so for a number of years.

SHERIDAN COAL OF OHIO (COALTON COAL OF KENTUCKY).

Position.—The Coalton coal is 100 feet below the Upper Freeport coal and about 50 feet below the Hatcher or Lower Freeport bed. It has been correlated with the Middle Kittanning coal of Pennsylvania. In this report the name Coalton coal will be applied to this bed, since in Kentucky it was originally worked at Coalton, and was widely known under this name.[a] It is the second bed above the Vanport ("Hanging Rock") limestone and ore.

Extent.—This coal has been known and worked for many years in the Hanging Rock region. According to the Ohio Geological Survey reports,[b] it is identical with the celebrated Nelsonville or Straitsville coal of the Hocking Valley. Up to the present time it has proved to be by far the most important commercial coal in this quadrangle, and in Kentucky much of it lying above drainage level has been removed. In Ohio, however, little has been removed above drainage level and none below.

As it occurs 30 to 40 feet above the next lower coal its outcrop will be found above drainage level farther to the east than the outcrop of the lower bed, but the area above drainage level underlain by it is comparatively small, being not more than one-tenth of that part of Ohio included within this quadrangle. It is present in all the hills near Coalgrove, Forestdale, and Sheridan; in the hills well up on Little Ice Creek, and also along Ohio River to a point about 2 miles above Sheridan. (See Pl. I.) Beyond this point it is hidden by the flood-plain deposits. Near North Kenova, just east of the bridge, no flood plain is present, and a coal which may possibly be referred to the Coalton bed lies nearly at the river's edge. It is about 55 feet below road level and is now worked in a small way by B. J. Davidson and Will Dillon. West of the bridge a few old openings on this bed were observed, but they are fallen shut and the thickness of the bed could not be determined. Just east of the Davidson and Dillon openings the coal disappears below Ohio River.

Development.—This coal is not now worked on a commercial scale, but the reason is evidently not the scarcity of material, as there is an ample supply of good coal still above drainage level. The old Sheridan Company ceased operations more than twenty years ago.

[a] Kentucky Geol. Survey, vol. C, 1884, p. 122.
[b] Ohio Geol. Survey, vol. 3, pt. 1, 1878, pp. 917–918.

At present the coal is of importance simply as a source of local supply and has been opened at many points where its outcrop approaches drainage level, notably on Little Ice Creek and its branches east of Forestdale, and in the hills along Ohio River near Sheridan.

Character.—The Sheridan coal in general ranges in thickness from about 3 to 4 feet, but in places exceeds the latter figure. As a rule it has a small bony parting, an inch or less thick, lying from 2 to 14 inches from the roof. The upper of its two benches is usually about a foot thick; the lower or main bench varies from 2 to 3 feet. Southeast of Lick Creek the two benches are represented by a single bench of 25 to 27 inches (section 3, fig. 1). The different measurements of this bed obtained in this field are given in fig. 1. It is possible that a third bench exists in places, for in Kentucky this very commonly appears.

The Coalton coal is a hard, splinty coal, breaking along charcoal layers into slabs, which range from 6 to 8 inches in thickness. It is

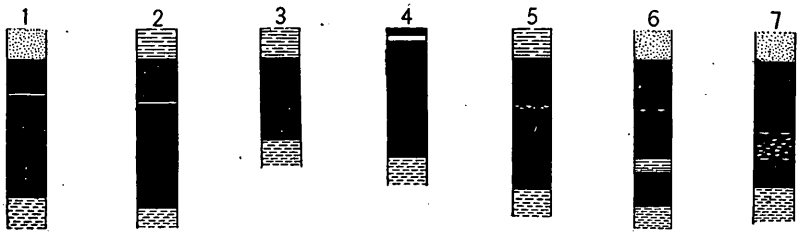


FIG. 1.—Sections of Allegheny coals in Ohio. Coal No. 7: 1, Elizabeth Wise, Little Ice Creek; 2, John Ide, Sheridan; 3, William Talbot, 1 mile southeast of Sheridan; 4, Henry Wineka, Lick Creek; 5, east of Forestdale. Coal No. 6: 6, country bank north of Coalgrove; 7, Harry Smith, north of Coalgrove. Scale, 1 inch = 5 feet.

too high in sulphur to make a first-class coke, therefore it will be used chiefly as a steam and domestic coal, being well adapted for stove and grate use. The analyses of this coal, given on page 71, are discussed on pages 71–72.

The roof of the coal is in some places massive sandstone and in others shale. The sandstone which overlies or underlies the coal becomes abnormally thick in places and cuts it out almost completely, leaving but a few stringers of coal to represent the bed. Such is its condition along the Ohio River, opposite the eastern suburbs of Ashland, where the sandstone of the lower part of the Allegheny formation is abnormally thick. For this reason the coal is not visible in many places where its horizon is exposed. It is reported also to be absent just west of Forestdale.

Economic features.—Owing to the southeast dips which prevail in this district the proper points for opening mines on this coal bed are on the southeast flanks of the hills. In sinking shafts care should

be exercised to place them with a view to working up the dip or in a northwest direction. The situation of the district with respect to market and transportation could hardly be improved. Many of the large cities of Ohio and Kentucky lie within a radius of 100 miles, and either railway or the very much cheaper river transportation is convenient, the Ohio being navigable the year around well above this point.

No estimate is attempted of the amount of coal of workable quality. It may be sufficient to state here that the Coalton bed underlies about nine-tenths of that portion of Ohio included in this quadrangle, and there is no apparent reason for supposing that it will not prove workable in almost its entire area.

NEWCASTLE COAL OF OHIO (WINSLOW COAL, OR NO. 6, OF KENTUCKY).

Extent and development.—The lower of the workable coals in Ohio has been called in the State reports the Newcastle or No. 5 coal, and is considered by Orton and the Ohio geologists as the equivalent of the Lower Kittanning coal of Pennsylvania. (See Pl. IV, p. 28.) As it is the first coal bed of importance above the Vanport ("Hanging Rock") limestone, it is locally called in Kentucky the "Limestone coal," a name which is also applied to it about Coalgrove, Ohio. It is worked on a commercial scale at Winslow, Boyd County, Ky., and therefore will be called in this report the Winslow coal. It is found at varying distances above the Vanport limestone, but it will average 40 feet above this bed and 30 feet below the Coalton coal. From the sections given on page 36 and in fig. 1 it will be seen that this coal lies below heavy sandstones at Coalgrove. Its outcrop is not indicated on the economic map, but, if drawn, would appear between that of the Vanport limestone, represented in red, and that of the Coalton coal, represented in blue. It will be seen that its outcrop is not of great extent, because the eastern dips carry it below drainage level. Where exposed it has been opened in many places, and it is now mined on a commercial scale near the base of the hill northwest of Coalgrove depot. Several country banks are working this coal near Forestdale, east of which the coal is below drainage level. Along the river pike this coal has been worked in a very small way at one or two points, but the linear extent of its outcrop here does not exceed a mile.

Character.—The two sections given in fig. 1 (p. 34) illustrate well the character of this coal. The first section, obtained just north of Coalgrove depot, is more typical than that measured at the country

bank of Harry Smith, as the bed usually occurs in three benches, which may vary as shown in the following section:

General section of Winslow coal, near Coalgrove.

Sandstone.	Inches.
Coal	8–16
Bone	1– 3
Coal	15–16
Shale	4
Coal	8–16

The bed is apt to be irregular in thickness, and the maximum figures given above were obtained at only one point. A fair average thickness is 3 or 3½ feet. The massive sandstone which overlies the bed furnishes an admirable roof, and little timbering is necessary. On the other hand, this sandstone is liable to roll and it may replace the coal completely. The coal is dry, of good quality, and well adapted for heating purposes. It does not furnish a good grade of coke, owing to the presence of a large amount of sulphur, but after washing it is suitable for coking. The coal mined at Coalgrove is shipped over the Norfolk and Western Railway to Portsmouth, Ohio.

BIG SANDY VALLEY DISTRICT.

EXTENT.

The Big Sandy Valley district includes that portion of this quadrangle whose natural outlet is along Big Sandy River. It includes all of Wayne County, W. Va., within the limits of this quadrangle, except that part whose outlet is along Twelvepole Creek; but as this small area is of little importance from an economic standpoint, it may be said that all of West Virginia included in this quadrangle has its natural commercial outlet along Big Sandy River. This district extends as far west as the ridge dividing the waters of Big Sandy from those of East Fork of Little Sandy River. The northwestern corner of this division is the summit of the ridge between Shope and Chadwick creeks, Boyd County. Southwest of this point the boundary is a sinuous line along the ridge mentioned, which lies east of Alley, Bolts Fork, and Estep. In this district is included Cooksey Fork and Cat Creek. From the head of Cooksey Fork the line marking the western boundary of the district passes to the confluence of Daniels Creek and Blaine Creek, thence along the latter creek to the south. It passes out of the quadrangle along the ridge immediately west of Rich Creek. (See Pl. I.)

STRATIGRAPHY.

This district includes the widest range of coals in the entire quadrangle, comprising, indeed, all the coal horizons here represented. All the coals, however, are not developed in this district on a work-

able scale, and a few beds appear not to have been formed at all in places. On account of the comprehensive character of the geologic column the description of this district will serve as a natural introduction to those which follow.

All the geologic formations represented in the quadrangle, with the possible exception of those of the Mississippian series, are developed in the Big Sandy Valley. The highest rocks represented belong to the Monongahela formation. This formation is only partly developed and is of very small extent, occurring in the hills which carry the Pittsburg coal near the mouth of Gragston Creek, Wayne County, W. Va. This is the only locality in this quadrangle where rocks of this formation are present. Its most important member is the Pittsburg coal lying at its base. This is capped by the Pittsburg sandstone, which is about 30 feet thick and is very massive. The remainder of this formation is composed of reddish shales and sandy sediments. About 100 feet of the formation are still left in the hills. (See Pl. IV, p. 28.)

The Conemaugh formation is completely developed in a small area in this quadrangle near the mouth of Gragston Creek, Wayne County, W. Va., in the deepest part of the basin. In the tops of the highest hills near the mouth of this creek is the Pittsburg coal mentioned in the last paragraph, the floor of which marks the top of the Conemaugh formation. The thickness of the Conemaugh is more than 300 feet. It is composed chiefly of shales, together with limestone and a few thin coal beds. It also contains sandstones which, with certain exceptions, are liable to be lenticular, and on this account are poor stratigraphic guides. The rocks of this and the overlying Monongahela formation are the poorest in the area with reference to coal resources, the only really valuable coal associated with them being the Pittsburg bed, which occurs in too small an area to be of great economic importance. The rocks of this formation, although a complete section is shown only over a very small area, are yet widespread over the surface of this district, occupying possibly two-thirds of the entire area.

The Allegheny, the next lower formation, is about 160 feet thick. A section of Allegheny rocks may be seen along the road northwest of Louisa from a point near the confluence of Canes Branch and Twomile Creek. The massive sandstone at the top of the Pottsville is in the roadbed at drainage level, and not far away the Winslow, or No. 6, coal bed has been opened 30 feet above it. At the forks of the road near the head of Canes Branch one of the lower limestones of the Conemaugh formation is present, with another limestone 40 or 50 feet below it on the west side of the ridge. The Mahoning sandstone, lying 50 feet under this lower limestone, is rather massive. West of this ridge, as Blaine Creek is approached, the sandstone at the top of

the Pottsville becomes abnormally massive and thick. The Allegheny here loses some of the distinctiveness which characterizes it in the northern part of the quadrangle, and its upper boundary is somewhat doubtful. Southward from the region around Louisa the rise in the beds causes the gradual disappearance of the Allegheny from the hills. North of this point the formation gradually descends to the center of the basin, until at Zelda the highest coal in the formation disappears below the flood-plain deposits. A rise in the beds brings the Allegheny above drainage level again north of Savage. The formation is present in whole or in part in nearly all the hills in the southern third of the Big Sandy Valley district and also at the north end of the district near the mouth of Big Sandy River. The coals of the Allegheny are not so well developed in this district as to the north and west. The thickness of the formation along Big Sandy River, north of Louisa, seems to be about the same as near Ashland and Coalgrove, 160 to 180 feet.

The Pottsville formation is well developed in the southern part of the district, and a fairly good section was compiled on the Chesapeake and Ohio Railway, along Levisa Fork and in the surrounding hills. This section was measured south of Louisa and is as follows:

Section of Pottsville on Levisa Fork south of Louisa, Lawrence County, Ky.

	Ft.	in.
Sandstone, massive, Homewood[a]	40–60	
Coal No. 4, Lick Creek coal (Upper Mercer).		
Ore, black band	8–12	
Concealed	20	
Sandstone, massive	20	
Shale or sandstone	15	
Coal No. 3, Torchlight (Lower Mercer).		
Probable shaly sandstone	50–60	
Coal		4–8
Probable sandstone	21	
Concealed, but probably shaly sandstone	19	
Concealed	17	
Sandstone, laminated	5	
Concealed	20	
Shale with five small coal beds, the topmost of which is the so-called "Little Cannel seam"	32	8
Sandstone, massive	40–100	
Interval	30±	
Shale, drab	5	
Shale, black	3	
Shale, dark	4	
Coal (*Sharon?*)	1	4

[a] It is probable that south of Louisa, where this sandstone is very massive and apparently homogeneous throughout, it is not wholly of true Homewood age. Its lower part probably belongs under coal No. 4, which was cut out in places by a thickening up of the lower sandstone member. In this case only the top should be regarded as the true Homewood sandstone.

	Ft.	in.
Shale and sandstone	5	
Coal bloom		6
Sandstone, massive (Sharon)	40±	
Shale	10	
Coal bloom	1	
Shale and sandstone	10	
Shale	5	
Limestone, blue		8
Shale, gray	2-5	
Limestone, blue	1	
Shale, dark	5	
Sandstone	4	
Shale	3	
Coal bloom	1-2	
Shale	3	
Coal bloom.		
Sandstone, massive	4	
Coal bloom.		
Fireclay		8
Sandstone		1½
Concealed	20±	
Sandstone, shaly, micaceous	10	

It will be seen that in general the section shows several massive sandstone groups, between which are intervals containing coals, shales, shaly sandstones, limestone, and iron ores, the total thickness of which is approximately 600 feet. The general sandy character of this formation is also noteworthy.

In the section certain Pennsylvanian equivalents have been inserted in parentheses. These correlations have been based on studies made by David White. The bed worked at Torchlight, known at the Torchlight coal in this report, is regarded by him as the equivalent of the lower coal worked at Boghead, Carter County, and both the lower and the upper coals worked on Stinson Creek at Boghead fall within the Mercer group of northwestern Pennsylvania. It would seem, therefore, that the Torchlight (No. 3) and No. 4 probably correspond to the lower and upper Mercer coals, respectively.

The reference of the group of thin coals, of which the "Little Cannel" is one, to the Sharon or No. 1 horizon is furthermore not sustained by the paleobotanic evidence, according to White. This group occurring in the interval of 32 feet 8 inches at railway level north of Torchlight represents a higher horizon than the Sharon. The coal underlying the massive sandstone, which begins to be prominent in the hills back of Chapman, is probably the representative of the Sharon in this section. At Gallup a lower sandstone is 50 to 60 feet above railroad grade, and a short distance north of the store it is 50 feet thick. This is probably the Sharon sandstone.

It will be observed that the portion of the Pottsville below the sandstone at Gallup (Sharon) is characterized, within the limits of the quadrangle, by the development of dark shales and gnarly cauda galli flags, including some limestones and coals of variable thickness.

THE COALS.

MONONGAHELA COAL (PITTSBURG BED).

In the tops of the hills near the center of the basin there is about 100 feet of the Monongahela formation. At its base is a coal which is referred to the horizon of the Pittsburg bed, though it is hardly comparable in thickness with this famous bed in West Virginia and Pennsylvania. It is nevertheless a coal of excellent quality, and only its very moderate area of not more than a few acres prevents its commercial exploitation. In the hills east of Lett, at the mouth of Gragston Creek, it has been opened on the land of Abraham Thacker and James Adkins, and is found to range in thickness from 2½ to 4½ feet. It averages about 3 feet and usually has a thin but strong shale roof overlain by massive sandstone 20 to 30 feet thick. The section obtained at one of the openings on the land of James Adkins illustrates the character of this bed (see fig. 2).

FIG. 2.—Section of Pittsburg coal at bank of James Adkins in hill west of Centerville, W. Va. Scale, 1 inch = 5 feet.

CONEMAUGH COALS.

It has been stated that the Conemaugh formation is in marked contrast with that lying below, both in the character of its rocks and in the fact that it contains no workable coals and only here and there a bed of iron ore. In the Big Sandy River Region this description holds fairly good with one exception. In the hills back of Cassville a small coal, called by I. C. White[a] the Mason coal, is found in the group of sandstones at the base of the Conemaugh. It is 2 feet thick. The same coal bed has been opened at a few points along Twelvepole Creek a few miles above Ceredo. It is as a rule so thin and so variable in its distribution that it can hardly be classed among the important coals of the future. It has now and may continue to have some local importance. With the exception of this bed the Conemaugh formation is probably devoid of workable coals.

[a] West Virginia Geol. Survey, vol. 2, 1903, p. 280.

ALLEGHENY COALS.

SECTIONS OF THE FORMATION.

The base of the Allegheny formation appears in the hilltops about 7 or 8 miles south of Louisa and dips rather steeply to the north, being very nearly at railroad grade at Eloise and a few feet below railroad level at Louisa. There are at least five workable coals in the Allegheny in different parts of this quadrangle, but in no single district are all these of workable thickness. Usually not more than two or three are workable in any particular locality. This is true for the region about Louisa and for the valley of Big Sandy River as a whole. A section obtained near Cassville will illustrate the character of the beds in the Allegheny formation.

Section at Cassville.

	Ft.	in.
Top of hill.		
Concealed and sandy débris	15	
Sandstone, massive	28	
Shale	3	
Shale, fossiliferous[a]	4	
Coal	2	
Sandstone, conglomeratic in places, with calcareous nodules about 15 feet from its top	53	
Probable top of Allegheny.		
Concealed	22	
Sandstone, massive	20	
Clay, flint.		
Shale, green	1	6
Shale, red	1	
Shale	12	6
Concealed, but containing a coal near the top	20	
Sandstone, laminated or shaly	1	
Shale, sandy	9	
Shale, greenish, and sandy shale	25	
Coal smut		2
Fire clay, green	3	
Sandstone	2	
Fire clay, drab	1	6
Shale, sandy	12	
Sandstone, massive	4	
Fire clay		3–4
Sandstone, laminated	19	
Limestone ore, nodular	1	
Shale	3	6
Coal No. 6	1	9
Fire clay, upper part fossiliferous	2	
Shale, sandy	6	
Coal		1½

[a] This shale is regarded by I. C. White as the representative of the lower Cambridge limestone and the coal underlying it as the Mason: West Virginia Geol. Survey, vol. 2, 1903, p. 280.

	Ft.	in.
Shale, green, fossiliferous	1	
Coal		5
Fire clay		6
Fire clay, siliceous	6+	
Concealed	7	6
Railroad grade.		

The lower part of this section was measured also in the first main cut on the Chesapeake and Ohio Railway, about a mile north of Louisa.

This section, which shows the variations that may take place within a short distance, is as follows:

Section north of Louisa.

	Ft.	in.
Coal	1	
Sandstone, laminated	2	
Coal		6
Shale	3–5	
Sandstone, laminated	4	
Fire clay		6
Sandstone, laminated	2	
Limestone, ferruginous		4–5
Fire clay	1	
Sandstone, laminated	2–3	
Fire clay, with nodular limestone	1	
Sandstone, laminated	3	
Limestone nodules, intermittent layer		6
Shales, drab, or fire clay	4	
Coal, changing to black flint		6
Fire clay	2	
Coal	1	6
Shale, dark fossiliferous	4	
Bone		6
Shale, drab fossiliferous	1	6
Coal		6
Fire clay, siliceous	5	
Railroad level.		
Fire clay, siliceous	3	
Concealed	3	
Shale, drab	5	

These two sections, obtained on opposite sides of the confluence of Tug and Levisa forks, illustrate well the character of the coal-bearing rocks in this vicinity. The sandstone member forming the top of the Pottsville is exposed at the mouth of Lick and Mill creeks, south of Louisa and Cassville; also at the lock just a short distance down Big Sandy River from Louisa, and at the mouth of Canes Branch. Its top, therefore, must be only a few feet below the flood plain on which the towns are built. This statement is corroborated by the evidence of the fossil plants, examined by David White, from the fossiliferous beds indicated in the lower parts of the above sections.

ZELDA COAL (NO. 9).

Name and position.—The Zelda coal is the No. 9 of Kentucky and the No. 7, Bayleys Run, or Waterloo coal of Ohio.

The highest coal of importance in the Allegheny formation in Big Sandy Valley usually occurs below a rather massive sandstone which, for reasons already stated, is regarded as the Mahoning sandstone. The coal below this sandstone, the Zelda coal, is thought to occur at the horizon of the Upper Freeport coal.

Extent and development.—In the valley of Big Sandy River the Zelda coal has been prospected at a number of points. The rise of the beds up Big Sandy River brings this coal above drainage at

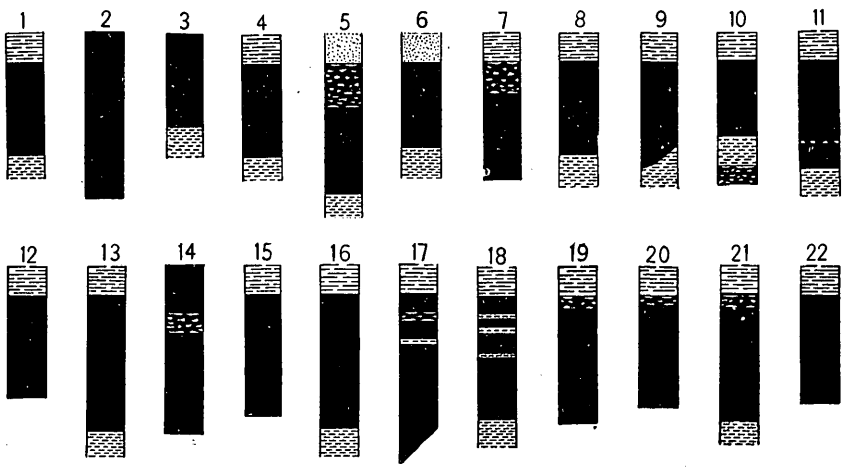


FIG. 3.—Sections of Zelda coal (Upper Freeport, Kentucky No. 9). Kentucky: 1, Clifton Dean, near Zelda; 2, Frank Yates, near Catalpa; 3, 1 mile north of Fallsburg; 4, Matthew Holley, mouth of Cat Creek; 5, 1 mile above No. 4; 6, C. C. Crank, Fallsburg; 7, west of Fallsburg; 8, John Bentley, Yatesville; 9, Wade Chapman, Yatesville. West Virginia: 10, on Norfolk and Western Railway, north of Miller Creek; 11, Alvin Stewart, opposite Zelda; 12, mouth of Little Hurricane Creek; 13, Christopher Bellamy, Little Hurricane Creek; 14, Elijah Thompson and William Wellman, Little Hurricane Creek; 15, Isaac B. Fish, Tabor Creek; 16, John Thompson, Long Branch of Tabor Creek (only main bench is shown); 17, Volney Artrip, head of Right Fork of Hurricane Creek; 18, head of Trace Branch; 19, 20, 21, near Bellups Gap; 22, Tug Fork. Scale, 1 inch = 5 feet.

Zelda, where it has been opened on both the Kentucky and the West Virginia side of the river. Just south of Zelda 26 inches of coal were measured at the bank of Clifton Dean (fig. 3, section 1). A short distance north of Dean's bank E. D. Milan has opened the same coal. South of Zelda it has been opened and worked in at least half a dozen places near the mouth of Mill Branch and at Gurnetts, where it ranges from 2 to 3 feet in thickness. Southwest of Catalpa it has been opened by Frank Yates, of Louisa, 48 feet above the railroad track, where it measures a little over 4 feet thick (fig. 3, section 2). This coal has also been opened near the mouth of Horseford Creek, on the property of Dr. John Berry, of Quincy, Ky. At this point

only 1 foot of coal is exposed, beneath a shale and sandstone roof, but the bed is reported to be 3 feet thick. South of Fuller, owing to the rise of the beds, the massive sandstone capping this coal may be seen from the railroad at a few points; but the coal underlying it has not been opened, except near the heads of some of the shorter streams which flow into Big Sandy from the west.

Fallsburg district.—The rise of the beds toward the south brings the coal bed above drainage level on Blaine Creek at the mouth of Long Branch, about 1 mile north of Fallsburg. Here it has the section indicated in fig. 3, section 3. A short distance to the south, near the mouth of Cat Creek, a section (4, fig. 3) almost identical with section 3 was seen at Matthew Holley's bank. The coal farther in the bank is reported 33 to 34 inches where thickest. About a mile farther up Cat Creek a section (5, fig. 3) showing about 25 inches of coal furnishes added evidence of the uniformity of the coal in this vicinity. The following section was measured east of Fallsburg:

Section east of Fallsburg.

	Feet.
Soil, sandy.	
Limestone débris.	
Soil, clayey.	
Shales, green	60
Sandstone	5
Limestone, crinoidal	2–3
Fire clay	1
Shale, red and green	20–25
Shale	20
Clay	4
Sandstone	45
Sandstone, massive	20
Coal bloom, Zelda.	

This section shows well the character of the beds above the Zelda coal in this region. The coal at the base of the section has been opened at a number of country banks in and about Fallsburg, where it averages about 2 feet thick, as sections 6 and 7 (fig. 3) show. West of Yatesville, at the banks of John Bentley, Wade Chapman, and James Compton, the coal bed is reported as ranging from 2 to 3 feet, and these figures were verified in several places (sections 8 and 9, fig. 3).

West Virginia.—The sandstone overlying the Zelda coal disappears below drainage level a short distance north of Zelda and is not exposed again until it rises above drainage level on the north side of the basin near Savage, Ky. From this point to the mouth of Big Sandy River no coal was seen immediately below the sandstone, but in a bed of shale, 20 feet or so below, an occasional bloom was noticed which may correspond with Crandall's No. 8, or the Hatcher bed. In West Virginia, near the mouth of Big Sandy River, the basal

sandstones of the Conemaugh are a very conspicuous feature in the landscape, and in recent cuts along the Norfolk and Western Railway a coal bed occupying a position corresponding to that of the Zelda coal was observed near the mouth of Miller Creek. This is the coal bed worked by Will Payne, a short distance above the mouth of the creek. It is reported to be 32 inches thick at Payne's bank, though, as will be seen from section 10 (fig. 3), it is very badly split by partings along the railroad. South of Neal it disappears below the flood plain. Farther east, on Whites and Gragston creeks, the horizon of this coal is above drainage, and in a few places the bed attains a workable thickness. Opposite Zelda, at Alvin Stewart's, the coal shows a thickness of very nearly 40 inches (section 11, fig. 3). About Hubbardstown and along Hurricane Creek both this coal and the next underlying bed outcrop in several places. The lower of these two coals is rarely of workable thickness, but the higher coal has been opened in several places and shows a thickness of 2½ to 3 feet and more (sections 12, 13, and 14, fig. 3). About a mile east of Hubbardstown the bed does not appear to be of sufficient thickness to work, but near the mouth and near the headwaters of Tabor Creek it has an average thickness of 3 feet (section 15, fig. 3), and in places, instead of a single bench, consists of two benches, as indicated in the following section, measured at the bank of John Thompson:

Section at John Thompson's bank, Tabor Creek.

	Inches.
Sandstone roof.	
Coal	6½
Shale and fire clay	37½
Coal	39½
Fire clay.	

Northeast of Cassville, on the headwaters of Right Fork of Hurricane Creek, and still farther northeast, on Trace Branch, sections (17 and 18, fig. 3) measured at the country banks working this coal give a good idea of its persistence and character. This coal has also been opened at one or two points on Mill Creek.

The coal opened just north of Bellups Gap is tentatively referred to this bed, but it may be a lower coal. It has been opened by Poley Ferguson and James Bellup. This is probably the same coal opened less than a mile northeast of Louisa, which has a similar section (sections 19, 20, and 21, fig. 3). The coal opened near Copley on Tug Fork is also regarded as a lower bed than the Zelda coal and may possibly be as low in the formation as the Coalton coal (section 22, fig. 3).

Character.—From sections of the Zelda coal given in fig. 3, it will be seen that it consists in general of a single bench ranging in thickness from 2 to 3 feet. It usually has a thin black shale or bone roof,

but is in many places overlain by massive sandstone. It rarely exceeds 2½ feet in thickness, and the measurement of 4 feet obtained at Frank Yates's bank, southeast of Catalpa, is apparently local. The coal is a lustrous, bituminous, semiblock coal, with splinty partings, and is highly esteemed for smithing and domestic purposes. The chief objection is to its thin section. Its quality apparently bears a certain relation to the thickness of the bed, for the thicker coal is reported to be of poorer quality at the head of Little Hurricane and Tabor creeks. It is quite probable that it will prove commercially valuable at some future time in the area indicated by the solid outcrop line. (See economic map, Pl. I.)

COALTON COAL (NO. 7).

The Coalton is the next lower coal bed in the Allegheny formation. Taken as a whole, this coal is the most important in the entire quadrangle, but in the valley of Big Sandy it is of minor importance. About two-thirds of a mile south of Potters a coal referred to this

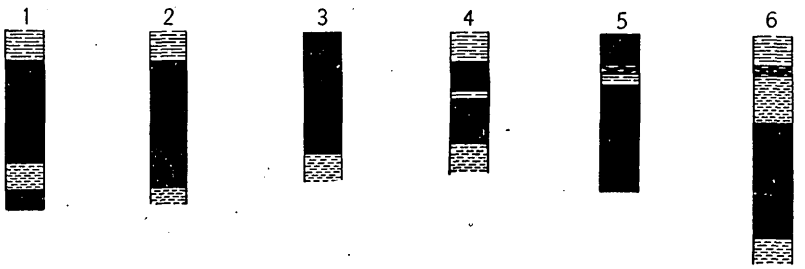


FIG. 4.—Sections of the Coalton and Winslow coals in Big Sandy River district. Coal No. 7 (?): 1, George Cooksey, Cat Creek; 2, Cat Creek; 3, Cat Creek. Coal No. 7: 4, two-thirds of a mile south of Potters. Coal No. 6: 5, T. J. Chapman, Lick Creek; 6, John Vaughn, Lick Creek. Scale, 1 inch = 5 feet.

horizon outcrops at railroad level, but is thin (fig. 4, section 4). This coal has been worked just north of the station.

On Cat Creek, below the mouth of Thompson Fork, a coal which is doubtfully referred to this horizon has been opened about 40 to 50 feet above the road. It is closely overlain by a rather massive sandstone, and in this respect resembles the Coalton coal, but the distance below the base of the massive sandstone forming the lowest member in the Conemaugh formation points to a higher bed. It may therefore be the next higher, or Hatcher, coal. Along Cat Creek it is not over 50 feet below the base of the Mahoning sandstone, whereas the ordinary distance below that sandstone of coal No. 7, or the Sheridan bed, around Ohio River is from 90 to 100 feet. It is certain that the usual number of coals is not developed in the Allegheny rocks along Cat Creek below the mouth of Thompson Fork, as the section in the hill between Cat Creek and Morgan Run indicates. The coal under

consideration has been opened on the property of W. A. Rice, John Cooksey, Willis Roberts, J. K. Chadwick, Mrs. Americus Wood, and Mrs. Nancy J. Carter, on Cat Creek, and also in the vicinity of Yatesville. Sections 1, 2, and 3 of fig. 4 illustrate the character of this bed in the valley of Blaine Creek.

WINSLOW COAL (NO. 6).

In the section given on page 42, above the railroad level a mile north of Louisa, there is a bed of coal 1½ feet thick 11 feet above the railroad track. In places this coal measures from 27½ to 29 inches, with a drab or black shale roof a foot or two thick and a clay floor. It is the same bed which has been opened in the hills west and northwest of Louisa and is probably the coal referred to as coal No. 6 in Crandall's report; also, it is probably the bed which is mined so extensively about Ashland and Winslow, in Boyd County, and at Coalgrove, Ohio. At these different places it is known as the limestone coal, from its position as the first coal above the Vanport ("Hanging Rock") limestone. Though it is worked extensively about Ashland, it has been thought best not to apply the name of that city to it, as the coal next above (the Coalton coal) is frequently referred to in the Ohio reports as the Ashland coal.[a] It is being mined and shipped from Winslow, south of Ashland, and hence may appropriately be known as the Winslow coal. In the Ohio reports it is usually termed the Newcastle coal. As the first coal above the Vanport limestone it corresponds, in position at least, with the Lower Kittanning or Miller bed of Pennsylvania.

Though this coal bed has been opened in many places near Louisa, only a few measurements could be obtained, as nearly all the banks in which the coal has been worked have fallen shut. Near the mouth of Twomile Creek and on Lick Creek it has been opened and worked on a small scale. This is probably the coal opened by John Vaughn and T. J. Chapman. (See fig. 4, sections 5 and 6.) It is reported of workable thickness in the hills north of Chapman's store on Threemile Run, and a few old openings on it were seen at this place. On Dry Ridge south of Irad it appears as a small coal not exceeding 2 feet in thickness.

In West Virginia, south of Cassville, it has been opened, and 32½ inches of coal were seen at an opening south of the town. On Mill Creek the coal has been opened at a few points, and though the upper part of the bed is somewhat injured by the presence of bone and shale, it usually contains a lower bench of bright, lustrous bituminous coal of good quality, averaging from 2 to 3 feet in thickness.

[a] Ohio Geol. Survey, vol. 3, pt. 1, 1878, p. 918.

CAT CREEK COAL (NO. 5).

Position.—The lowest workable coal in the Allegheny formation in the Big Sandy Valley district occurs below the Vanport limestone. This coal usually lies directly on, or a very few feet above, the Homewood sandstone. Where the two sections given on pages 41–42 were measured, it may be below the lowest member shown and hence not appear in the section. This coal is regarded as the equivalent of the main workable bed on the headwaters of Cat Creek, and as it probably attains its maximum development in that region and is generally known in this part of Kentucky as the Cat Creek bed, it will be called in this report the Cat Creek coal. Crandall, in his general section of this part of Kentucky, has placed No. 5 coal, to which he gives the names Cooksey Fork and Pennington coal,[a] as the first below the horizon of the Vanport limestone, and therefore it appears probable that Crandall's No. 5 or Cooksey Fork coal is the same as the Cat Creek bed of this report. Crandall states that this coal occurs 30 to 40 feet below the limestone ore, referring to the ore associated with the Vanport limestone. This distance is rather large for the region about the head of Cat Creek.

Extent and development.—About Louisa the presence of this coal is nearly always indicated by a bloom. Its position above the Homewood sandstone is best seen in the gorge of Lick Creek near its mouth, and on the Lick Creek pike. About 2½ miles southwest of Louisa it has been opened by Mordecai Wilson, but the bank is now fallen shut. Near Osie coal has been dug, but the bed is reported to be thin. In West Virginia, south of Cassville, this coal is usually present, but is thin and, as on the Kentucky side, is very rarely worked. A short distance south of Louisa it is below the flood plain. In the immediate valley of Big Sandy and its tributaries to the south it will probably not prove workable over any considerable area.

This coal is the most important bed on the headwaters of Cat Creek, and there and to the west on the headwaters of Cherokee Creek and Dry Fork it attains its maximum thickness in this quadrangle. Further descriptions and an analysis of it are given in connection with the mention of its occurrence on Cherokee Creek (p. 103). At the headwaters of Cat Creek it has not been developed on a commercial scale, owing to remoteness from transportation. The extent of its outcrop in this locality is limited, as the northward dips carry it below drainage level near the mouth of Thompson Fork. On the map its outcrop line in the valley of Cat Creek is practically coincident with the red line which indicates the horizon of the Vanport limestone and its clay. It has been opened by Andrew

[a] Report on the eastern coal field: Kentucky Geol. Survey, vol. C, p. 19, 1884, pl. 1.

Webb, Andrew Cooksey, and W. H. Moore, and at Moore's bank the following section was measured:

Section of Cat Creek coal bed at bank of W. H. Moore.

	Inches.
Shale, black.	
Coal	1½
Bone	4½
Coal	17½
Bone	½
Coal	24
	48

A thickness of 4 feet 10 inches to 5 feet is reported from other country banks in the immediate vicinity. In some places, at least, this coal is sufficiently thick and free from impurities to make it valuable, but in other places it is so badly split up by impure partings that it will have little value except for country trade. The following two sections illustrate this impure phase:

Sections of Cat Creek coal bed.

	Inches.
Shale, black, containing small stringers of coal	1
Coal	1½
Shale, black	4
Coal	5
Shale, black	12
Coal and shale	4
Coal	4½
Bone	1
Coal	9
	42
Shale, black.	
Coal	4
Shale, black	19
Coal	2
Bone	1
Coal	1
Bone	½
Coal	8
Bone or coal	½
Coal	1½
Clay.	
	37½

The fact that it has a good section on Cat Creek and shows well on Cherokee Creek is sufficient evidence that this coal bed is well worth careful attention. It should be prospected with a diamond drill in the intermediate territory before actual operations on it are begun.

Character.—The Cat Creek coal is of excellent quality and when not badly split up gives much satisfaction as a domestic fuel, being hauled many miles into the surrounding country.

POTTSVILLE COALS.

LICK CREEK (NO. 4).

Extent and development.—The highest coal in the Pottsville is from 55 to 75 feet above the Torchlight bed. It is locally known as the "5-foot vein" but is sometimes called the "Big vein" and probably corresponds with coal No. 4 of the Kentucky Survey. Its maximum development is in the hills east of Lick Creek and between Lick Creek and Levisa Fork, and it may be conveniently designated, therefore, the Lick Creek coal. From the fact that it overlies the Torchlight bed it occurs over a smaller territory above drainage level, and is not found as far south in the hills as the Torchlight. Though locally thicker than the coal below, it will probably not be found so persistent and uniform. It has been prospected by the Torchlight Coal Company between Threemile Creek and Levisa Fork, where it proves to be of workable thickness, and in this region it is about 60 feet above the Torchlight bed. East of Threemile Creek, prospects have been opened on it on Donithon Branch, where it is also workable. In West Virginia the coal at this horizon does not appear to be of workable thickness; at least no openings were observed on it. West of Lick Creek the horizon is marked by a coal bloom or smut, but in no place has it been found sufficiently thick to work profitably except for local purposes. It has been worked for family use at one or two points on San Branch near Irad and also one-fourth of a mile below the point where Little Blaine Creek enters Big Blaine. So far as known the coal has never been worked on a commercial scale in Big Sandy Valley. In this district the most promising field in which to prospect for this coal is in the hills along Levisa and Tug forks, south of Torchlight.

Character.—Sections obtained from this bed are shown in fig. 5. The section obtained at the head of Lower Gavitt Creek on the property of the Torchlight Coal Company differs strikingly from the remaining three, obtained from test drifts of the Louisa Coal Company in the hills between Lick Creek and Levisa Fork, just west of Torchlight. The upper 20 inches of the coal on Lower Gavitt Creek appear to be much broken up. The lower benches, which average about 19 or 20 inches, are separated by a small clay parting. In places the upper bench consists of clean coal, giving the three benches as in the Torchlight bed. The coal is also reported with three benches on the headwaters of Donithon Creek, but here the upper bench is slightly thicker than either of the two lower. The section

measured by C. M. Weld for the Torchlight Coal Company shows this character as follows:

Section of Lick Creek coal bed at the head of Ox Hollow, Donithon Creek.

	Inches.
Coal	25½
Parting	5½
Coal	18
Parting	2½
Coal	12
	63½

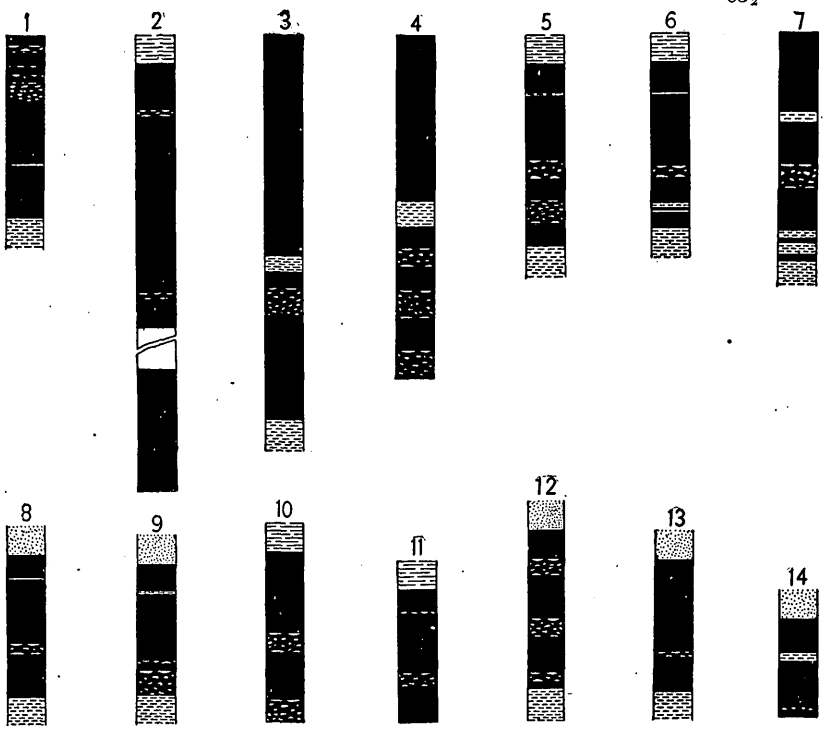


FIG. 5.—Sections of higher Pottsville coals in Big Sandy Valley district. Lick Creek coal (Kentucky No. 4): 1, Torchlight Coal Company, Lower Gavitt Creek; 2, 3, 4, Louisa Coal Company, between Lick Creek and Levisa Fork. Torchlight coal (Kentucky No. 3): 5, Torchlight Coal Company, head of Lower Gavitt Creek; 6, mine of Torchlight Coal Company; 7, Threemile Creek; 8, Andrew New, opposite (west of) Torchlight; 9, opening north of No. 8; 10, Henry Cochrane, Lick Creek; 11, Left Fork Little Blaine Creek; 12, Right Fork Little Blaine Creek; 13, Kelly Frailey, Right Fork Little Blaine Creek; 14, Andrew Hayes, Right Fork Little Blaine Creek. Scale, 1 inch=5 feet.

In the hills along Threemile Creek this coal will probably average between 3 and 4 feet.

West of Levisa Fork, on the property of the Louisa Coal Company, this coal thickens, as will be seen from fig. 5, sections 2, 3, and 4. In general the coal in this vicinity is irregular, but consists, where observed, of two main benches separated by a clay parting varying from a few inches to 5 feet. The coal south of the prospect pits of this company is reputed to be very irregular and of poor quality, but these statements can not be corroborated by the writer, as nothing was

seen of it at any point. West of Lick Creek, about one-half mile above the mouth of Rhubens Branch, the coal measures about 2 feet on the outcrop in a well-exposed section showing the top of the Pottsville and the Allegheny, as follows:

Section on Rhubens Branch.

Hilltop.	Ft.	in.
Shale, red	30	
Sandstone	20	
Shale, red	20–25	
Bench.		
Sandstone, shaly	18	
Shale, sandy	16	
Sandstone, shaly	6	
Shale, light olive	7	
Clay, white	1	
Soil, ferruginous clayey	30	
Shale, sandy	9	
Sandstone, coarse, yellow, massive	15	
Shale	10	
Clay	5	
Shale	5	
Clay with iron-ore nodules	5	
Shale, black (coal?)		2–3
Shale, gray	10	
Coal		2
Shale, drab	7	
Shale, purple	5	
Sandstone	8	
Coal No. 5		12
Sandstone, laminated	15	
Coal No. 4 (Lick Creek coal)		24
Sandstone, massive	25±	
Coal No. 3.		
Sandstone, massive.		

This section indicates the erratic character of the Allegheny and shows how difficult it is to locate its exact upper boundary.

The massive sandstone at Busseyville marks the top of the Pottsville formation. This sandstone rises in the direction of the forks of Little Blaine Creek, and a short distance below the residence of L. D. Pigg the coal appears above drainage level and has been opened about 15 feet above the road to the left. A short distance beyond the same coal shows a section as follows at F. R. Bussey's bank:

Section of coal bed at F. R. Bussey's bank, near Busseyville.

Sandstone, massive.	Inches.
Coal and black shale	30
Sandstone lentils, sometimes absent	2
Shale and bone	10
Coal	5
Shale, drab fissile	22
Coal	15
Bone	1

	Inches.
Coal	2
Bone	2
Coal	15+

About 60 feet below this coal, at road level, is the bloom of another and lower coal, which has been opened by L. D. Pigg in the hill to the west. This coal has a section as follows:

Section of coal bed opened by L. D. Pigg near Busseyville.

	Inches.
Limonite, nodular	4
Shale	19
Bone	3
Coal	4
Shale	19
Bone	4
Coal	7

These coals are believed to be above the true Torchlight coal, which shows as a bloom at the road corner at the confluence of Left and Right forks of Little Blaine Creek. It is possible that one of these two beds represents the Lick Creek coal and that the other may represent a new bed in the section. It is also possible that these coals may represent the two benches of the Lick Creek coal, the parting of 5 feet of clay in the region east of Lick Creek having expanded to 60 feet farther west. The data on this point are not sufficient to make it absolutely certain that these two beds represent the two benches of the Lick Creek bed, but the writer is inclined to this view. Neither of the two coals, where seen outcropping, is of commercial importance.

Where the Lick Creek coal is of workable thickness it is of a bright, hard, bituminous variety, with occasional bands of splint or semi-cannel coal. The upper of the two lower benches appears to be the more uniform, but in places the lower may probably be worked with it. Locally, however, it is badly split by bony partings. At many points between Levisa Fork and Tug Fork all three benches may be worked if sufficient care is exercised in separating the clay and bone partings. As a rule the roof of this coal is formed by shale, but in some places the base of the massive Homewood sandstone extends down practically to its top. The following analyses indicate the character of this coal:

Analyses of Lick Creek coal.

	1.	2.
Moisture	6.00	0.97
Volatile matter	32.40	32.70
Fixed carbon	57.40	55.69
Ash	4.20	9.58
Sulphur	.049	1.05

1. Furnished by J. H. Northup, of Louisa, Ky., from a sample collected at the head of Donithon Creek.
2. Furnished by A. C. Collins, of the Louisa Coal Company. Otto Wuth, analyst. Sulphur is included in the total.

The foregoing analyses show a good coal of the bituminous grade, corresponding favorably with much of the Pittsburg coal of western Pennsylvania. It contains a rather higher percentage of volatile matter and correspondingly lower fixed carbon. On account of its hard and somewhat splinty character it will bear transportation and stocking well. It is doubtful whether it will prove to be a good coking coal, but experiments with regard to this point have not been made.

TORCHLIGHT COAL (NO. 3).

Name.—The next lower workable coal in the Pottsville group is perhaps the most important of all the beds thus far developed on the upper waters of Big Sandy River and its tributaries in this quadrangle. In the Kentucky reports this coal is known as No. 3, or McHenry coal, the latter being the name of the property on which the coal was first worked on any marked scale. In this description it will be referred to as the Torchlight bed, from the fact that the Torchlight Coal Company has worked it more extensively than any other company at Torchlight, on the Chesapeake and Ohio Railway 6 miles south of Louisa, and opposite the old McHenry property on the west side of Levisa Fork. It is locally known also as the "Check House vein." It corresponds to the Lower Mercer coal of Pennsylvania.

Extent.—The Torchlight coal first appears above drainage level on Threemile Creek near the Threemile schoolhouse, and is reported on Levisa Fork near the bed of the creek just north of the railroad bridge at Walbridge. It is probably present in all the hills south of these points in the territory included between Tug and Levisa forks and also in West Virginia. East of Threemile Creek, however, it does not seem to have been extensively prospected and little seems to be known about it. In the hills between Threemile Creek and Levisa Fork it has been fairly well prospected, and this is also true of the territory lying between Levisa Fork and Lick Creek to the west. It is present in the hills along Left and Right forks of Little Blaine Creek, but owing to northward dips disappears below drainage level a short distance north of the confluence of these two forks. A reference to the map (Pl. I) will show the outcrop of this bed so far as it is known to be of workable thickness.

Development.—This coal was first opened at McHenry's bank, on the west side of Levisa Fork opposite Torchlight. Since then it has been developed on a commercial scale by the Torchlight Coal Company at Torchlight. During the summer of 1905 the mine was closed, but it started up again in the following spring. In the hills west of Levisa Fork this coal has been faced in several places by the Louisa Coal Company to ascertain its possibilities. It has also

been opened by Andrew New and others northwest of Torchlight. On Lick Creek several small country banks have been opened and a small amount of coal has been removed for the country trade by Richard Childers, Henry Cochrane, and others. On Left Fork of Little Blaine Creek this coal appears to have a section similar to that in the region about Torchlight. It has been opened at a few places along this creek a short distance south of its confluence with Right Fork.

Along the pike east of Adams it is found well up in the hills on the south side of the creek and near road level on the north side, owing to the steep dips. It has been opened in this region by Kelly Frailey, Andy Hayes, and others. It is possible that the coal opened by James Adams west of Adams corresponds to the Torchlight bed.

Character.—Ten sections of the Torchlight coal are represented in fig. 5. It will be seen from these sections that the coal bed is somewhat variable. In places it occurs as a single bench, as at the bank of Richard Childers, on Lick Creek, where 37 inches of clean coal were measured, but usually it consists of two or three benches. As a rule a clay parting separates the top benches. This clay parting is in general of knife-edge thinness (sections 5, 6, 8, 9, 11, fig. 5), and is, perhaps, entirely cut out in some places, as at the Henry Cochrane and Kelly Frailey banks (sections 10, 13, fig. 5), on Right Fork of Little Blaine Creek. It rarely attains a thickness of an inch, though in exceptional cases it may exceed this measurement, as at an opening of the Torchlight Coal Company on Threemile Creek, where a parting of 3 inches was measured (section 7, fig. 5). The third or lowest bench ranges from less than 6½ to over 14 inches in thickness. It is separated from the middle bench by a persistent bone parting averaging 3 to 4 inches.

The coal in this bed is of both the splinty and the soft bituminous varieties. The top bench above the clay parting is usually soft; the middle bench, though generally of soft, lustrous bituminous coal, in many places contains hard, splinty layers and is therefore slightly harder. The lowest bench is as a rule of hard, dull, splinty coal, and serves as an excellent base for pillars in mine working. This bench is also drilled before shooting. In mining, all three benches may be worked and the bone or "niggerhead" between the two lower benches removed by hand picking. The roof of the coal bed varies. It is in some places shale and in others massive sandstone. The shale, where present, ranges in thickness from a few feet up to 15 feet, more or less, and sometimes gives much trouble in mining. The roof of the coal, where it is composed of shale, has to be carefully watched and rather heavily timbered to avoid falling and "creeping." On this account mining with a shale roof is attended with more danger and expense than where the coal is overlain by sand-

stone. Above the layer of shale there is usually a very massive sandstone of varying thickness, which serves as one means of identifying this bed.

Below the lowermost worked bench there are in many places one or two smaller benches of coal separated from the main bed by a fire clay or bone parting (sections 6 and 7, fig. 5). These are never mined. The true floor of the coal, as a rule, is clay. A few analyses of this coal are as follows:

Analyses of Torchlight coal.

	1.	2.	3.	4.	5.
Moisture	4.60	2.86	2.10	1.90	1.23
Volatile matter	35.70	37.49	35.95	35.47	35.82
Fixed carbon	53.28	40.85	37.79	35.86	53.37
Ash	6.42	18.80	24.16	26.27	8.40
Sulphur	1.08	1.11	1.77	1.22	1.18

1. Sample from McHenry's coal bank, Lawrence County, Ky. Report on the eastern coal field: Kentucky Geol. Survey, vol. C, p. 18. Robert Peter and Mr. Talbut, analysts.
2. Torchlight Coal Company's mine, second entry. Ricketts & Banks, analysts.
3. Torchlight Coal Company's property on Lower Gavitt Creek. Ricketts & Banks, analysts.
4. Torchlight Coal Company, Fivemile Shoal. Ricketts & Banks, analysts.
5. Crop coal from hill between Levisa Fork and Lick Creek property of the Louisa Coal Company. Otto Wuth, analyst. Sulphur is included in the total.

From these analyses it will be seen that the volatile matter averages about 35 per cent and the fixed carbon approximately 45 per cent. The ash and sulphur are comparatively high, especially in the samples analyzed by Ricketts & Banks for the Torchlight Coal Company. The lower and dirty benches were probably included in the samples analyzed by this firm, but in the mining of the three upper benches this material would probably serve as a floor; or, if it were found necessary to remove it, it could be picked out and gobbed, and the main and clean benches shot down from above. The main benches would yield from 2½ to 4 feet of fairly clean coal; on an average, perhaps about 3 feet. With this figure as an average, the yield per acre may be conservatively placed at 3,500 tons. From the sections of the coal given in fig. 5, it will be seen that the danger of introducing unduly large amounts of ash into this coal during the course of actual mining is very great, and the amounts of ash represented in analyses 1 and 5 are perhaps below what would be found in practice. If the entire bed—that is, the three main top benches—is to be mined and successfully marketed, pains must be taken to eliminate the bone and clay where they are of abnormal thickness. This may be accomplished either by hand picking—a slow, tedious method and one which in the hands of miners is liable to lead to injury both to the reputation of the company and to the coal—or by washing. The expense of the latter operation ought not to exceed from 5 to 7 cents per resulting ton of coal. In no case would it appear advisable to mine any coal below the lower splint band.

LOWER COALS.

Extent.—The lowest coals developed in this district are those nearest its southern edge, as the rise of the beds to the south brings up successively lower horizons toward the southern edge of the quadrangle. Certainly the lowest exposed coal beds in the entire quadrangle occur in the section southwest of Gallup. As will be seen from the section of the Pottsville formation on pages 38–39, and from the sections on Pl. IV (p. 28), four small coals are found below the Sharon sandstone. None of these coals has ever been worked in this quadrangle, though one of them measures 24 inches at one point. Between the Sharon and the next massive sandstone above is about 50 feet of shale with two small coal beds. The highest of these coals has been worked near a sharp bend in the railroad track south of Torchlight. Where measured on the outcrop this coal is 16 inches thick. The sandstone above it was formerly, though probably erroneously, correlated with the Sharon sandstone seen on Everman Creek. About 2 miles south of Torchlight there is at this horizon 100 feet of almost continuous sandy beds with two slight breaks near the middle. Above this massive member are several small coal beds in an interval of 30 to 35 feet. A detailed section of this group of coals, measured near the mouth of Lower Gavitt Creek, below Torchlight, is as follows:

Section of coals at the mouth of Lower Gavitt Creek, Lawrence County, Ky.

	Ft.	in.
Shale, black, and clay	2	2
Coal	1	7
Parting "Little Cannel"		½
Coal		2
Sandstone, laminated	10	
Coal	1	
Shale, sandy, or fire clay	2–3	8
Coal	2	5
Shale	2	5
Coal		3
Shale, drab to dark	2	
Coal	1	8
Shale, black, and fire clay	2	3
Slate, black, and bone.		
Fire clay	3	
Bed of creek.		

The uppermost of these coals is workable over a considerable area in the southeast corner of the quadrangle and may be looked for at a distance of about 140 feet below the Torchlight coal. It is present in the hills along Levisa Fork and Threemile Creek, gradually rising

from railroad level at the mouth of Lower Gavitt Creek, just below Torchlight station. West of Levisa Fork this coal appears above drainage level near the head of Lick Creek, the group of coal blooms in which the "Little Cannel" belongs appearing near the summit of the ridge in the road at the head of Lick Creek. The character of the coal in this vicinity could not be determined, owing to the fact that it has not been opened, but west of the Left Fork of Little Blaine it has been opened in a few places near the level of the creek and is of workable thickness, though badly split up by bone and fire-clay partings.

On Right Fork of Little Blaine the lithologic succession is not so characteristic as to the eastward. Near Adams a massive sandstone appears above the bed of the creek and rises gradually to the south up the creek. On the hill southeast of Adams a distinct coal blossom may be seen close to the top of this sandstone with the shale above it. The sandstone underlying this coal may be traced with hardly a break up the creek, and about three-fourths of a mile south of Adams the coal directly above it is worked. Instead of being overlain by shale, as at Adams, it is now capped by a very massive sandstone, and the coal, as nearly as can be estimated, is about 110 feet below the Torchlight bed, and is regarded tentatively as of the "Little Cannel" group, though it may be higher.

Development.—The "Little Cannel" coal has been opened near the head of Threemile Creek and at one time was mined and shipped from this locality over the old Chatteroi Railroad. About 5,000 tons are reported to have been shipped before the road's alignment was changed to its present location along Levisa Fork. Operations ceased as a result of the financial panic in 1893, and since then nothing on a commercial scale has been attempted.

A short distance south of Torchlight the coal has been worked on a small scale and a few hundred tons have been removed, under lease from the Torchlight Coal Company. There are small openings north of the station and in the hills on the west side of the fork. Developments on Left and Right forks of Little Blaine Creek are of local importance only and supply the country trade. Though this coal is above drainage level along the headwaters of Rich Creek, it does not seem to be of sufficient thickness to justify opening it on even a small scale.

Character.—This bed of coal is known as the "Little Cannel" bed about Torchlight for the reason that it contains near the middle of its upper bench a thin band of coal with enough volatile matter to place it among the cannel coals. Sections obtained near Torchlight (sections 1 and 2, fig. 6) show this coal to vary from a thickness of 19½ inches north of the tipple to 2 or 2½ feet south of the tipple of the Torchlight Coal Company. This coal is split into two benches with a part-

ing of one-half to 1 inch of clay near the bottom. The cannel layer is not shown in the sections given in fig. 6, but occurs near the middle of the upper bench and ranges from 3 to 6 inches in thickness. It resembles splint coal rather than true cannel. Perhaps the chief value of this bed in the future will result from this band of cannel. Four inches of cannel to 2 feet of coal may be taken as a conservative average of the two grades of coal in this bed. On this basis it comprises one-sixth of the total coal and would yield about 483 tons per acre, assuming the specific gravity of 1.194 determined by Mr. Hislop. It separates fairly readily from the bituminous coal above and below and breaks out in large blocks.

The coal, as a whole, is moderately lustrous, with yellowish brown streaks. The cleavage is laminated with cross fracture, angular to

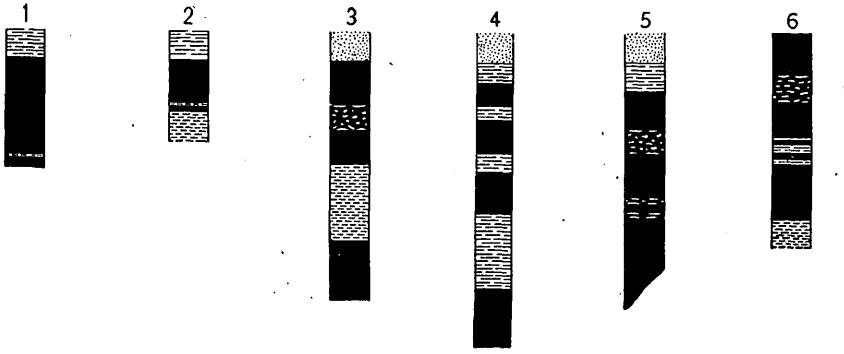


FIG. 6.—Sections of lower Pottsville coals in Big Sandy district. 1, "Little Cannel" coal, north of Torchlight; 2, "Little Cannel" coal, south of Torchlight; 3, Hiram Blackburn, Left Fork Little Blaine Creek; 4, John R. Pack, Right Fork Little Blaine Creek; 5, Mary Hayes, Right Fork Little Blaine Creek; 6, E. G. McInster, Right Fork Little Blaine Creek. Scale, 1 inch = 5 feet.

subconchoidal. On the fire it intumesces and agglomerates. Analyses are as follows:

Analyses of "Little Cannel" coal from Levisa Fork.

	1.	2.
Water	2.25	2.70
Volatile matter	54.95	45.61
Fixed carbon	39.35	47.17
Ash	2.95	3.90
Sulphur	.50	.62

1. Department of mines and metallurgy, World's Columbian Exposition, analyst.
2. George R. Hislop, Paisley Gas Works, analyst.

George R. Hislop, of the Paisley Gas Works, who has made a rather exhaustive test of this coal and has also studied the resulting gases, reports that "this is an excellent cannel coal. It is easily distilled, yields a large volume of 34.20 candle gas, and affords at the

same time 10.25 hundredweight per ton of excellent residual coke. The foul gas contains a moderate percentage of impurities. Compared with main Lesmahagow cannel coal taken as 100, calculated on the basis of 13,000 cubic feet of gas and 1,535.5 pounds of sperm per ton, and having regard for the secondary products and the cost of purification of the gas, this coal is equal to 107.48."[a]

TRANSPORTATION FACILITIES.

Transportation facilities in the Big Sandy Valley district are furnished at present by the Chesapeake and Ohio Railway along Levisa Fork in Kentucky and by the recently completed Norfolk and Western Railway along Tug Fork in West Virginia. The line of the Chesapeake and Ohio Railway was formerly up Threemile Creek after crossing Levisa Fork at Walbridge, and the roadbed of this old line, from which the steel was removed about fifteen years ago, is still in fair condition for a spur track from the main line at Walbridge, should the developments on Threemile Creek warrant its construction. In addition much of the Big Sandy region is readily accessible by water. The improvements along the river projected by the Federal Government, which are now partly completed, are expected to provide navigable depths many miles south of the limits of this quadrangle and to provide a navigable season through the entire year instead of six months, which is now the average. The facilities for cheap transportation that will be offered when these improvements are completed are so obvious as to need no comment here.[b]

CHESAPEAKE AND OHIO RAILWAY DISTRICT.

EXTENT.

The district tributary to the Chesapeake and Ohio Railway includes nearly the whole of Boyd County, together with small parts of Greenup, Carter, and Lawrence counties, Ky. Its eastern boundary has already been described as the ridge separating the waters of Big Sandy and East Fork. The ridge separating the waters of Little Sandy River and East Fork of Little Sandy has been chosen as its western boundary. On the south it is limited by the ridge south of Straight Creek and the headwaters of East Fork. This district includes all the operations along the Ashland Coal and Iron Railway as far south as Straight Creek.

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[a] Compare other cannel coals on pp. 88–92.

[b] See Survey of Big Sandy River, West Virginia and Kentucky, including Levisa and Tug Forks: House Doc. No. 326, 56th Cong., 1st sess.

GEOLOGY.

The rocks in this district are comprised in the Pottsville, Allegheny, and Conemaugh formations. The highest beds belong to the Conemaugh. This formation is not represented in its entirety at any point west of Big Sandy River, so far as known. The eastward dips which cause the lower beds to cover most of the surface west of the Ashland Coal and Iron Railway bring the Conemaugh beds lower and lower in the hills toward Big Sandy River. They are the only surface rocks in the southeastern part of this district, where they have a thickness of 300 to 400 feet. At the base of this formation is a rather massive sandstone, well shown west of Alley in the hills bordering Pigeonroost Creek. Above the sandstone, at varying distances, but rarely exceeding 40 feet and usually less, occurs a fossiliferous limestone, one of the Cambridge beds, which is closely overlain by another massive sandstone. Thus the lower hundred feet of the formation is usually sandy and is accordingly comparable with the lower part of the Conemaugh at the mouth of Big Sandy River. Though here and there the upper part of the formation contains massive sandstone, it is shaly for the most part, the shales being reddish and purplish, with local green layers. Many of these shaly members would be of value were they situated near lines of transportation. No commercial coals are known in this formation.

The Allegheny formation in this district has a thickness averaging from nearly 180 to 200 feet. The general section (Pl. IV, p. 28) illustrates well the number and relations of the coal and clay beds in this formation. About Ashland its basal portion is very sandy and comparable with the lower part of the Allegheny in Ohio. (See section, pp. 30–31.) Farther south the massive phase of the sandstone, at least above the Winslow coal bed, seems to change to a more thinly bedded or shaly sandstone, the remainder of the interval between the Winslow and Coalton coals being shaly. The Coalton coal is usually overlain by a massive sandstone above which is a thin red or purple shale bed, well exposed on the county road east of Summit. From the top of the sandstone overlying the Coalton coal to the base of the Mahoning sandstone the beds are prevailingly shaly in character, and include the Hatcher and Zelda coal beds.

The materials of most economic importance in this group of rocks are coal, fire clay, and iron ore. In most places the valuable coal beds are confined to the lower half of the formation, but in a few localities the higher coals are workable. Not more than three distinct workable coal beds were seen, and in most places only two coals are of workable thickness. A valuable bed of fire clay occurs well toward the base of the formation associated with the Vanport ("Hanging

Rock") limestone, and this limestone is overlain in many places by a bed of iron ore, which in the early seventies was greatly esteemed and extensively mined by stripping. Between the Winslow and Coalton coal beds, about 20 to 25 feet above the latter, is found a kidney iron ore which about thirty years ago was worked to some extent, and about 25 feet above the Coalton coal is another horizon of kidney ore.

In a general way the rocks of this formation cover the surface of the district in a zone conforming in trend with the structure contours—that is, northeast and southwest. West of the Ashland Coal and Iron Railway the Allegheny is present in the tops of the hills, but east of the railroad the dips cause the formation to occupy a lower and lower position in the hills and to disappear well up toward the head of East Fork and Straight Creek. In the northwestern part of the district they cover most of the surface, but in the southeastern part they are entirely below drainage level.

The lowest beds in this district are exposed along East Fork of Little Sandy River, in the northwestern part of the district. Here are Pottsville rocks at least 260 feet thick. To the east, approaching the center of the basin, the Pottsville gradually descends below drainage level, and except along Ohio River the territory covered by it east of the Ashland Coal and Iron Railway is very small. West of the Ashland Coal and Iron Railway, in the hills dividing Little Sandy from East Fork the Pottsville reaches well up to the hilltops, and its rocks are conspicuous on the surface. The formation is prevailingly sandy, but perhaps not quite so much as in the region along Tug and Levisa forks. The top member, the Homewood sandstone, maintains its usual prominence in most parts of this district. Along Ohio River near Ashland, and to the southeast, near Cliffside Park, this member is unusually massive, attaining in some places a thickness of 75 feet. It is a question whether all this sandstone is really of Homewood age, for west of Ashland it apparently forms one massive cliff reaching to the base of the fire clay at the horizon of the Vanport ("Hanging Rock") limestone. It is quite possible, therefore, that the upper part of this member may be of Allegheny and not Pottsville age. Though the Homewood sandstone in this district is generally massive, south of Princess and near Coalton and Rush it dwindles to a shaly sandstone, never exceeding and rarely reaching a thickness of 10 feet. Taken as a whole, it is, however, the most prominent bed in the Pottsville in this district. The underlying beds are prevailingly sandy, chiefly sandy shales and shaly sandstones, becoming in places prominent cliff makers.

The number of coal beds in these rocks is not definitely known. It is probable that there are more than have heretofore been recognized. Near Princess tunnel, for instance, a section was measured from the road corner near the store of the Princess Land and Mining Company

to the highest exposed rock above the tunnel, and in this section four coal beds showed within a distance of 70 feet below the top of the Homewood sandstone. On the road ascending the hill, a few rods northwest, G. H. Ashley measured another section to the top of the hill, which showed the coal beds at the top of the Pottsville and also some of those in the Allegheny. This section is as follows:

Section near Princess tunnel.

Top of hill.	Ft.	in.
Sandstone, shaly	8	
Sandstone, shaly, calcareous	2	
Shale, olive	6	
Sandstone, hard	2	
Shale, olive	6	
Streak of dark shale.		
Clay, drab	2	
Iron ore	1	
Shale, olive	6	
Coal (No. 8)		2+
Clay, light drab	2	
Shale, olive, and sandstone	12	
Shale, olive	12	
Iron-ore nodules		8
Clay, drab, or shale	4	
Sandstone, olive, shaly	7	
Coal (No. 7)	1	3
Shale, drab	3	
Shale, sandy, and shaly sandstone	15	
Iron ore, red		6
Shale, olive	5	
Sandstone, hard massive	15	
Coal	1	9
Clay, drab	3	
Coal		½
Clay, drab flint		6
Clay, black carbonaceous flint		0–2
Clay, light drab, sandy at base	7	
Sandstone, green and white, fine-grained (Homewood—top of Pottsville)	8	
Shale, olive, and fire clay	4	
Iron ore		6
Shale, drab	6	
Coal		5
Clay		2
Coal		5
Clay, light drab	3	
Shale, dark drab		6
Clay, dark drab to black	1	
Clay, drab	2	
Sandstone, thin-bedded, shaly	12	
Shale, sandy	5	
Coal		1½

	Ft.	in.
Shale, reddish brown		1–4
Coal		2
Flinty lentil		0–2
Coal	1	
Clay		9
Coal		6
Fire clay, light drab, sandy	4	
Coal		5
Clay		1
Coal		3
Shale, sandy and drab fire clay	6	
Shale, sandy	12	
Sandstone	15	

The following section, compiled from barometric measurements along the northern edge of the area from Argillite eastward to Hood Creek, gives a general idea of the character of the Pottsville rocks and shows also the position of the workable coals:

Section from Argillite to Hood Creek.

	Ft.	in.
Sandstone, Homewood	30	
Coal, workable in places.		
Sandstone, shaly	20–40	
Coal.		
Sandstone	6	
Coal		2–3
Sandstone	6	
Coal (No. 3), workable in places.		
Sandstone, massive	10	
Concealed	15±	
Coal		5
Fire clay	4	8
Shale and massive sandstone	35	
Coal, workable.		
Probably sandy	50	
Coal		4
Sandstone, shaly	20	
Concealed	10	
Shale, black, and fire clay	10	
Concealed	10±	
Sandstone, massive	10	
Concealed	10±	
Sandstone, massive	10	

On Catletts Creek and in the eastern part of Ashland there is an important bed of fire clay underlying the Homewood sandstone. Formerly the iron ore in this formation in this district was of considerable economic importance, notably the bed occurring 30 to 40 feet above the Danleyton coal, called by P. N. Moore "the main block ore."[a] None of the beds of iron ore of this formation are now worked.

[a] Report on the eastern coal field: Kentucky Geol. Survey, vol. C, 1884, pp. 133–138.

THE COALS.

ALLEGHENY COALS.

UPPER COALS.

The highest coal bed that has been worked in this district corresponds with coal No. 9 or the Upper Freeport coal of the Ohio section and with the Zelda coal in the Big Sandy Valley. It is not of sufficient thickness to be of any practical importance. It has been opened by Albert Baldridge near the mouth of Garner Creek and is reported to be 18 to 20 inches thick. In the road 20 feet below is the bloom of a lower bed, probably the Hatcher coal, which is not of workable thickness here.

COALTON COAL (NO. 7).

Name.—The highest important bed in this district is the Coalton coal, or No. 7 of the Kentucky reports, known also as the Sheridan and as the Ashland[a] coal, though the latter term is not used much in northeastern Kentucky. In southern Ohio this is considered the most important of all the coal beds and is known under a variety of names, according to the location where it is developed, and shows a commercial thickness. Its most common names are derived from the mining centers Nelsonville and Straitsville, along the Marietta and Cincinnati Railroad. It is also known as the Carbondale or Mineral City coal, and in Gallia and Lawrence counties the name Sheridan is applied. The name Coalton will be used in this report, for it was mined originally at Coalton and was widely known under the name of Coalton coal.

Geologic position.—The Coalton coal lies at about the middle of the Allegheny formation. As it is the highest workable coal in nearly all of the district under consideration, no great difficulty should be experienced in identifying it. It lies in most places about 35 to 45 feet above the next lower bed, the Winslow coal or No. 6 of the Kentucky Survey, and from 40 to 60 feet below the next higher or Hatcher coal, No. 8 of the Kentucky series. It will be found about 100 feet above the top of the Homewood sandstone where the Allegheny formation is normally developed and about the same distance below the base of the Mahoning sandstone. Below it at a distance of 25 feet and above it at almost the same distance there are two persistent bands of kidney ore, the lower known as the yellow kidney and the upper as the red kidney ore. These ore beds have long been used as datum planes from which to determine the position of this coal, as they are among the most persistent and reliable ore horizons in this region.

[a] Ohio Geol. Survey, vol. 3, pt. 1, 1878, p. 918.

Extent.—The outcrop of the coal will be seen from the economic map (Pl. I). Its zone is about 10 miles wide in the northern part of the district and follows the structure lines to the southwest, gradually tapering as it approaches Willard and Webbville. The rise of the beds southward and beyond these towns soon carries this bed above the hilltops. It is present in all the hills bordering Williams Creek and its tributaries, Straight Creek, and East Fork and its branches, southeast of Naples. In the Flatwoods area south of Ashland the hills do not rise quite high enough to catch it. Though present on Catletts Creek and Keyes Creek, it is doubtful whether it is so thick as in the region farther west. Its horizon is also believed to be above drainage level on Chadwick Creek. On Garner Creek it has been opened at a few country banks.

In general the western limits of the Coalton coal outcrop coincide with the boundary between Boyd and Greenup counties, and south of Greenup County follow the divide between Little Sandy River and East Fork. The points on the various creeks where it descends below drainage level toward the center of the basin are plainly shown on Pl. I.

Development.—It may be stated that over nearly all of this district where any body of the Coalton coal is found in the hills it has either been prospected or worked. Southwest of Ashland in the hills bordering Hood Creek it is prospected 40 to 50 feet above the Winslow coal. Near Winslow and Summit it has been opened on many farms, but very few of the prospects were in good condition in the summer of 1905, while the reverse was true of the underlying Winslow. In many places the two beds had been opened on the same hillside, but the higher coal had usually been abandoned first. This fact may be explained in either of two ways. The average country bank is worked for a short time, and when the workings extend far into the hill and the expense of timbering increases, as well as the danger from the roof, the farmer, unless he has an experienced miner digging for him, will abandon his bank and open in another place. Another explanation is that the lower of the two coals immediately southwest of Ashland may be superior for domestic purposes. It is a fact that on many of the farms there is only one opening on each of these two coal beds and only the lower coal is worked. At Winslow, above the Ashland Coal and Mining Company's No. 8 mine on the Winslow coal, the upper or Coalton bed was opened but afterward abandoned. It is reported as too "pockety" to be worked with profit.

This coal bed has been opened at many points on Shope Creek near Clinton furnace. It disappears below drainage level at the point where the Catletts Creek road joins the Shope Creek road. Along East Fork of Little Sandy it has been opened on numerous

farms about Mavity and Cannonsburg. On Garner, Pigeonroost, Fourmile, and both branches of Trace Creek, and, in fact, on all the creeks flowing into East Fork, east of the Chesapeake and Ohio Railway and north of Garner and Alley, many openings have been made on this bed.

The commercial operations naturally have been confined to the territory lying close to the Chesapeake and Ohio Railway. With the exception of a little work done by the Ashland Iron and Mining Company at Winslow, now abandoned, operations on this bed begin at Princess and extend as far to the south as Willard. The names of companies working the coal at present are given on the margin of the economic map (Pl. I). With a few exceptions the operations are mostly on a small scale. The most important group of mines are those belonging to the Ashland Iron and Mining Company, situated near Rush, in both Boyd and Carter counties. Some of these are worked by the company and others are worked under lease. The Straight Creek Mining Company is another large producer, as are also the Princess Land and Mining Company, the Eastern Kentucky Railroad, John Wurts, and the Adkins Coal Company. The remaining operations are small and at the time of the writer's visit in 1905 some of them were closed. In some of the mines pillars were being drawn, indicating a nearly exhausted condition. The mines along the Chesapeake and Ohio Railway from Princess to Rush have been worked many years and large quantities of coal have been shipped. Most of the coal above drainage level and conveniently situated for exploitation has been removed, and the present operations are largely remnants of what were once very much larger and important mines. In some of the hills the coal is reported as completely exhausted.

Physical aspects.—A series of 25 sections (fig. 7) of the coal bed in this district will give a fair idea of the thickness of this bed. It will be observed that the coal occurs usually in either two or three benches, but in a few places, as at the mines of the Ashland Iron and Mining Company on Rush Creek, four benches were observed (section 10). Most of the measurements made in this district and to the southwest about Willard, Carter County, indicate that more commonly there are three benches. These benches are separated by bone or clay partings. The upper parting generally ranges from 1 to 5 inches and rarely exceeds 1 foot in thickness. In most places the lower parting is bone from one-half inch to 2 inches thick. About Rush this parting is clayey in character and thin. On Mile Branch the thin clay stratum observed above the two benches is of interest as pointing to conditions of deposition similar to those observed elsewhere, but changing after this clay was deposited, with the result that shale was laid down instead of coal.

As a general rule the upper bench is not mined. This is due to two or more causes—first, this bench is variable in thickness, and, second, it is liable to contain much sulphur and bone. The latter condi-

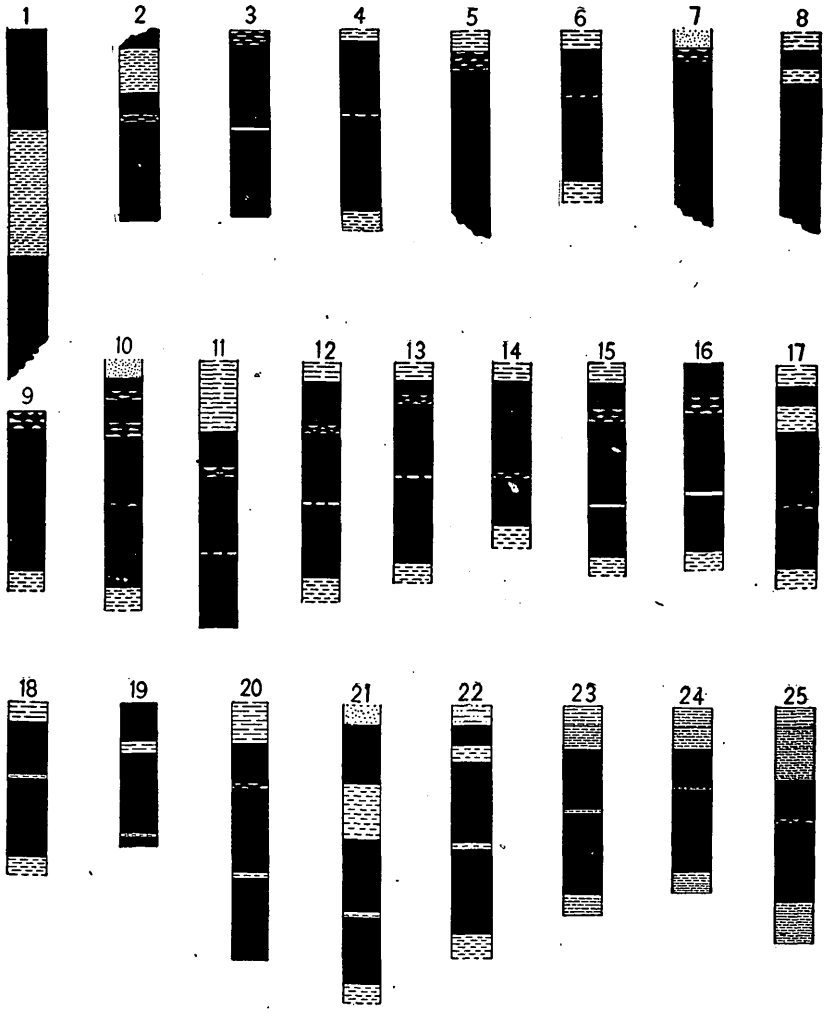


FIG. 7.—Sections of Coalton coal (Kentucky No. 7) in Chesapeake and Ohio Railway district. 1, Hills southwest of Ashland; 2, near Summit; 3, Princess Land and Mining Company, Princess; 4, Richard Jauchius, east flank of ridge between Mavity and Coalton; 5, east of Coalton; 6, Mavity; 7, 8, W. V. Sexton, head of Pigeonroost Creek; 9, James Sexton, Pigeonroost Creek; 10, Ashland Iron and Mining Company, head of Rush Creek; 11, 12, George Hull, Rush Creek; 13, John Runyon, North Fork Trace Creek; 14, Equilly Conley, west of Bellefont; 15, Straight Creek Mining Company, Straight Creek; 16, W. P. Clay, Straight Creek; 17, Morning Glory Coal Company, Grant; 18, Alex McAlvin, Cobb Fork; 19, Norton Branch Coal Company, Sandy Shoal mine (Ashley); 20, Adkins Coal Company, Rush; 21, Ashland Iron and Mining Company, No. 10; 22, Ashland Iron and Mining Company, No. 1; 23, Mile Branch, northwest of Kilgore; 24, Ashland Iron and Mining Company, No. 2; 25, Mile Branch, 1 mile northwest of Kilgore. Scale, 1 inch = 5 feet.

tion seems to prevail at the openings about Straight Creek and Denton. Though it varies greatly from point to point, it seems to be of

workable thickness in some localities, as at the George Hull mines on Rush Creek (sections 11 and 12, fig. 7). A fair thickness of the upper bench was measured in the mine of the Straight Creek Coal Company and at the opening worked by W. P. Clay about a mile farther north near the Straight Creek Coal Company's tunnel, but in this locality the upper bench is too heavily impregnated with sulphur to be marketable (sections 12, 15, and 16, fig. 7). At the Morning Glory Company's mine near Grant it is of workable thickness but so variable that little dependence can be placed on it. In this mine 26 inches of coal were measured at one point and at others it is not present. A similar condition was observed by G. H. Ashley on Mile Branch. At most of the other openings visited the upper bench is too thin to be worked. The two lower benches are almost always workable, but even this statement needs some qualification. For example, a measurement on this bed in the hills southwest of Summit gave a thickness of 6 inches to the upper of these two benches and on Mile Branch two measurements by Mr. Ashley show 1 foot of coal at two different points. Exceptional thinning was also noted in the main lower bench, as indicated by the measurements obtained at the Sandy Shoal mine near Rush, where it is only 2 inches thick (section 19, fig. 7). These exceptional figures for the two lower benches of this bed do not destroy the value of the general statement that these benches are usually of workable thickness. They are mined together, the bony parting being separated by hand. They average very close to 20 inches each, the lower being usually slightly thicker than the other. The two benches range collectively from about 3 feet 3 inches to 4 feet, a fair figure for the bed as a whole being about 3 feet 6 inches, not counting the bony parting. As much as 4 feet 9 inches of coal has been seen, though this figure must be regarded as altogether exceptional. No average minimum thickness can be given, for the coal varies from the figures given above to a mere knife-edge and in places completely pinches out. In the description of the general geology of this district a mass of sandstone was described as usually overlying the coal. As a rule it does not immediately overlie the coal, but where it does the coal suffers and at some places may be reduced to only a few inches in thickness. The operations on this bed near Coalton have long since been suspended and a measurement in the hills to the east was obtained at a small roadside bank (fig. 7, section 5). This measurement indicates a possible coalescence in the two lower or main benches. A similar condition of affairs was observed at the country banks of James and W. V. Sexton at the head of Pigeonroost Creek (fig. 7, sections 7 and 9).

The roof of a coal, though not a part of the bed itself in the strict sense of the word, is nevertheless of great importance, for on its

character may depend the margin of profit that justifies the mining of the coal. The roof of the Coalton bed is usually shale and is considered to be fairly strong. It ranges in thickness from a few inches to as many feet. In some places this shale is sandy; in others it is replaced by a massive sandstone, the coal in many such places being very thin. At the George Hull's opening near the head of Rush Creek a few feet of cannel shale were seen above the coal. The cannel shale was also observed at an opening owned by John Runyon on North Fork of Trace Creek. This shale sometimes scales off or "draws" and gives more or less trouble in the entries, but in the rooms little or no difficulty was reported from this source. The floor of the coal is apt to roll somewhat, but this is not common. Faulting is rare and where present is very slight. Small faults with a throw of 18 inches were reported near Rush at the Ashland Iron and Mining Company's opening No. 10. The superintendent of the mine reported that the largest fault known to him in the region around Rush was one near Star Furnace, with a throw of 6 feet.

Chemical aspects.—The coal itself is bituminous, but the two workable benches are not exactly alike. The upper bench is soft and lustrous and breaks into thin blocks or slabs along charcoal layers, a characteristic very common among the coals of this region. The lower bench is much harder as a rule than the upper bench and contains dull bands of splint coal. This coal is not gaseous. It is a dry-burning, noncoking coal now widely used in this part of the State for steaming and domestic purposes, and in the last three decades it has acquired an enviable reputation as an iron-making coal, being still used in the raw state for this purpose by the Ashland Iron and Mining Company at its furnace in Ashland. Its application to iron making began in 1866, when it became evident that the timber supplies which had furnished charcoal for the numerous furnaces situated in the Hanging Rock region were on the wane. Its use has continued down to the present time, naturally decreasing as many of the furnaces shut down on account of the high cost of mining the iron ore of this region as compared with the cost of Lake Superior and Alabama iron ores.

The analyses of this coal show a rather high percentage of sulphur for an iron-making coal. The coal mined along Williams Creek near Rush by the Ashland Iron and Mining Company was formerly washed and coked before using, but since the company's washer in Ashland was destroyed the coal is used raw. The ash is somewhat variable, but in the amounts of volatile combustible matter and fixed carbon the coal shows a very uniform character, as will be seen from the following seventeen analyses:

Analyses of Coalton coal from northeastern Kentucky.

	1.	2.	3.	4.	5.	6.	7.	8.
Water	4.80	5.00	4.06	4.40	3.30	7.70	6.40	6.60
Volatile combustible matter	34.20	34.50	34.24	31.10	33.30	28.16	27.22	34.36
Fixed carbon	54.90	55.40	54.70	57.90	57.60	53.04	58.88	54.64
Ash	6.10	5.10	7.00	6.60	5.80	11.10	7.50	4.40
Sulphur	1.31	1.29	1.85	2.10	2.48	1.06	.97	.72
Coke	61.00	60.50	61.70	64.50	63.40	64.14	66.38	59.04

	9.	10.	11.	12.	13.	14.	15.	16.	17.
Water	6.06	6.40	4.40	3.20					5.19
Volatile combustible matter	32.94	31.40	38.00	35.06	35.20	39.90	38.40	42.51	32.87
Fixed carbon	54.80	57.66	52.86	54.40	43.30	53.30	54.75	52.06	55.57
Ash	6.20	4.54	9.14	7.34	21.50	6.80	6.85	5.43	6.57
Sulphur	1.87	1.67	2.20	2.63	1.30	2.05	2.05	1.32	1.68
Coke	61.00	62.20	62.00	61.74					62.30

1. Average sample of coal from stock house at Ashland furnace, representing coal as actually used in the furnace. Sampled by P. N. Moore.

2–5. From rooms in mine No. 4 of Ashland Coal Company near Coalton, Boyd County, Sampled by P. N. Moore.

6–8. From the upper, middle, and lower benches of the coal bed at the old Star Furnace mines above the furnace near the mouth of Rachel Branch, west of Kilgore. The samples were taken from the pillars which had been exposed for some time and probably contained less sulphur than the freshly broken coal. Sampled by A. R. Crandall.

9 and 10. From the upper and lower benches of the coal, here consisting of but two members, at an opening on Gum Branch of Straight Creek, Mount Savage Furnace property, Carter County. These samples were selected from coal on the dump and hence are probably not so nearly representative as those taken in the mines. Sampled by P. N. Moore.

11. From the old Watson drift on Lost Creek, near Willard, Carter County. Sampled by P. N. Moore.

12. From several rooms in the mine west of Dry Fork at Willard, Carter County, main entry. Sampled by P. N. Moore.

13–16. Analyses furnished by the superintendent of the furnaces of the Ashland Iron and Mining Company at Ashland; owing to their incomplete character they are not so good as the other analyses.

17. Average of first twelve analyses.

As will be seen, most of the analyses are of coals collected by P. N. Moore and A. R. Crandall and published in the report of the Kentucky Geological Survey on the eastern coal field (vol. C, p. 181). These samples were collected by "cutting a large number of pieces of coal from the whole thickness of the bed, taking them in regular succession from top to bottom, thus representing the coal exactly as it appears at the place of sampling. Slight partings of pyritous bands, large enough to be rejected in mining, were not of course represented in the sample, but otherwise impurities were taken if they occurred at the place of cutting. Wherever possible the sample was taken from a number of rooms in each mine, or, where the coal was not opened, from as many outcrops as possible. The constant endeavor has been to secure samples representing the coal as it actually occurs in the mines." The analyses of these samples were made by Robert Peter and Mr. Talbutt, of the Kentucky Geological Survey.

Some striking facts are brought out by the foregoing figures. The main feature is the remarkable uniformity displayed over the broad area from which the samples were collected, indicating care on the part of the samplers and uniformity in the methods employed.

The average of Peter's and Talbutt's analyses is given in column 17 and shows how slightly most of the analyses deviate from the average. The figure for ash, given in analysis 6, is of interest and corroborates a statement made earlier in this bulletin as to the bony character of the topmost of the three benches. It is this bony character in conjunction with its high sulphur content that stands in the way of its exploitation even where it is of workable thickness. The content of sulphur at first sight seems rather high for an iron-making coal. If all this sulphur went into the iron it would perhaps spoil the product, but figures indicating the amount of sulphur in all the raw materials used in the charges as well as in the pig iron are necessary to indicate the way in which this constituent is distributed in the slag and pig.

The coal is not an iron-making coal through its entire extent, but only at certain localities, and even in a given mine the variation in the impurities may be such that only certain rooms or entries can be worked for furnace coal.

This bed has been regarded as the equivalent of the Hocking Valley coal of Ohio, of which Orton says[a] that "as a furnace coal it is not surpassed in the State and scarcely by any known bituminous coal." A comparison, therefore, between the Coalton coal of Kentucky and the Hocking Valley coal of Ohio and other coals which in the past have been used in the raw state in the blast furnace may have some interest. The following analyses represent coals which according to Moore have been applied for such use in Ohio, Indiana, and Illinois:

Analyses of iron-making coals from the east-central coal field.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Water	5.19	5.93	5.64	6.22	8.57	4.96	6.21	13.82	6.49
Volatile combustible matter	32.87	36.48	36.51	32.55	32.70	34.62	34.29	35.16	41.88
Fixed carbon	55.57	52.41	52.21	56.57	55.43	56.03	54.78	49.96	46.45
Ash	6.57	5.13	5.73	4.66	3.30	4.39	4.72	1.06	5.18
Sulphur	1.68	1.09	1.57	.95	.47	.62	.62	1.47	2.93

1. Average of twelve analyses of Coalton coal in northeastern Kentucky.
2. Average of ten mines of the Hocking Valley. Ohio Geol. Survey, vol. 5, 1884, p. 924. N. W. Lord, analyst.
3. Average of upper, lower, and middle benches of the Nelsonville, Ohio, bed. Ohio Geol. Survey, vol. 5, 1884, p. 975. N. W. Lord, analyst.
4. Average of eighteen samples from the great bed in the immediate valley of the Hocking and about Straitsville. Ohio Geol. Survey, vol. 3, p. 683.
5. Jackson Shaft coal, Jackson County, Ohio. Ohio Geol. Survey, vol. 5, 1884, p. 1015. N. W. Lord, analyst.
6 and 7. Lump coal from bed No. 1, Schmidgall Coal Company, Murphysboro, Jackson County, Ill. Composition and character of Illinois coals; Illinois Geol. Survey, Bull. No. 3, p. 70. S. W. Parr, analyst.
8. Brazil block coal from No. 1 shaft, Brazil Block Coal Company, Clay County, Ind. Twenty-first Ann. Rept. Indiana Dept. Geol. Nat. Res., 1896, p. 106. W. A. Noyes, analyst.
9. Brazil block coal from No. 3 shaft, Brazil Block Coal Company, Parke County, Ind. Twenty-first Ann. Rept. Indiana Dept. Geol. Nat. Res., 1896, p. 186. W. A. Noyes, analyst.

[a] Ohio Geol. Survey, vol. 5, 1884, p. 923.

These analyses of Ohio, Indiana, and Illinois coals show a fairly close agreement with the average analysis of the twelve samples of the Coalton coal of northeastern Kentucky. The figures for volatile combustible matter and fixed carbon are exceptionally close; the ash, moisture, and sulphur show considerable variation. The above analyses, taken from the various State reports, may be compared with analyses of samples collected by P. N. Moore and A. R. Crandall from the same beds in the different States mentioned. The mode of sampling was the same as that followed in the Kentucky field, and on account of this uniformity in sampling the results of the analyses given on page 71 and those which follow are really more strictly comparable:

Analyses of iron-making coals from the east-central coal field.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Water	5.19	3.26	3.74	4.40	4.54	2.62	3.44	2.40	2.70	2.68	3.46
Volatile combustible matter	32.87	33.76	36.32	35.08	29.68	32.01	31.86	35.10	36.38	36.32	36.64
Fixed carbon	55.57	54.42	55.74	55.20	57.06	58.58	59.54	55.50	55.64	53.58	53.80
Ash	6.57	8.56	4.20	5.32	8.72	6.76	5.16	9.00	5.28	7.42	6.10
Sulphur	1.68	2.247	1.299	1.659	0.758	2.472	1.370	2.373	1.664	1.803	1.848
Coke	62.30	62.98	59.94	60.52	65.78	65.34	64.70	62.50	60.92	61.00	59.90

1. Average of twelve analyses of samples of the Coalton or No. 7 coal from northeastern Kentucky.
2, 3, and 4. Hocking Valley or Nelsonville coal, from mine near Nelsonville, Ohio. 2 is from the upper, 3 from the middle, and 4 from the lower division of coal.
5. From the well-known Jackson shaft coal of Ohio.
6 and 7. From two of the best mines in the Big Muddy coal region, near Murphysboro, Ill. Large quantities of coal from both of these mines have been used in the furnaces at South St. Louis.
8, 9, and 10. Indiana block coal, from vicinity of Brazil, Ind. Samples representing the coals from three different mines. Each sample was taken from several rooms in the same mine, so as to represent the mine as fairly as possible. These mines rank among the best of that region, and coal from all of them has been successfully used in the furnace for making iron.
11. From the Sheridan mines, Lawrence County, Ohio.
2–5 and 11 sampled by A. R. Crandall; 6–10 sampled by P. N. Moore.

The results show a surprising uniformity, and though the Kentucky coal shows a higher moisture content than the other coals, yet in other respects, especially when the amount of sulphur is considered, it compares favorably with the iron-making coals of Ohio, Indiana, and Illinois.

Amount of coal.—The question of the amount of high-grade coal which is still available is of great importance. The extent of the territory above drainage level underlain by the Coalton coal can be readily seen on the economic map (Pl. I). It should be borne in mind, however, that in the region where this coal is indicated as lying above drainage level it has been largely worked out and, as has been mentioned, most of the mines now working it are nearly in a state of exhaustion. The eastern limit of the coal above drainage level is indicated on the economic map. This coal has never been exploited beyond this line by shafts. It has been mentioned (p. 46) that in the

valley of Big Sandy River its character is such that it may never become commercially available, but all over the district now under consideration it has been justly relied on as a uniform and persistent bed. Just where the coal begins to change its character from a workable to a nonworkable bed is, of course, problematical. But it is reasonable to suppose that the change to the condition observed along Big Sandy River on the south side of the basin may be gradual and that there may prove to be a very considerable body of workable coal below drainage level on the western side of the basin. Thus far prospecting with the diamond drill has not been attempted and the eastern limits of workable coal are still in doubt. The coal will have to be worked by shafting and must be approached with the plan of working up the rise—that is, to the north or to the northwest. On account of the uncertainty connected with the exact zone of change from a commercial to a noncommercial bed, it has seemed inadvisable to make an estimate of the good coal still available. It is believed, however, that the amount is large and will repay careful prospecting with the diamond drill.

WINSLOW COAL (NO. 6).

Geologic position.—The next lower workable coal in this district is known as coal No. 6 in the Kentucky reports. It is known as the "limestone coal" in the region about Ashland, Ky., from its position as the first really important bed above the Vanport ("Hanging Rock") limestone. The names Keyes Creek and River Hill coal are also applied to it. In Ohio this bed is known as the Newcastle coal[a] and is correlated with the Lower Kittanning of Pennsylvania. It is usually found about 20 feet or more above the Vanport limestone or ore, and its distance below the Coalton is from 40 to 50 feet. About midway between the two coal beds is the red kidney iron ore. These three well-known horizons should serve to readily identify this bed of coal. Near Ashland, Ky., and Coalgrove, Ohio, the rocks associated with it are massive sandstones and all over the northeastern part of the district where this coal is workable the beds both below and above it are prevailingly sandy. The conditions under which the top of the Pottsville formation was deposited seem to have continued into early Allegheny time.

Extent.—The outcrop of the coal where workable has not been indicated on the map, for the Winslow lies so close below the Coalton coal that the representations of the two would be well-nigh indistinguishable. The Winslow outcrops in the northern part of Boyd County, where it is extensively mined and used. Outside of this part of the quadrangle the coal, so far as known, is not workable

[a] Ohio Geol. Survey, vol. 5, 1884, p. 122.

over any great area. It is particularly important about the city of Ashland. Along Little Hood Creek it is present in the hills on both sides, and near Pollard, Oakview, Winslow, and Summit there are openings on nearly every farm. On account of its development about Ashland it was thought that the name "Ashland coal" might be applicable, but the next higher workable coal, or Coalton bed, is sometimes inappropriately known by that name. The name "Winslow coal" will be used in this report, as the bed is now being mined on a commercial scale at Winslow on the Chesapeake and Ohio Railway, a short distance southwest of Ashland. This bed of coal is present in all the hills between Little Hood and Catletts creeks, along Ohio River, and on Keyes Creek.

Development.—It is extensively developed in a small way in the northern part of Boyd County. In most places, however, the operations are on a small scale, most of the railroad mines apparently being closed, with the exception of mine No. 8 of the Ashland Iron and Mining Company at Winslow. About Ashland the coal is extensively mined at small banks and hauled in wagons to the city, where it supplies the local demand for fuel, and is used also by the Ashland brick plants, by the river boats, by the furnaces of the Ashland Iron and Mining Company for generating steam, and in other ways up and down Ohio River. It is highly regarded as a steaming coal and retails in Ashland and Catlettsburg at 8 or 9 cents a bushel.

Character.—The Ohio reports state[a] that coal from this bed has furnished the entire supply of Ironton for manufacturing and domestic purposes and that upon the mines of this bed all the manufacturing interests of Ironton have been built. This is very high praise for a bed of coal. The section of this bed, together with the quality of the coal around Ironton, are strictly comparable with similar features of the coal at Ashland. The two towns lie within sight of one another. The accompanying sections (fig. 8) give a fair idea of the thickness of the coal.

From the sections it will be observed that the coal usually occurs in three benches, the upper two separated generally by a thin bone parting, rarely more than 1½ inches thick. These top benches without the bone parting range in the aggregate from 2½ to 3 feet in thickness. They are separated from the lower bench by a clay or shale layer 3 to 8 inches thick. The lower bench is from 6 inches to 2 feet thick and is usually worked. The roof of the coal is sandstone, though in places between the top of the coal and the base of the overlying sandstone a few inches of dark shale is present. The sandstone locally thickens up and replaces the coal completely, and rolls of a few square feet in area are not uncommon. Some slight faults are reported. The floor of the coal is usually clay. The coal

[a] Ohio Geol. Survey, vol. 5, 1884, p. 1044.

in the upper two benches is splinty and harder than that in the lower bench, which crushes badly in the pillars. Like the other coals in the district, the upper two benches readily break into blocks or slabs 6 inches or more thick. The coal should be classed, therefore, as a semiblock coal. It is not a good coking coal, but after being washed has been made into coke by the Ashland Iron and Mining Company and used in the furnaces in Ashland. The coke is apt to be soft and spongy and contains a rather high percentage of sulphur. The results obtained, however, when mixed with a small amount of Pocahontas coke were satisfactory, and a very good coke was made by mixing it with a small amount of Kanawha coal and coking the mixture. Like all the coals in this district, it bears stocking and transportation well.

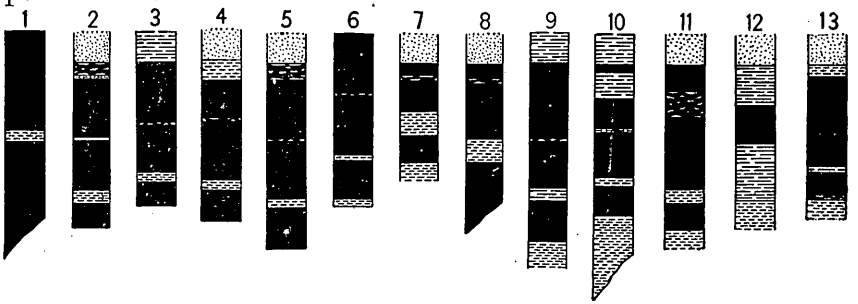


FIG. 8.—Sections of Winslow coal (Kentucky No. 6) in northern part of Boyd County. 1, 2, County road one-half mile east of Winslow; 3, Ashland Iron and Mining Company, William Wurtz, lessee, near Winslow; 4, Mrs. George McKnight, three-fourths mile north of Winslow; 5, Nancy McKnight, three-fourths mile northeast of Winslow; 6, Ashland Iron and Mining Company, No. 8, Winslow; 7, J. M. Ferguson, south of Ashland; 8, James Patten, Keyes Creek; 9, near Oakview (Ashley); 10, John Gerard, near Oakview (Ashley); 11, in hills west of Ashland; 12, Rush; 13, Newcastle coal, Ohio, section at Newcastle. Ohio Geol. Survey, vol. 5, 1884, p. 1044. Scale, 1 inch = 5 feet.

Analyses of Winslow coal.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Moisture			5.19	3.40	2.94	2.70	4.04	3.65		
Volatile matter	43.52	42.95	41.86	32.30	32.50	36.70	33.60	36.59	40.17	2.97
Fixed carbon	50.54	52.10	47.69	55.40	56.70	52.60	53.34	52.62	51.49	88.26
Ash	5.94	4.95	5.26	8.90	7.74	8.00	9.00	7.11	8.34	8.77
Sulphur	1.83	2.54	1.40	1.23	1.97	1.71	1.31	1.71	1.57	1.24

1. Mine No. 12 of the Ashland Iron and Mining Company near Winslow, Ky.
2. West of Ashland.
3. Newcastle coal from tunnel mines near Ironton, Ohio. Ohio Geol. Survey, vol. 5, 1884, p. 1045. N. W. Lord, analyst.
4. Turkey Pen Hollow.
5. Keyes Creek.
6. Horse Branch.
7. Amanda furnace.
8. Average of first seven analyses.
9. Washed coal from Ashland Iron and Mining Company's No. 8 mine at Winslow.
10. Coke from No. 12.

Analyses 1, 2, 9, and 10 furnished by the Ashland Iron and Mining Company; 4, 5, 6, and 7 by Peter and Talbutt, Report on the eastern coal field: Kentucky Geol. Survey, vol. C, p. 21.

The analyses of this coal show discrepancies so great that it is difficult to say which represents the average for the region. The

analyses furnished by the Ashland Iron and Mining Company are unfortunately incomplete, but if the moisture in them is considered a part of the volatile matter some idea of the latter constituent may be had by subtracting the average moisture in these analyses where it is given from the volatile matter, in which it is apparently included. The results obtained by this process indicate a content of volatile matter between that given by Peter and Talbutt's figures and that given by Lord. Averaging these results with those given in the last five analyses, the volatile matter represented in all will average about 36.59 per cent. Other averages are given in column 8. The results are fairly characteristic of a bituminous coal of high grade. The percentages of fixed carbon and volatile matter indicate a good gas coal, but of course a coal furnishing only a second-grade coke would hardly be used for gas making. Though the coal has been washed and coked, it furnishes a nonmarketable product. Coke from this coal has never been used alone in the furnace, but always with some standard coke, like Pocahontas and Kanawha coke.

As a steam fuel the coal gives excellent satisfaction. Its average analysis, indicated in column 8, shows a very close resemblance in composition to the average analysis of the Coalton coal in this region, which is highly regarded as a steam coal. It contains less moisture than the Coalton coal, but more ash. The sulphur in the average analyses of these two coals is about the same and the volatile matter and fixed carbon in both coals are very close. In the Coalton coal the fuel ratio—that is, the quotient of the fixed carbon divided by the volatile matter—is 1.69 and in the Winslow coal this ratio is 1.43, a difference of about 0.25.

The sulphur content of the Winslow coal is rather high, but with respect to its content of moisture and the percentages of fixed carbon it compares very favorably with the good grades of bituminous coal of Ohio and Illinois. It does not rank with the best West Virginia, Pennsylvania, Kentucky, Virginia, and Arkansas coals.

Amount of coal.—This coal has been described as one of the more important beds in the southern part of Lawrence County, Ohio. It is equally important across Ohio River on the Kentucky side about Ashland. Its area of greatest development also is confined to this region. Southward about Cannonsburg and Princess this bed gradually becomes thinner, until at Rush, where the following section was obtained, the coal becomes too thin to have any commercial value whatever:

Section of Winslow coal at Rush.

	Feet.
Shale, blue, some of it light in color	1
Coal	1
Shale, black	1½
Fire clay.	

It thus appears that in the region where the Winslow coal is best developed the next overlying coal is not developed on a workable scale, and vice versa.

Coal No. 5 is reported by Crandall as having been worked near Buena Vista furnace, on Straight Creek, Boyd County, and though badly broken up by partings shows 38 to 40 inches of good coal.[a] Crandall's section at this point is as follows:

Section of No. 5 coal bed on Straight Creek.

	Inches.
Shale.	
Coal and shale.	
Shale	6
Coal	5
Shale	5
Coal	27
Shale.	

Peter and Talbutt[b] found the composition of this coal to be—

Analysis of coal No. 5 near Buena Vista furnace, on Straight Creek.

Moisture	3.20
Volatile matter	32.30
Fixed carbon	53.00
Ash	11.50
Sulphur	2.00

No openings on this coal were noted by the writer.

POTTSVILLE COALS.

A brief description of the rocks of the Pottsville formation has been given on pages 19–20, 62–64. It has been stated that the rocks of this formation are prevailingly sandy, and that associated with these sandy beds, which may be pure sandstone, sandy shale, or shaly sandstone, are three classes of economic deposits—coal, fire clay, and iron ore. In this place only the coals will be considered.

CATLETTS CREEK COAL (NO. 4).

Geologic position.—The highest coal in the Pottsville formation in this district may be called the Catletts Creek coal from the fact that it is exploited along the creek of that name. It corresponds stratigraphically with the Upper Stinson coal at Boghead and with the Lick Creek coal of the Big Sandy Valley district. Its position directly below the Homewood sandstone serves to locate it at once in the geologic column. Its distance above the next lower workable coal in this district is probably not more than 40 to 50 feet, and it lies approximately the same distance below the Vanport ("Hanging Rock") limestone in the Allegheny formation in the eastern part of Ashland, though this measurement depends largely on the varying thickness of the Homewood sandstone.

[a] Kentucky Geol. Survey, vol. C, 1884, p. 19. [b] Idem, p. 20.

Extent and development.—Although this coal outcrops over a broad area in the district, it has proved of workable thickness in very few places. Its outcrop, if drawn on the map, would come a little below that of the clay indicated by the red line.

In the eastern part of Ashland it has been prospected at numerous points on the road leading to the city cemetery. Farther up Ohio River, at the Weaver Pottery Company's plant, between Sandy City and Catlettsburg, it was formerly worked, but the bank had fallen shut at the time of the writer's visit. It is probable that this coal may be of workable thickness between this point and Ashland, although there is a possibility that it may be replaced by the massive Homewood sandstone of this region. On Catletts Creek it is workable and may be easily traced for 2 miles west of Catlettsburg to a point where it disappears below drainage level. In the valley of Hood Creek, a short distance northwest of Summit, it has been opened by William Crane, and near the mouth of Shope Creek A. J. Harris, on whose land the coal has been opened, reports 3½ feet of coal with an important fire clay below. At Music it has been opened, but is so badly broken by partings as not to be a commercial coal. So far as known, it is not workable at any other point in the district. Developments on this coal are not on a commercial scale. In all the localities described above, except at the opening of the O'Kelly Brick Company, it is worked only during the winter months for local trade.

Character.—The reason for its restricted exploitation is at once evident from its section. It is, in fact, a thin coal bed, and this character, in connection with the fire-clay parting running through the center of the bed, will probably bar it from the list of commercial coals of this district for some time to come. Both benches nowhere measure more than 2½ feet together, and the parting in the middle is in places as thick as one of the benches of the coal. It usually has an excellent roof of massive sandstone, which makes it a safe and cheap coal to work. Its clay floor is important commercially, for it it is of workable thickness and of a quality good enough to serve as a bond in refractory brick. The coal could readily be worked at a profit in connection with the fire clay, and this seems to have been understood by one firm, the O'Kelly Fire Brick Company, which mines the clay and coal in the eastern part of Ashland (fig. 9, section 3). The coal is of the lustrous bituminous variety, but contains splinty bands and is on this account rather hard. It breaks into thin slabs and hence is blocky in its nature.

TORCHLIGHT COAL (NO. 3).

Geologic position.—The next lower workable coal in this district is at a distance of 40 or 50 feet below the base of the Homewood sandstone and hence at the same distance below the Catletts Creek coal.

East of Danleyton it has been opened, together with the coals occurring below it, at a few points about 80 feet below the top of the Homewood sandstone, which, in this region, is a prominent cliff maker and can be readily traced. This is not the second coal below the base of the Homewood sandstone, as on the Hood Creek pike two small beds were observed at small distances above this coal. It is very probable, however, that it is the next main workable coal below that occurring immediately beneath the Homewood sandstone. It is also certain that this coal, which is the one opened on the lands of the Means Russell Iron Company in the valley of Hood Creek, can not be the Catletts Creek coal, for the two coal beds are found in the section exposed from the point where the main Hood Creek pike crosses Hood Creek northwest of Pollard to the Flatwoods area. It is probable that it is the equivalent of the Torchlight coal of the Big Sandy River

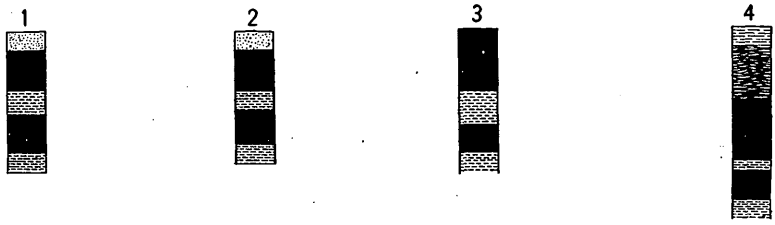


FIG. 9.—Sections of Catletts Creek (Kentucky No. 4) and Torchlight (Kentucky No. 3) coals in Boyd County. Catletts Creek coal: 1, Alex. Chapin, Catletts Creek; 2, country bank, Catletts Creek; 3, O'Kelly Brick Company, Ashland. Torchlight coal: 4, Hood Creek, west of Ashland. Scale, 1 inch = 5 feet.

region, and of the Lower Stinson coal at Boghead, and hence is No. 3 in the Kentucky series.

Extent and development.—This coal bed is present above drainage level in workable thickness over only a small part of Boyd County. Both to the east and to the south the dips carry it below drainage level. To the west and south, however, in Greenup and Carter counties, it is found above drainage level, having a wide distribution near the western limits of the quadrangle. Within this district it has been worked on only a small scale, owing to the fact that it is thin and badly broken by partings, but along Canes Creek and Stinson Creek in Greenup and Carter counties it is one of the most important cannel coals. It is present in workable thickness in the ridge separating Little Sandy River from East Fork, but on the eastern flank of the ridges it is not worked, except at a few country banks. Its outcrop, where known to be workable, is indicated on the economic map (Pl. I). The most important past development on this bed was in the valley of Hood Creek, west of the city of Ashland, directly overlying a massive sandstone. Though it has been opened in many places northwest of Pollard on the lands of the Means Russell Iron Company, all the openings have for some reason

been allowed to fall in. The section and character of the coal here are unknown. The following is a section of the bed:

Section of No. 3 coal bed of the Kentucky Geological Survey in the valley of Hood Creek, west of Ashland, Ky.

	Inches.
Shale roof.	
Coal with bony streaks	15½
Coal, bituminous, with splint bands	18
Clay	3½
Coal	9
Fire clay.	

The bank is situated so that it is often flooded at periods of high water. The above section is the only one in this district which the writer had an opportunity to measure; hence it would be unjust to base a judgment as to the character of the coal on such slight evidence. It is apparent at once that if the section is a true criterion of the bed, it has little market value at present. The upper bench, which is the main workable bench, may be all coal in many places and not largely bone as indicated. If this bony character is not widely prevalent the upper bench alone would have commercial possibilities. The parting between the two benches, in connection with the thinness of the lower bench, injures the value of this bed.

The coal in the upper bench is hard and contains splint bands, and like most of the coals in the region will bear stocking and transportation without much crumbling. On this account it is a coal which can be shipped for long distances and not suffer much in transit.

DANLEYTON COAL.

Geologic position.—The position of the Danleyton coal bed in the geologic column is very plainly indicated in the section between Argillite and Hood Creek (p. 64). It is known locally as the "clod seam," owing to a clay parting which it contains. Openings on it have been made at many places near Argillite and Danleyton, and it may be called the Danleyton coal. It occurs 110 feet below the base of the Homewood sandstone and from 30 to 40 feet below the horizon of an ore bed which must have been of considerable importance in the region, as it has been benched to a great extent. This ore has been regarded by Moore as the main block ore,[a] but its relations to the base of the Homewood indicate a lower ore. Certainly the coal opened below it is much too far below the Homewood to be regarded as the equivalent of the No. 3 or Torchlight coal.

Extent.—The Danleyton coal is present in the hills bordering East Fork of Little Sandy between Danleyton and Naples, but south of Naples it is below drainage level. Near Argillite it occurs 150

[a] Kentucky Geol. Survey, vol. C, 1884, p. 138.

feet above railroad grade, and has been opened in the surrounding hills. There is an almost continuous line of country banks on the outcrop where it is above drainage level on Culp and Henry branches, and nearly every farmer about Danleyton also has opened this coal for his private use. A short distance east of Danleyton it goes below drainage level. It has been opened near Hunnewell, on the Eastern Kentucky Railway, as described elsewhere (p. 92). At all these points the development is purely local.

Character.—The accompanying sections (fig. 10) illustrate the character of this coal. They show a striking similarity in their general features. The coal where seen is always in two benches, separated by a clay parting. Each bench ranges from less than a foot to 1½ feet in thickness. The lower 4 or 5 inches of the upper bench is in places bony. The clay parting ranges from 6 inches to more than a foot in thickness. In no place was more than 31 inches of good coal seen in both benches. The coal is of the usual bituminous variety. The upper bench is perhaps more lustrous than the lower, but

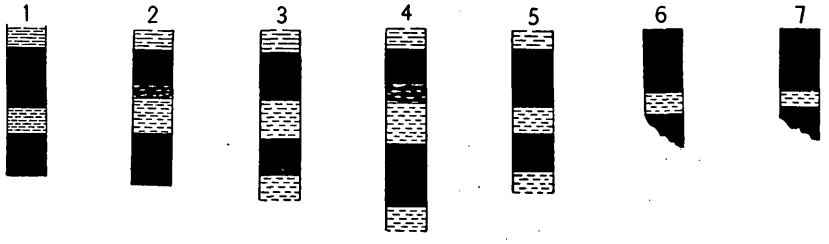


FIG. 10.—Sections of Danleyton coal. 1, Mouth of Pigott Branch; 2, J. H. Pruitt, Culp Creek; 3, mouth of Pigott Branch; 4, Henry Branch; 5, A. W. Callahan, Danleyton Church; 6, south of Danleyton; 7, Turkey Fork. Scale, 1 inch = 5 feet.

it may also be dull and splinty. The lower bench locally breaks out into blocks and contains splinty bands. The thinness of this bed and the presence of the clay parting are serious hindrances to its commercial possibilities. So long as thicker coals are prevalent in the region this bed can hardly compete with them in the trade. It is conveniently situated with respect to transportation, and in the future may be developed for shipment. It is reported to be an excellent stove and steam coal, and is widely used by the farmers.

LITTLE SANDY VALLEY OR EASTERN KENTUCKY RAILWAY DISTRICT.

EXTENT.

The Little Sandy Valley district is in the northwestern part of the Kenova quadrangle. Its eastern boundary is the ridge separating the drainage of East Fork of Little Sandy and Williams Creek from that flowing into Little Sandy River. It will be seen that this is an irregular line running southwest from the northern edge of the quadrangle to the ridge just west of Means tunnel. Southwest of

this point the boundary swings west and south to Mount Savage, thus allowing a part of the Little Sandy drainage basin to be included in the Chesapeake and Ohio Railway district. The line of the Chesapeake and Ohio Railway has been arbitrarily chosen as the southern limit of this area. The reason for the choice of these boundaries is that the district thus set apart is a unit commercially, all the coal mined in it being shipped over the Eastern Kentucky Railway, which follows Little Sandy River more or less closely till it reaches Ohio River.

GEOLOGY.

This district lies on the northwest side of the basin, which extends nearly across the quadrangle from its northeastern to its southwestern border. The beds dip southeast. It will be seen at once that from the center of the basin to the northwestern edge of this area lower and lower beds appear in the valleys. Therefore the lowest beds stratigraphically are those in the valley of Tygarts Creek.

The rocks outcropping in this district occur in both the Pennsylvanian and the Mississippian series. The former series in this district includes the Pottsville formation and a part of the Allegheny. The Mississippian series includes the Maxville limestone lying at its top and a part of the Waverly group.

The Allegheny formation is, for the most part, confined to the hills east of Little Sandy River, but its base is present in the tops of some of the highest hills between Little Sandy River and Tygarts Creek.

The next lower formation is the Pottsville. Considered from both an areal and an economic standpoint this is the most important formation of the region. Its entire thickness is represented and, since it differs so markedly from its equivalent in the Big Sandy River region, it has been thought advisable to prepare a general columnar section which will represent it in this district (Pl. IV, p. 28). It includes the rocks from the top of the Maxville limestone to the top of the Homewood sandstone, in all very nearly 400 feet. In some places it may be thicker than this, but in others its thickness may be nearer 300 feet. The prevailing character of the rocks in this formation is sandy. Lying 20 to 30 feet above the Maxville limestone occurs the lower and one of the most important sandstone members in the Pottsville—the "conglomerate rock" or "conglomerate formation" of the Kentucky Geological Survey. It is not a simple sandstone at all points; on Everman Creek a distinct black shale which locally contains coal occurs near its middle. The fossils obtained from this shale point to its equivalence with the Jackson shaft coal of Ohio and the Sharon coal of Pennsylvania. At the top of the Pottsville is another important sandstone member, the Homewood sandstone, ranging from 25 to 50 feet in thickness in this particular district, though in other parts of the area it may attain a thickness

of 100 feet or dwindle to a few feet of sandy shale. There are other important sandstones in this area; for example, below the Danleyton coal about Argillite and Hunnewell a massive sandstone 60 to 70 feet thick shows in the hills, and locally the shaly sandstones and sandy shales so characteristic of this formation assume a decidedly sandy phase, becoming, in fact, true sandstones. The deposits of chief economic interest in the Pottsville are coal, clay, and iron ore. There are at least four different coal horizons, attaining importance in different parts of the district, and if the thin beds which are used locally but which may never assume much commercial importance be counted the number is considerably increased.

The next lower member in the section is the Maxville limestone. This rock has some economic importance but does not contain any coal beds. It is very restricted in its distribution; it outcrops on Everman Creek at a few points and in the valley of Tygarts Creek. It is not over 20 or 25 feet thick.

The Waverly group underlies the Maxville limestone. Its best development in this area is in the valley of Tygarts Creek. In the hills about Warnock G. H. Ashley measured a little over 100 feet of this group, composed of shale, shaly sandstone, and sandstone. The Waverly group has been divided into several formations, the topmost of which are the Logan, 100 to 150 feet thick, and the Blackhand, 50 to 500 feet thick. There are no grounds to warrant dividing the rocks below the Maxville into more than one formation in this area. They may be regarded, therefore, as belonging to the Waverly group. They are of minor economic importance, as they contain no coal beds, clay, or iron ore within the limits of this district.

THE COALS.

ALLEGHENY COALS.

The rocks included in the Allegheny formation in this district lie chiefly east of Little Sandy River and cover only a small part of the surface. The two important coal beds in the lower half of the Allegheny—namely, the Coalton and the Winslow—are present in small areas on the divide between Little Sandy River on the west and East Fork and Williams Creek on the east. These deposits in general are rather small to be exploited commercially, though in some localities considerable coal has existed. At the head of Stinson Creek, for instance, the Coalton coal is of some importance. The remaining coal beds of the Allegheny formation, outcropping along the eastern margin of the Little Sandy River region, owing to its southeastern dip, will be worked and shipped along the Chesapeake and Ohio Railway and are considered in the description of the district tributary to that line (pp. 60–82).

POTTSVILLE COALS.

UPPER STINSON COAL (NO. 4).

Geologic position.—The highest workable coal in the Pottsville formation occurs near the base of the Homewood sandstone. It thus corresponds in position with the Lick Creek coal, south of Louisa, and the Catletts Creek coal. It is opened and worked at Boghead by the Kentucky Cannel Company, where it occurs 30 feet above the Lower Stinson coal. Strictly, then, this coal should be called coal No. 4, if we are to adhere strictly to a system of numerals for the coal beds. Both this coal and the underlying bed fall within the Mercer group of northwestern Pennsylvania.

Extent and development.—This coal has been called the "Yankee vein" near Hunnewell, and according to report has been worked near that place. It is of workable thickness over a fairly broad area. It is present and as a rule is of workable thickness in most of the hills of this district east of Little Sandy River. Workable thickness is

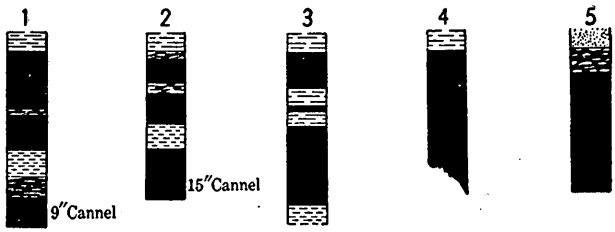


FIG. 11.—Sections of Upper Stinson coal (Kentucky No. 4). 1, 2, Kentucky Cannel Company, Boghead, Ky.; 3, Miss Drendy Jacobs, hill west of Canes Creek; 4, 5, Mount Savage. Scale, 1 inch=5 feet.

reported about Hunnewell, but its greatest thickness is to the southwest, in the hills at the head of Wilson and Upper Stinson creeks. In places it is a splint and bituminous coal, and at Boghead it contains an important cannel layer.

At the head of the smaller tributaries flowing into Wilson Creek from the east it is opened on the places of Miss Drendy Jacobs and C. G. Brammell. At an opening on Miss Jacobs's property the thickness of this bed is well shown (fig. 11, section 3). On the county road between Boghead and Seney its bloom shows, but the coal has not been opened and little is known of its thickness and character. On Lower Stinson Creek it is worked by the Kentucky Cannel Company at Boghead, and according to report the old Lexington and Carter Coal Mining Company worked the bed in the past in the hills southeast of the present openings of the Kentucky Cannel Company, shipping their coal overland to the Chesapeake and Ohio Railway at Music Still farther south, in the hills north of Mount Savage furnace, this coal has been opened and worked, though it is rather thin and badly

broken by clay partings. At some of the prospects visited at other points near Mount Savage it shows an excellent section, as seen in fig. 11 (sections 4 and 5). This coal, therefore, is present in workable thickness over considerable territory lying between the heads of Canes Creek and Straight Creek. West of Little Sandy River it is present only near the tops of the highest hills.

Character.—It will be seen from a study of the sections of this coal bed that it is very irregular in thickness. The coal at Boghead is comparable with that measured west of Canes Creek at the bank of Miss Drendy Jacobs. At both these points the bed consists of three benches, separated by either bone or black clay or shale partings. The coal in the upper bench ranges from 7½ to 11½ inches, and in places has a few inches of bone over it. The middle bench ranges from 1½ to 11 inches and is of soft bituminous coal, as is the upper bench. These two benches are separated by a parting not exceeding 6 inches thick of bone or black shale. At Boghead the coal shows a bottom bench of cannel, varying between 9 and 15 inches, and separated from the middle bench by about 6 inches of bone or clay. In most places the coal bed has a clay floor and a shale roof which requires careful timbering. West of Cane Creek the coal in the upper two benches is soft lustrous bituminous coal, as at Boghead, but the bottom bench, which measures 2 feet or more, is splinty and dull. At Mount Savage the coal appears to be irregular, showing in one place the simple section indicated in sections 4 and 5 (fig. 11), but in other places being badly broken by clay or shale partings and having a roof of shale or clay or the massive Homewood sandstone. This coal is opened at many country banks near Mount Savage.

West of Canes Creek near the Greenup-Carter county line this coal is developed in three benches; the upper two are ordinary soft lustrous bituminous coal and the lower bench is hard and splinty. Both varieties are mined for local use in the region and give excellent results when used for domestic and steam purposes. At Boghead also the upper two benches are soft ordinary lustrous bituminous coal mined in connection with the cannel but kept separated from it. The cannel from the lower bench is peculiar in structure. It is not homogeneous and compact and does not break with the conchoidal fracture characteristic of the more familiar types of cannel coal when seen in large lumps. It is irregularly bedded, or lenticular, the individual beds or lenses varying greatly in their two larger dimensions. In places the width, however, is not more than an inch. The thickness of these lenses varies; in some places they are from a quarter to a half inch thick, but elsewhere they are exceedingly thin. Along the bedding planes are flecks of lustrous material. These may be due

(1) to material of different composition originally or (2) to material which may possibly have undergone less physical change (maceration) before consolidation, or (3) some of these patches may be slickensided surfaces or planes of movement, suggesting the possibility that the structure of the rock may be secondary and due to movement after the coal had been deposited. When examined closely the material composing the lenses is seen to be typical cannel in every way, having the dull appearance of more massive cannel coal, breaking with conchoidal fracture, and being homogeneous and compact, all on a small scale. With the exception of the small lustrous patches and its structure when viewed in large-sized fragments, it is like more massive cannel coal. The coal mined from this bench is kept separate from the bituminous coal of the same bed and, with the cannel from the next lower bed, is shipped abroad, where it is used chiefly as a gas enricher, being very high in volatile matter and fairly low in fixed carbon and moisture.

LOWER STINSON COAL (KENTUCKY NO. 3).

Extent.—The next lower workable coal in the Pottsville formation occurs 30 feet below that just described. Thus, were the numbers applied to coals which are workable locally, this would really be No. 3 in the series. This is probably equivalent to the Hunnewell cannel coal. In the past it was extensively worked in the vicinity of Hunnewell furnace and the cannel in it was said to range in thickness from 3 to 4 feet. It is present in all the hills in this district east of Little Sandy River, becoming higher in the hills toward the west. North of Turkey Fork it seems to lose its cannel bench, but south of this stream it is worked by the Kentucky Cannel Company near Hunnewell for the cannel it contains. At the head of Canes Creek its bloom shows at several points along the road, but little prospecting has been done on it and not much is known of its character. Its most important area in this district, and, indeed, in the entire western part of the whole quadrangle, is the irregular square included between Lower Stinson Creek on the north, the limits of this district on the east, the Chesapeake and Ohio Railway on the south, and Little Sandy River on the west. In this area it is fairly uniform in thickness, though it varies somewhat in physical character. At Boghead it is worked by the Kentucky Cannel Company on a commercial scale, chiefly for its cannel bench, which occurs near the middle of the bed. On the waters of Upper Stinson Creek it has been opened at numerous points. West of this creek and between it and Little Sandy River the coal bed seems to lose its cannel bench at most points and to consist of two benches of ordinary bituminous and splint coal. In the hills about Robin Run and the small tributaries

of Little Sandy River southeast of Grayson it has been opened at many points and in every place is of fair workable thickness. The persons on whose land the coal is worked and where measurements were obtained are named on page 89. Most of the hills west of Little Sandy River rise high enough to contain this coal bed, but at the time of the writer's visit apparently very little prospecting had been done on the bed in this region and its identity with the coal described southeast of Grayson could not be established with any great degree of certainty. What is considered the equivalent of the Lower Stinson coal has been opened on Barrett Creek and Everman Creek and contains some cannel coal in both benches, as indicated in the section obtained on the land of David Childers (fig. 12, section 12). North of Everman this coal is present over broad areas in the hills bordering Claylick, Oldtown, Lost, and Canes creeks and Fall Branch, but at no points were any openings in such condition as to enable the writer to measure or study the coal in detail. Near the mouths of these creeks the coal will be found between 200 and 300 feet above the bottom lands. Crandall[a] states that in the neighborhood of Raccoon, Buffalo, and Laurel furnaces, which are located in or near the northwest corner of this district on Raccoon, Claylick, and Oldtown creeks, respectively, this coal is present and usually 3 feet thick. There seems to be no reason why it should not be present in workable thickness over a considerable area west of Little Sandy River.

Character.—The sections in fig. 12 give an idea of the thickness of this coal and the number and character of its partings.

As will be seen from the sections the coal in some places consists of two and in other places of three or even four benches. Southeast of Grayson, at most of the country banks, it contains two benches (sections 2, 3, and 4, fig. 12), separated usually by a thin bone parting. The upper bench ranges from about a foot to 15 inches in thickness; the lower averages about the same. The coal varies in character in the two benches. At some points a cannel layer, from 1 to 2 inches thick, is present at the top of the upper bench, and at the George Armstrong bank (section 2, fig. 12) a 6-inch cannel layer was observed at the top of the lower bench. As a rule, the lower bench is more splinty and harder than the upper, but this is not invariably true. This bed averages about 2½ feet of excellent coal in the region southeast of Grayson. On Everman Creek (section 12, fig. 12) it contains more coal but also has a bad bony parting.

Where worked at Boghead and Hunnewell, the bed usually consists of three benches. The upper bench is ordinary lustrous bituminous coal and varies in thickness, being about 5 inches thick at Boghead and slightly less than a foot at Hunnewell. It is separated

[a] Kentucky Geol. Survey, vol. C, 1884, pp. 17–18.

from the middle cannel bench by a bone or clay parting, which is from 1½ to 9 inches thick, being thicker near Hunnewell than at Boghead. The bottom bench is similar in character to the top bench. At Boghead it ranges from a foot to 14 inches in thickness, and at Hunnewell it is slightly thinner. It is separated from the middle cannel bench by a clay parting of variable thickness, this parting at Boghead reaching about 20 inches. The middle bench of cannel coal is the most valuable part of the bed at Boghead and Hunnewell. At the latter place it is about 15 inches thick. At the old Hunnewell workings 3 to 4 feet of cannel coal were reported as formerly mined, but no such thicknesses as this are now being worked. At Boghead

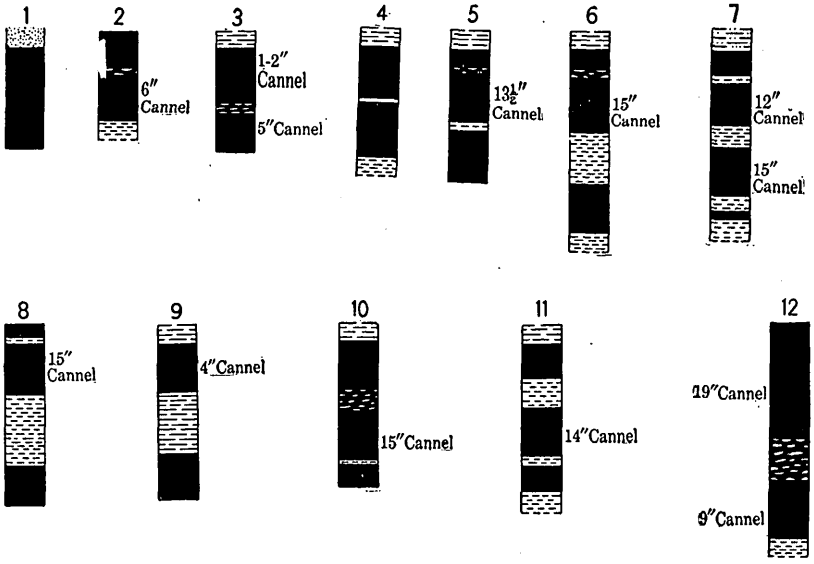


FIG. 12.—Sections of Lower Stinson coal (Kentucky No. 3). 1, Hill east of Grayson; 2, George Armstrong, 2 miles southeast of Grayson; 3, Robin Run, 2 miles southeast of Grayson; 4, John Crawford, Robin Run; 5, 6 (measured by G. H. Ashley); 7–9, Kentucky Cannel Coal Company, Boghead, Ky.; 10, 11, Kentucky Cannel Coal Company, Hunnewell mine; 12, David Childers, Everman Creek. Scale, 1 inch = 5 feet.

it is of about the same thickness, but at one point Doctor Ashley measured 27 inches of cannel, separated near the middle by a brown slate or clay parting 5 inches thick. George R. Hislop, of the Paisley Gas Works, Paisley, Scotland, has examined the cannel coal from the Boghead and Hunnewell districts. Of the former he says: "A sample of this coal representing the entire product of the seam is black and possesses a yellowish-brown streak and high luster. The fracture is slaty, coarse, and dull, with impressions of stigmaria, while in cross fracture it is conchoidal, with coatings of fire clay on the natural partings [joint planes presumably]. It is very compact and cohesive. On the fire it partially and slightly intumesces. The color of the ash is brown. It is well defined in stratification and is

of very uniform density." His report on the Hunnewell cannel coal is as follows: "The coal is black, possesses considerable luster and yellowish-brown streak. The fracture is slaty, coarse, and partly semiscalariform, with numerous impressions of stigmaria. The cross fracture inclines to conchoidal, with deposits of calcium carbonate, clay, and iron bisulphide [pyrite] on the natural partings [joint planes]. It is massive, compact, and very cohesive. On the fire it does not intumesce. The color of the ash is pale brown. It is well defined in stratification and of very uniform composition and density."

Both the Boghead and Hunnewell cannels were analyzed and subjected to practical tests by Mr. Hislop, with the following results:[a]

Results of tests of Kentucky cannel coal.

	Boghead.	Hunnewell.
Specific gravity	1.175	1.215
CHEMICAL ANALYSES.		
Moisture expelled at 212° F.—per cent	1.21	2.75
Volatile matter—do	54.92	47.23
Fixed carbon—do	35.17	43.58
Ash—do	8.08	5.55
Sulphur—do	.62	.89
GASEOUS PRODUCTS.		
Gas per ton of coal at 60° F. and 30 inches barometer—cubic feet	14,752	14,260
Gas from 1 cubic foot of coal—do	541.37	483.44
Specific gravity of the gas—air 1,000	700	644
Hydrocarbons absorbed by bromine—per cent	15.33	14.25
Durability of 1 cubic foot by 5-inch jet flame—minutes	72 $\frac{4}{5}$	66 $\frac{18}{55}$
Value of 1 cubic foot of gas in sperm—grains	915.60	843.12
Value of gas from 1 ton of coal in sperm—pounds	2,158.72	1,725.86
Illuminating power of gas in standard candles—candles	38.15	35.13
Sulphureted hydrogen (H_2S) in foul gas—per cent	1.25	1.75
Carbon dioxide (CO_2) in foul gas—do	2.50	2.50
Carbon monoxide (CO) in foul gas—do	7.00	5.50
Sulphur eliminated with volatile products—pounds	9.85	12.09
LIQUID PRODUCTS.		
Tar per ton of coal—gallons	20.34	20.12
Ammoniacal liquor per ton of coal—do	4.43	11.31
Strength of ammoniacal liquor—° Twad	4.00	3.00
Hygrometric water per ton of coal—gallons	2.71	6.16
Aqueous absorbent capacity of coal (determined by complete saturation)—per cent	1.35	2.80
SOLID PRODUCTS.		
Coke per ton of coal—pounds	972.83	1,108.35
Carbon in the coke—per cent	81.40	88.80
Ash in the coke—do	18.60	11.20
Sulphur in coke per ton of coal—pounds	4.03	7.84
Heating power of 1 pound of coke (water from boiling point into steam), pounds	11.18	12.20

In summarizing the properties of these cannels Mr. Hislop makes the following statements. Of the Boghead cannel he says:

This is an exceedingly rich cannel coal, yielding, as it does, an illuminating equivalent of 2,158.72 pounds of sperm candles per ton, while the coal contains a very small percentage of water and a moderate amount of sulphur. This

[a] Mr. Hislop's results were kindly furnished by Mr. S. G. Bates, of the Eastern Kentucky Railway.

coal will be found a valuable one for the enrichment of inferior gases. Compared with main Lesmahagow cannel coal, represented by 100 (calculated on the basis of a production of 13,000 cubic feet of gas and 1,535.5 pounds of sperm per ton, and having regard also to the value of secondary products and the cost of purification of the gas), this coal is equal to 134.03.

Of the Hunnewell cannel coal he says:

This is a remarkably rich cannel coal; it is easily distilled, yields a large volume of 35.15 candle gas, and affords 9.9 hundredweight of coke per ton of medium quality, and quite available for heatings in furnaces or producers in combination with that from a bituminous coal. The coal contains about the average amount of sulphur, but a very small per cent of water. Compared with main Lesmahagow cannel coal, represented by 100 (calculated on the basis of production of 13,000 cubic feet of gas and 1,535.5 pounds of sperm per ton, and having regard also to the value of secondary products and the cost of purification of the gas), the coal is equal to 111.23.

In the Kentucky State mine inspector's report for 1899[a] there are some interesting comparisons given between other cannel coals of Kentucky and certain type cannels of Great Britain. The Boghead and Hunnewell cannel coal compares favorably with these, as will be seen from the following table:

Results of tests on cannel coals of Great Britain and Kentucky.

Location.	Gas per ton of coal (cubic feet).	Illuminating power of gas (standard candles).	Value of gas from 1 ton of coal (pounds of sperm).	Coke per ton of coal (pounds).
GREAT BRITAIN.				
Lesmahagow	13,201	34.52	1,562.00	1,019
Tyne Boghead	13,155	38.22	1,723.00	1,301
New Battle	12,461	35.34	1,509.00	983
KENTUCKY.				
Falling Rock	14,210	36.15	1,761.51	1,178
Bear Creek	14,630	41.24	2,069.00	995
Pineville Coal Co.:				
Boghead, Bell County	15,805	36.26	1,964.87	1,089
Willaford	15,835	44.55	2,418.68	995
Kentucky Cannel Co.:				
Boghead, Carter County	14,752	38.15	2,158.72	972.83
Hunnewell, Greenup County	14,260	35.13	1,725.86	1,108.35

With main Lesmahagow cannel coal as 100 (calculated on a basis of a production of 13,000 cubic feet of gas and 1,535.5 pounds of sperm per ton, and having regard also to the secondary products and the cost of the purification of the gas)—

Falling Rock cannel is equal to 112.07
Bear Creek cannel is equal to 137.11
Pineville Willaford cannel is equal to 148.81
Kentucky Cannel Company's Boghead cannel is equal to 134.03
Kentucky Cannel Company's Hunnewell cannel is equal to 111.23

The figures and analyses given above need hardly any comment. They indicate that the cannel coals of this district now worked by the

[a] See pp. 111–115 of that report.

Kentucky Cannel Company are of the highest grade, the only hindrance in mining being the moderate extent of the territory underlain by them, in which respect they are like most other cannel coals.

DANLEYTON COAL.

Extent.—About 60 to 70 feet below the Hunnewell cannel coal is a bed which has been dug near Hunnewell and which outcrops on the hill on Cane Creek to the south. It also occurs in the hill 2 miles southeast of Grayson in a similar position, but locally at a greater interval below the Lower Stinson coal. About Hunnewell it is called the "clod seam," but it can not be positively stated that this is the "clod seam" of the Danleyton-Argillite district. The presumption is strongly in favor of their identity, but at the time of visit the opening at Hunnewell had fallen shut and the coal could not be seen. It is probable that the bed occurring near Hunnewell about 110 feet above the road is the Danleyton bed, as the two are characterized by an unusually massive underlying sandstone, and their distance, 100 feet below the base of the Homewood, is about the same. Near Hunnewell depot, about 30 feet below this bed, is a 10-inch coal which is probably not workable in this district, and on Turkey Fork a small 4- to 5-inch bloom was seen about the same distance above it. It is possible that these coals are those reported by Moore as occurring above Crandall's No. 1 coal[a] near Raccoon, Buffalo, and Laurel furnaces; hence the coal under discussion would properly be called No. 2 in the series of workable coals in this region. The difficulties in the way of correlating this coal bed with a coal bed west of Little Sandy River are many. East of Little Sandy River, on Culp Creek, Turkey Fork, and Cane Creek, the position and relationship of this coal are fairly clear with reference to the key rocks at the top of the Pottsville and at the base of the Allegheny. West of Little Sandy River the latter beds are generally absent from the hills, hence there is nothing definite to tie to except the Sharon conglomerate, which is somewhat scanty in its areal distribution.[b] It is believed, however, that this bed is not of any great importance west of Little Sandy River, a conclusion similar to that reached by Crandall.

Development.—East of Little Sandy River it has been opened on many farms near Argillite, but never has been shipped, so far as known. A description of the coal in this immediate region has been given on page 82. Farther south, in the hills along the Eastern Kentucky Railway, it is present, and has been opened on Turkey Fork and near Hunnewell,[c] 110 feet above the county road. The bloom of this coal shows on Black Branch of Little Sandy, east of Pactolus,

[a] Kentucky Geol. Survey, vol. C, 1884, p. 16. [b] Idem, p. 46. [c] See p. 82.

and in general on all the county roads east and southeast of Grayson ascending the small creeks to their sources. On Upper Stinson Creek, near Stinson, a coal, presumably the Danleyton, lies 100 feet below the old workings of the Lexington Carter Company, which has been reported as working the Upper Stinson or No. 4 coal. This would make the coal come about 70 feet below the Lower Stinson cannel coal. It has been prospected at this point, and was reported 22 inches thick with two partings. A small coal 20 to 30 feet above it occurs here similar to that on Turkey Fork.

West of Little Sandy River the first coal bed of any importance above Crandall's No. 1 on Barrett Creek, being thus No. 2 of the Kentucky series, is found about 120 feet above the top of the Sharon conglomerate. It is approximately 60 feet, or slightly more, above Crandall's No. 1 of this region, and about the same interval, or slightly more (70 feet), below No. 3 coal. West of Little Sandy River this coal is usually present, but, like the first workable coal bed

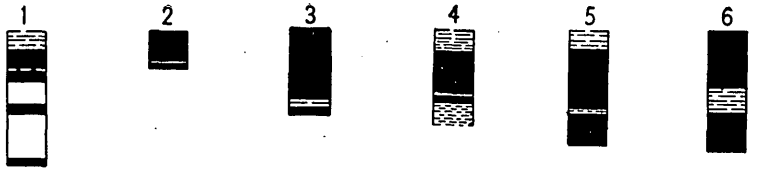


FIG. 13.—Sections of Danleyton and Barrett Creek coals. Danleyton coal: 1, 2, Everman Creek. Barrett Creek coal: 3, George Everman; 4, John Duley, Wolfpen Branch of Everman Creek; 5, A. J. Womack, Right-hand Fork of Everman Creek; 6, Near Samaria, Lost Creek. Scale, 1 inch = 5 feet.

above, it is opened at so few points that a good idea of its characteristics can with difficulty be obtained. Two openings on Everman Creek were visited, but the coal is so badly broken by bone partings as hardly to be valuable. Sections 1 and 2, fig. 13, show the coal as measured. It should be added that these sections were measured near the outcrop, where the true character of a coal is sometimes obscured. At the bank of David Childers, where the second section was obtained, it was reported that there are 3 feet of coal. At the time of the writer's visit in October the owner had not begun to dig his winter supply of fuel and the inner workings were not accessible. It is questionable whether this bed will add much to the coal resources of this district.

BARRETT CREEK COAL (NO. 1).

Extent and development.—The next lower workable coal corresponds to No. 1 of the Kentucky Geological Survey. In Crandall's general section this coal is placed about 40 feet above the top of the Sharon conglomerate, which is practically the same position as is

given to it in the writer's general section. (See Pl. IV, p. 28.) It is about 60 feet below the next higher workable coal, but its position with reference to the Sharon conglomerate where this bed is present will serve in most places to identify it. Crandall has stated that "it appears to be the equivalent of the Jackson Shaft coal in Ohio."[a] This is perhaps placing the equivalent of that Ohio coal a little too high in the Kentucky series, for the coal associated with the black shale lying within the Sharon conglomerate on Everman Creek appears to contain a fossil flora similar to that of the Jackson Shaft coal of Ohio, and hence is probably more nearly the stratigraphic equivalent of the Ohio coal than the bed 50 to 60 feet above the top of the Sharon.

The coal has been developed on Barrett Creek at many points. It has also been opened on Wolfpen Branch and Righthand Fork of Everman Creek. On Canes Creek, about 2½ miles west of Hopewell station, it has been opened by Marion Smith, and though reported thin it is of excellent quality for smithing purposes. On Lost Creek near Samaria it has been opened on the land of Mr. Stevens. Its bloom also shows on Oldtown Creek and its north fork. It is present in all the hills in this district west of Little Sandy River and will be found in workable thickness, at least for local use, over a broad area.

East of Little Sandy the coal is not so extensively distributed above drainage level owing to the eastern dips. Between Argillite and Laurel it appears as a small bloom at a few points on the county road along the Eastern Kentucky Railway, but has not been opened, so far as known. It is probably this coal which is opened at a few points on Cane Creek south of Hunnewell, where it is about a foot thick.

Character.—The sections in fig. 13 give an idea of the thickness of the Barrett Creek coal. The sections show that it is comparatively thin, and, though usually of workable thickness, at many points it falls below what might be regarded as commercial requirements for this region, namely, 2 feet. It consists at most points of two benches, an upper carrying from 1 to 2 feet of coal, and a lower, usually thinner, ranging from 2 inches to a foot. It has near its base a clay, shale, or bone parting, in places 6 inches thick. Crandall[b] reports this coal bed as being at Raccoon furnace, just north of the northwestern corner of this area, about 30 inches thick; near Buffalo furnace on Claylick Creek 3 feet, with a clay parting near its middle; and near Hopewell station 3 feet. The coal is, for the most part, of the soft bituminous type, but in some places the lower bench is hard and splinty. Mr. Ashley observed a thin cannel bench at the top of the upper bench on Lost Creek. The coal is regarded as of very high grade for local and smithing purposes.

[a] Kentucky Geol. Survey, vol. C, 1884, p. 11. [b] Idem, pp. 11–13.

LOWER COALS.

About 50 to 60 feet below the Barrett Creek coal occurs a single small coal bed and in places a second coal a few feet still lower. These are thin beds lying near the top of the Sharon conglomerate, and possibly the lower coal is within the stratigraphic equivalent of the Sharon. Where only one of these coals is present it is impossible to tell which of the two it is. One of these coals was exposed in an excavation below the post-office at Grayson and appears at several points on the county road south of the town. It was opened in the bed of Town Branch to the west. It rests directly on a thin bed of quartz or quartz-like micaceous sandstone, not over 5 to 6 feet thick, which is a fairly persistent stratum in the immediate neighborhood of Grayson. The two coals near the bridge over Little Sandy River, east of Grayson, are probably equivalent to the coals just mentioned south of the town. They also are too thin to work at this point. In the valley of Upper Stinson Creek directly east of Grayson two coals show just at the foot of the hill to the left of the road going east, and at the edge of the meadow the lower of these coals is 20 inches thick and has a bone floor and a shale roof. The fossils collected by Mr. White were not distinctive. Near the north end of the tunnel of the Eastern Kentucky Railway, south of Hopewell, this coal shows, but here also is too thin to work. The coal was also noted east of Pactolus on the hills near Black Branch, where it is too thin to export, though it is of some local importance.

The lowest coal of importance in this region occurs within the Sharon conglomerate itself. The dual character of this sandstone member is shown on Everman Creek near its junction with Wolfpen Branch, where a black shale is present 15 to 20 feet below its top. In places this shale is coal bearing, and the thin coal found in this position at the farm of John Duley farther up Wolfpen Branch is regarded by David White as the stratigraphic equivalent of the Jackson Shaft coal of Ohio and the Sharon of Pennsylvania. This coal has also been worked on Barrett Creek almost at water level. Opposite the residence of L. D. O'Roarke 6 inches of coal shows. The coal has been opened farther up the creek, where the county pike turns over the hill to Everman Creek. On Canes Creek the Sharon is very massive, and this coal again appears but is only 6 inches thick. Like the other coals below No. 1, this is too thin to be commercially valuable.

DISTRICT TRIBUTARY TO SOUTHERN TERMINUS OF EASTERN KENTUCKY RAILWAY.

EXTENT.

The district, including approximately the southwestern quarter of the quadrangle, contains in its northern part the southern 8 miles of the Eastern Kentucky Railway, passing through Willard and ending

at Webbville. Nearly all the lumber, staves, and country merchandise shipped out of this region go via this railroad, hence the reason for applying the above title to it. It includes all of Elliott County within the Kenova quadrangle, the extreme western part of Lawrence County, and a very small portion of southern Carter County.

GEOLOGY.

STRATIGRAPHY.

The Conemaugh, Allegheny, and Pottsville formations are represented in this district. In the northern part, east of Willard, in the deepest part of the basin, the surface is entirely made up of Conemaugh rocks. Immediately west of Willard and in a few isolated areas on the hilltops west of Dry Fork, Conemaugh rocks outcrop. A good idea of the character of this group of rocks may be had by climbing the hill east of the mouth of Thompson Fork or ascending Lost Branch, Belle Trace Creek, Beetree Fork, or Straight Creek east of Denton. Between 300 and 400 feet of the Conemaugh is shown, consisting of sandstones, shales, limestones, iron ore, and coal streaks. The coal in this formation is too thin and pockety to be of any importance except locally. There are at least three or four thin beds of limestone, the most persistent being a siliceous bed 4 to 5 feet thick lying near the base of the Conemaugh, about 180 feet above the Coalton coal as measured at Willard. This limestone and possibly the higher beds might be used locally as a source of fertilizer. The lower limestone probably corresponds to one of the Cambridge limestones of the Ohio geologic section. There are some rather massive sandstones scattered through the group of rocks, notably in its lower 100 feet. Some of the sandstone appears to be good enough for building purposes.

The Allegheny formation is in this district, as usual, the most important from an economic standpoint. A section measured west of Willard gives a fair idea of the sequence of the coal beds in it. It must not be understood that all the coals observed in this section will appear in the Allegheny, in other parts of this district, for the formation is somewhat variable. As an instance of this, on the west side of the hill where the following section was measured the formation had thinned somewhat, and, though the exposures were fairly good, fewer coals were found in it.

Section in hill west of Willard, Carter County.[a]

Top of hill.	Feet.
Sandstone, massive, and sandstone débris	45
Limestone, massive, drab, fossiliferous (Cambridge limestone)	4–5
Partly concealed with sandy débris and sandy shales	60

[a] This section represents the average of two distinct barometric determinations.

	Feet.
Sandstone, massive, white to light brown	25
Coal bloom No. 9 (top of Allegheny).	
Fire clay	2–3
Shale, sandy, and shaly sandstone	20
Coal bloom No. 8.	
Concealed and sandy	15
Limestone, yellow	1½+
Shale, drab	15
Coal (workable) No. 7.	
Sandstone, laminated	20
Ore, limestone.	
Concealed	10
Coal bloom No. 6.	
Shale (fire clay at top)	15
Coal, two small blooms 6 inches apart.	
Shale and fire clay	20
Coal bloom No. 5.	
Sandstone, laminated	10
Sandstone, massive (Homewood)	30
Coal bloom (coal has been worked).	
Fire clay.	
Sandstone and shale	15
Coal bloom (coal has been worked).	
Sandstone	10±
Base of hill.	

The Allegheny formation ranges in this district from about 120 feet to possibly 200 feet in thickness. In places it may even be thinner than 120 feet. It includes at least three valuable coal beds workable at different points, at least one valuable fire clay, and iron-ore deposits, but the bulk of it, as usual, is composed of sandstone and shale. It forms the surface in a more or less irregularly curved strip, which follows the direction of the contour lines from Straight Creek to the southwest and then trends southeastward to the limits of this district. Many of the hilltops west and south of the main Allegheny belt are formed by this group of rocks. Roughly, it covers about one-third of the surface in this district.

The lowest formation present in this district is the Pottsville. In places it is between 500 and 600 feet thick, and it is prevailingly sandy throughout, though containing some shale beds. Its two most prominent members are the Homewood sandstone near the top and the Sharon conglomerate near the base, each of which attains in many places a thickness of 100 feet of very massive rock. The Homewood member is broadly distributed; the line or outcrop of its top, if represented on the map, would coincide very closely with the red line which indicates the outcrop of the fire clay associated with the Vanport ("Hanging Rock") limestone. The Sharon conglomerate appears in the valley of Little Sandy River, along Brushy, Hood, and Upper

and Lower Laurel creeks, and on Field Branch. Roughly, this formation covers perhaps about one-half of the surface in this district. The Pottsville formation is of importance economically, containing coal beds locally workable and at some points cannel coals. It also contains iron ore, fire clay, and sandstone of value. These beds are described in detail under the appropriate headings.

STRUCTURE.

The structure of this district is more involved than that of any of the districts previously described. The synclinal trough which traverses the quadrangle from northeast to southwest begins to die out in the vicinity of Willard and Webbville. Between these two towns the basin rises sharply toward the west. About Webbville and to the south the beds are generally inclined to the north and northeast; about Willard and to the north the pitch to the southeast is very sharp. Near Daniels Creek the Homewood sandstone thickens abruptly toward the west, giving rise to a slight dome in the rocks lying on the top of this sandstone and to a slight depression or basin as it becomes thinner again toward Cherokee Creek. West of Cherokee Creek the structure is not marked, though there is a gradual westward rise of the beds. About the town of Blaine the beds dip more sharply than at any point in the area, and at the bridge over Hood Creek apparent dips range from 11° to 24° in a nearly due north direction. Mr. Ashley discovered two minor faults in the hills east of Blaine, but they are of small magnitude, and a short distance away the beds can be traced continuously.

THE COALS.

CONEMAUGH COALS.

The blooms of a few coal beds show wherever any considerable section of the Conemaugh formation is exposed. A small coal bed occurring within 10 feet of the bottom of the Cambridge limestone appears to be fairly persistent and has been dug for local use near the head of Belle Trace Creek, Jordan Fork, and Straight Creek. This coal is not commercially valuable.

ALLEGHENY COALS.

UPPER COALS.

The two upper coals of the Allegheny formation outcrop at many points in this district, but apparently are too small for exploitation. In the section in the hill west of Willard (pp. 96–97) these two coals appear, the No. 8 or Hatcher coal about 32 feet above the Coalton, which has been dug into along the roadside, and the Zelda or No. 9

coal about 25 feet higher up. The intervals in this vicinity are apparently much less than those prevailing along Ohio River. At the head of Thompson Fork and the tributary flowing into it from the north the Zelda coal is thick enough to be worked for local use, and the following section was measured near the head of the main fork. (See also section 1, fig. 14.)

Section of coal No. 9, near head of Thompson Fork.

	Inches.
Sandstone.	
Bone	8
Coal	26
Fire clay.	

COALTON COAL (NO. 7).

Geologic position.—In the northern part of the district the Coalton coal is of considerable economic importance. Its occurrence here is merely the southwestern continuation of this coal in the Chesapeake and Ohio Railway district. About Willard it is found at 65 to 90 feet above the top of the Pottsville. The former measurement was obtained in the hill west of the town; the latter is the more usual interval. The coal bed occurs 50 feet above the fire clay at the Vanport limestone horizon at the north end of the town, about 30 feet above the Winslow coal, and 180 feet below the Cambridge limestone. Owing to the persistence and broad distribution of the Cambridge limestone it will serve as an excellent base from which may be calculated the depth below the surface of the Coalton coal well up on the headwaters of the numerous smaller creeks flowing into Little Fork. It is quite possible that deviations from the interval measured at Willard will be found.

Extent and development.—About Willard and north of Webbville the Coalton coal has been opened and worked at many places. In this vicinity it outcrops well down in the hills so that tipples may be conveniently run out to the main line of the Eastern Kentucky Railway or to short spur tracks. It outcrops in the hills between Straight Creek, Belle Trace Creek, and Lost Branch, disappearing below drainage level on Lost Branch near the mouth of Crooks Creek. A large body of valuable coal still remains untouched in these hills, and east of the points where it goes below drainage level no shafts have ever been sunk to reach it. Numerous country banks show this coal to be of fair thickness to points about a mile above the mouth of Belle Trace Creek and about a mile above the mouth of Lick Branch, west of Willard. South of Webbville the coal is present in the hills along Caney, Dry, and Equal forks, rising to the south. It has never been opened in this region. West of Dry Fork and Cherokee Creek the rise is so great that the coal is found only

near the tops of the hills, and consequently in small bodies. It is found in the ridge between Equal Fork and Blaine Trace Branch and to the west in the ridge between Little Fork and Blaine Trace Branch, where 3½ feet of cannel coal is reported; it is present also in the hills north of Hurricane Creek. West and northwest of Willard the beds rise so steeply that the Coalton coal is present only here and there in the tops of the highest hills, as, for instance, at the head of Field Branch and Johns Branch.

The center of development of this bed lies about Willard and Webbville and at or near the mouth of Lost Branch, Lick Branch, and Belle Trace Creek. The only large commercial operation on this bed is that of the Eastern Kentucky Railway on Lost Creek.

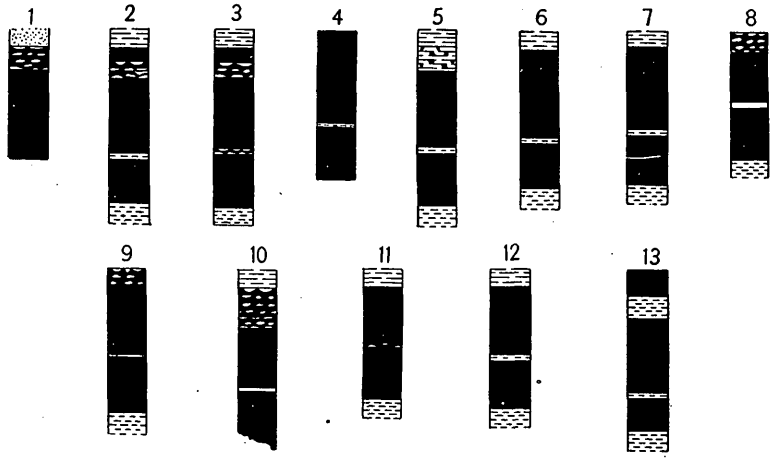


FIG. 14.—Sections of Zelda and Coalton coals. Zelda: 1, Head of Thompson Fork. Coalton: 2, East Kentucky Railway mine, Partloe (Mayapple post-office), Lost Branch; 3, James H. Williams, Lost Branch; 4, A. E. Fauson, Lost Branch; 5, southern part of Willard; 6, east of Willard; 7, east of Willard (Ashley); 8, 9, mouth of Belle Trace Creek; 10, on Little Fork, north of mouth of Lick Branch; 11, near mouth of Lick Branch, west of Willard, on small tributary from the north; 12, Lick Branch, west of Willard; 13, head of Davies Branch (Ashley). Scale, 1 inch = 5 feet.

This company formerly mined this bed on an extensive scale south of Willard, but at present all the old mines are shut down. From the economic map an idea of the extent of this coal above drainage may be readily obtained.

Character.—The thickness of this coal may be seen from the sections in fig. 14. It will be noted that the coal shows great uniformity in its division into benches and also in the thickness of these benches, and, though not indicated in the figures, the character of the coal in the different benches is also uniform. On Lost Branch and at the head of Davies Branch where measurements were made three benches are developed (sections 2, 3, and 13, fig. 14.) The top bench is from 4 to 7½ inches thick and is not worked. In the immediate vicinity of Willard only two benches were noticed (sections 5, 6, and

7, fig. 14). The upper bench is about 2 feet thick, grading into bony coal at the top; the lower bench is usually a little more than a foot thick and is separated from the top bench by an inch or two of clay or shale. Near the mouth of Belle Trace Creek the upper bench seems to thin considerably and to range where measured from 15 to 20 inches in thickness (sections 8 and 9, fig. 14), and the lower bench, which is about 16 or 17 inches thick, is comparable in thickness with this bench near Willard. On Lick Branch, west of Belle Trace Creek, the sections obtained are about the same as those seen on the latter stream. The total thickness of these two worked benches rarely reaches 45 inches and averages most commonly about 3½ feet. From 40 to 45 inches of workable coal in the upper two benches may therefore be considered a maximum for this bed. From these thicknesses it thins out to nothing at some places where rolls in the roof and horsebacks occur.

The roof is as a rule fairly massive shale of variable thickness, usually capped by a very massive sandstone. The immediate roof is generally bony coal. The foreman of the Eastern Kentucky Railway mine at Partloe reports that the roof gives little or no trouble. Falls are rare, but posts are used. The floor is clay, but so far as known it is not mined for economic purposes.

The coal is bituminous. The upper bench is soft and full of charcoal partings; the lower bench is hard and splinty. Both are worked and shipped, the bone and clay partings being picked out by hand. Mining is fairly difficult.

The composition of this coal is illustrated by the analyses given on page 71. These figures are for the most part those of coals collected in the region about Rush, but analyses 11 and 12 represent samples collected from Lost Creek and west of Dry Fork near Willard and may be taken as typical of the coal in this vicinity. The application of this coal to iron making has been treated at some length in the discussion of its chemical character in the Chesapeake and Ohio Railway district (pp. 70–73) and will not be considered further here. It is not a coking coal, the output of the Eastern Kentucky Railway mine at Partloe being used exclusively along the railway for steaming and domestic purposes, for which it is admirably adapted.

WINSLOW COAL (NO. 6).

Extent and development.—The next lower coal corresponds with coal No. 6 of the Kentucky series and has been described in the section on the Chesapeake and Ohio Railway district under the name Winslow coal, owing to its fairly extensive exploitation at Winslow. Here, as in the district just referred to, it occupies a position between the Coalton coal above and the Vanport ("Hanging Rock") lime-

stone below. In the district north of Daniels Creek, Lawrence County, and on the ridges east and west of Blaine Trace Branch and at the head of Ison Creek, Elliott County, it is usually from 45 to 60 feet above the Vanport limestone, and as this limestone is very near the top of the Pottsville or Homewood sandstone, the same interval may serve also when the coal is referred to the latter horizon. About Willard, near the fire-clay mines in the northern part of the town, the smut of this bed was noted about 20 feet above the fire clay associated with the Vanport limestone and about 30 feet below the Coalton coal. West of the town it is about the same distance below this coal and above the Vanport limestone. Its identification in and about Willard is easy, as the red limestone ore overlying the Vanport limestone has been extensively worked at this place in the past. The coal is broadly distributed.

Though it outcrops in all the hills about Willard, it has never been worked and nothing can be stated definitely as to its character. It is probably too thin to be of any great value. Its bloom was noted in the hills skirting Dry Fork, Equal Fork, and Blaine Trace Branch. At the head of Equal Fork and Perkins Branch it is of workable thickness, and at a few country banks the coal is being opened. In this locality it will repay careful prospecting, for the underlying coal also is a most valuable bed, and should the Eastern Kentucky Railway be extended southward from Webbville to Blaine it would pass near enough to the heads of Perkins Branch and Equal Fork to make the coal in this locality of probable commercial importance. South of this point very little is known about it, but it should be found in the hills northeast of Canes Creek and in the ridges bordering Irish and Cherokee creeks. In the hills north of Daniels Creek and west of San Branch it has been opened and worked in a small way. On Brush Creek, south of the Elliott-Lawrence county line, this coal has been opened by J. Porter and is sufficiently thick to be worked in a local way. In the hills north of Mount Savage it seems also to be fairly persistent. At the head of Ison Creek, west and northwest of Stephens, Elliott County, a cannel coal is found about 50 to 60 feet above the top of the Pottsville and is referred to this horizon. It has been opened by L. A. Clark, W. B. Boggess, Isom Ison, and others in this region. This is the only known occurrence of cannel coal at this horizon. Northwest of Willard, near the hilltops at the heads of Johns Branch and Field Branch, this coal is present, but the area which it covers is small, owing to the steep rise of the beds to the west.

Character.—The sections of this coal obtained are so few in number that no reliable generalizations can be made regarding its physical character. Neither can it be stated that their paucity is an index of the thinness or poorness of the coal, for about the head of Equal Fork

and Perkins Branch and in the hills west of Dry Fork a considerable body of this coal exists in workable thickness. The area underlain by it is fairly comparable with that underlain by the Vanport limestone, which is indicated by the red line on the economic map (Pl. I), but as the coal lies somewhat higher in the hills its area will be slightly smaller than that of the limestone. As judged by sections 1 and 4, fig. 15, this coal is fairly comparable in this immediate locality with the same bed in the Chesapeake and Ohio Railway district. It carries three benches, separated by thin partings of bone or fire clay. The two top benches are soft bituminous coal; the lowest bench is hard splint. In this immediate territory the roof is shale and the floor clay. Little is known about the coal to the west, except along the edges of the quadrangle west and northwest of Stephens and north of Fielden. In this region the coal is largely cannel. Sections obtained here also show three benches (section 3, fig. 15). This coal has been opened in the hill south of Brush Fork by L. A. Clark

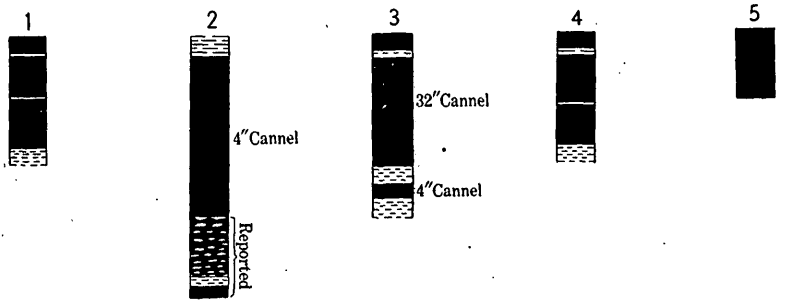


FIG. 15.—Sections of Winslow coal (Kentucky No. 6). 1, W. M. Clark and A. C. Campbell, head of Perkins Branch; 2, 3, head of Ison Creek (Ashley); 4, Dry Fork; 5, ridge between Equal Fork and Blaine Trace Branch. Scale, 1 inch = 5 feet.

and W. B. Boggess, and at Mr. Clark's bank it was reported 4 feet thick. Nothing is known of its character outside of the inconsiderable area bounded by Little Fork, Brush Fork, and Critches Creek, and in this district the acreage of cannel coal is not large, owing to its position very near the hilltops. It is, however, a valuable cannel coal, which will be worked in the future when cheaper transportation facilities are obtainable.

CAT CREEK COAL (NO. 5).

Extent and development.—The next lower coal is the most important coal in this district. It reaches its greatest thickness along Dry and Caney forks and Cherokee Creek and in the hilltops northwest of Willard, at the head of Johns Branch. It is the lowest coal in the Allegheny formation in this area and closely underlies the Vanport limestone. If it were correlated with one of the Pennsylvania or Ohio coals it would probably correspond to either the Brook-

ville or the Clarion; certainly not with any of the Kittanning coals, for these are all above the Vanport limestone. In this district little difficulty will be experienced in identifying this coal bed. Its position 20 feet or so below the Vanport limestone and on or near the top of the Homewood sandstone, which along Cherokee, Dry, and Caney creeks is very massive, should serve at once to locate it. This coal bed without doubt corresponds to coal No. 5 of the Kentucky Geological Survey. Its occurence in this district may with a fair degree of certainty be regarded as the western continuation of the coal occurring on Cat Creek, and so this name is used in this district. It has been carefully prospected in the hills lying about the head of Cherokee Creek, Dry Fork, and Equal Fork, and along Caney Fork well toward its mouth. It is present in the hills bordering Dry Fork and dips rather steeply to the north, disappearing below

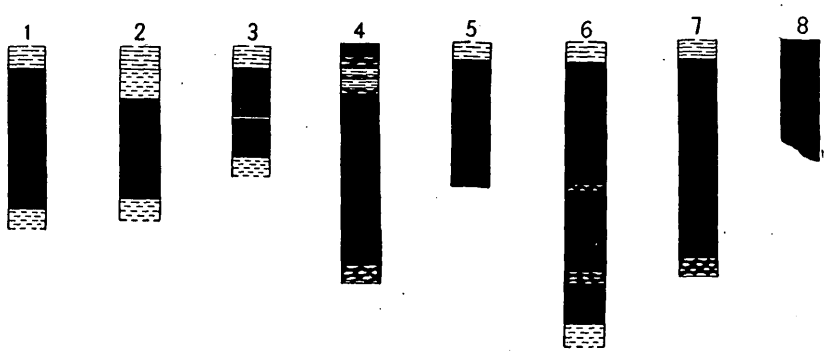


FIG. 16.—Sections of Cat Creek coal (Kentucky No. 5). 1, J. C. Webb, Caney Fork; 2, James Bryant, Caney Fork; 3, Henry Campbell, Caney Fork; 4, J. A. Young, head of Cherokee Creek; 5, James Wheeler, ridge east of Backbone; 6, 7, James Adams, head of Johns Branch; 8, J. C. Johnson, near head of Equal Fork. Scale, 1 inch = 5 feet.

drainage level before Webbville is reached. The same dip in the beds also causes its disappearance below drainage level before it reaches the mouth of Caney Fork. It is present in the ridge between Blaine Trace Branch and Equal Fork, and where seen near Backbone it is a thick coal bed of excellent quality. Its position is indicated by a bloom at many places in the ridge lying still farther to the west between Little Fork and Blaine Trace Branch. The southernmost point where its bloom was seen is in the hills just northeast of Blaine, but nothing is known of its character here. A large territory is underlain by this valuable coal in the region about Caney Fork, in the hills along Dry Fork and Cherokee Creek, in the hills between Equal Fork, Blaine Trace Branch, and Little Fork, and possibly south of Perkins Branch. Northwest of Willard this coal bed also appears in the hills and has been opened at a few places at the head of Johns Branch. At the banks of James Adams (sec-

tions 6 and 7, fig. 16) and John W. Barber the coal is comparable in thickness with the coal seen at the head of Cherokee Creek.

No attempt has been made to develop this coal on a commercial scale, though the construction of a spur track up Dry Fork is apparently a simple matter and such a spur would tap a large body of coal.

Character.—Measured sections of this coal are given in fig. 16. The sections given for this coal on Caney Fork were measured in small country banks and very near the outcrop and it is possible that they may not represent the true thickness of the coal. As seen on Caney Fork, the coal will probably average between 3 and 4 feet in thickness. As a rule the roof of the coal here is shale.

At the heads of Dry Fork and Cherokee Creek and to the west at the heads of Perkins Branch and Equal Fork the coal attains its greatest development in this district. At the J. A. Young mine, on a small creek entering the head of Cherokee Creek from the east, more than 4 feet of excellent clean coal was measured (section 4, fig. 16). From this mine a large block of coal representing the entire thickness of the main workable bench was taken to the Louisiana Purchase Exposition at St. Louis. At some points in the mine a lower bench, less than 1 foot in thickness, is reported, but this is not everywhere present. As a rule the roof is shale and the floor is bone passing into clay. In the ridge between Equal Fork and Blaine Trace Branch, a short distance east of Backbone, Mr. Ashley measured 38 inches at a bank owned by James Wheeler. It was reported that the usual thickness is 3½ feet. Mr. Ashley also measured 30 inches of coal in the ridge west of Equal Fork at the bank of J. C. Johnson, but 3 feet were reported to him.

The Cat Creek is a bright, lustrous bituminous coal, containing streaks of harder coal with probably some splinty layers. Without much doubt it will serve well for steaming and domestic purposes, but its efficiency as a coking coal has not yet been determined. It was used to supply the engine running the drill which bored a hole 2,000 feet deep near J. A. Young's residence at the head of Cherokee Creek, and it gave splendid satisfaction as a steam generator. From the fact that it separates into rectangular blocks of fair size and may be removed from its position in blocks the thickness of the entire main bench, it may appropriately be classed among the block coals. The following analysis was made by the Kentucky State chemist:

Analysis of coal No. 5 from J. A. Young's bank at head of Cherokee Creek.

Moisture	7.04
Volatile matter	36.88
Fixed carbon	53.72
Ash	2.36

The analysis shows this coal to be of very high grade. The moisture is rather high, but ash is low. No sulphur is given, but this constituent was probably not determined, as it is quite certain that some sulphur is present.

Economic aspects.—The marketing of this coal is an important consideration. The Eastern Kentucky Railway has extended its line as far south as Webbville, but under present conditions this does not materially help the exploitation of coal at the head of Dry Fork and Cherokee Creek. To get this coal to market it will be necessary to extend the railroad as far as the head of Dry Fork at least. This can be easily and cheaply accomplished, owing to the easy grade and absence of sharp curves on Dry Fork. Should the road be continued to Cherokee Creek, the divide would probably be tunneled. It may not be expedient to do this, for the bulk of the coal could be readily tapped by spur tracks from the main line up Dry Fork. It is generally understood that the Eastern Kentucky Railway proposes to extend its tracks as far south as the town of Blaine.

POTTSVILLE COALS.

UPPER STINSON COAL (NO. 4).

Geologic position.—In this district the Upper Stinson coal, though widely distributed, can not be classed among the important beds except locally. It has been stated that it is the highest coal in the Pottsville formation and that it occurs directly below the massive sandstone member (Homewood sandstone) forming the top of this formation. Its position below the top of the Homewood sandstone and hence below the Vanport ("Hanging Rock") limestone is variable, depending on the thickness of the Homewood, which is also variable.

About Willard the Homewood sandstone is massive, though not more than 30 to 40 feet thick. In the hills bordering Dry Fork and Cherokee Creek it seems to be less than 50 feet thick, but to the west it is thicker, at many places from 80 to 110 feet. At the heads of Justice, Leadenham, Hilton, and Wells branches and farther south in the region about Backbone and north of Stephens it is 110 feet or even thicker. South of Backbone and Stephens it becomes thinner again. At the head of Wiley, Collier, and Knob branches this member is unusually massive. Thus the Upper Stinson coal occupies a variable position with reference to the top of the Homewood sandstone, occurring usually from 40 to 110 feet below it.

Extent and development.—The coal is broadly distributed in this district. In its northern part it is present in the hills at the heads of Huff Creek and Field and Johns branches. An opening belonging to Silas Walker west of the head of Field Branch showed this coal

to be of workable thickness. The section measured is given in fig. 17 (section 1). On most of the waters of Blaine Creek and Little Fork the bloom of this coal bed shows, but few openings on it were observed, the presumption being that as a rule it is not workable. On Hilton Branch a coal regarded as the equivalent of this coal appears to be chiefly cannel. About a mile from the mouth of the branch on its north side, about 200 feet above the creek bed, there are two openings. At the one nearer the mouth of the creek, on the farm of Elijah Sturgill, 9 inches of coal were seen with more below, capped by 6 inches of shale overlain by very massive sandstone. Mr. Sturgill, jr., reports the usual thickness of the cannel coal to be about 3 feet with less than a foot of bituminous coal overlying it. Farther up the creek, on the land of William Corey, a section of the same bed was measured, and is represented in section 3, fig. 17. Mr. Corey reports

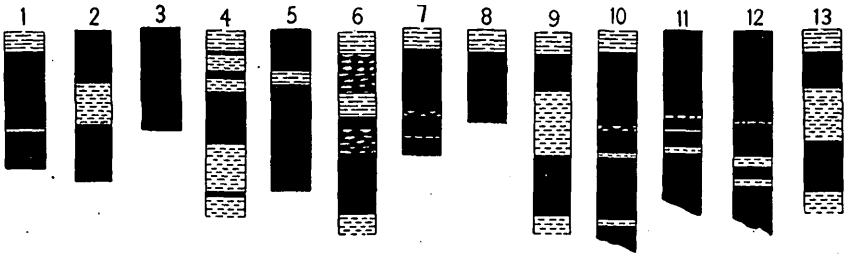


FIG. 17.—Sections of Pottsville coals. Upper Stinson coal (Kentucky No. 4): 1, Silas Walker, west of head of Field Branch; 2, northeast of Sarah (Ashley); 3, William Corey, Hilton Branch. Lower coals: 4, F. E. Holbrook, Right Fork of Blaine Creek; 5, A. T. Boggs, Right Fork of Blaine Creek (reported); 6, W. H. Lyons, Right Fork of Blaine Creek; 7, Levi Kitchen, Dry Fork; 8, head of Leadenham Branch; 9, J. N. Sparks, Halton Branch, west of Fielden (Ashley); 10, 11, 12, Robert Green, Halton Branch, west of Fielden (Ashley); 13, J. M. Green, head of Little Fork, west of Sarah. Scale, 1 inch = 5 feet.

29 inches of cannel as a maximum. The cannel coal was not seen north or south of Hilton Branch.

The coal in this district, aside from the cannel phase just described, is of the usual soft, lustrous character, in many places containing bands of harder splint.

LOWER COALS.

The next lower workable coal in this district occurs in most places 160 feet below the top of the Homewood sandstone. It will be found in this position along Right Fork of Blaine Creek and on the streams which flow into it from the north and on the headwaters of Little Fork. Possibly the coal opened by R. T. Berry east of the town of Blaine belongs here also. It is a question whether this coal can be regarded as the exact equivalent of the Lower Stinson or Torchlight bed, but in the sense of its being the second workable coal in the Pottsville, counting from its top, it may be called for convenience

No. 3. A section obtained in the ridge south of Rockhouse Branch showed five small coal beds lying between the coal under discussion and what is probably the top of the Pottsville formation. The occurrence of so many coals between the so-called No. 3 in this district and the top of the Pottsville is probably not very widespread, although it is quite probable that there is more than one coal in this interval. These intermediate coals may be locally workable. The conditions here present a strong argument against adhering strictly to a system of numerals in correlating coal beds over broad areas.

This coal, as has been said, occurs 160 feet below the top of the Pottsville formation on Right Fork of Blaine Creek. In the northern part of this district it will be found at a less distance from this horizon, and at the head of Field Branch the interval can not exceed 80 to 100 feet. Here this coal is not of workable thickness, but it is of more than ordinary interest from the fact that it consists largely of cannel. A section measured on the farm of Silas Walker showed 12 inches of cannel underlain by 8 inches of ordinary soft, bituminous coal. South of this place a coal, probably the equivalent of this bed, has been opened at the head of Leadenham Branch by Jackson Wilcox. The coal here has a shale roof and measures approximately 2 feet (fig. 17, section 8). Near Backbone and Stephens it is found near the bed of the creek and has been worked on a small scale for local supply. No measurements of the coal were obtained in this vicinity. On Dry Fork, about 2 miles south of Webbville, it has been opened by Levi Kitchen near the bed of the creek, and the section shows about 2½ to 3 feet of coal containing small partings of bone in its lower half (fig. 17, section 7). This coal is highly esteemed in the immediate neighborhood for smithing and domestic purposes. South of Cherokee it will be found near road level above the massive sandstone outcropping near the bridge over the creek. It has been opened at several points in the vicinity of Fielden and Sarah, where it is called the "mud seam." On Canes Creek, Rockhouse Branch, Knob Branch, Equal Fork, and in the vicinity of Willard sections obtained from this coal show it to be badly broken, and, though an important source of supply for local purposes, it is a question whether a coal with so many partings can become of commercial importance in the near future. Except where the coal is of the cannel type, as observed near the head of Field Branch, in Carter County, it is of the same character as the rest of the coals in this district—namely, partly splint and partly soft, lustrous bituminous coal.

The Barrett Creek coal, or No. 1 of the Kentucky series, has been opened at a few points on Deer Creek, northwest of Willard, and near Rosedale. The coal on Deer Creek shows at the two points where measured a somewhat better section than it does on Barrett Creek. (Compare fig. 18, sections 1 and 2, with fig. 13, sections 3,

4, 5, and 6.) Its position, about 60 feet above the top of the Sharon conglomerate, which is prominent along Little Sandy River in this region, serves to identify it. At Mrs. Rebecca Tackett's this bed shows 3 feet of clean, bright, lustrous coal with no partings, but at the bank of William Herbelan, well up on the east fork of Deer Creek, though the coal is still about 3 feet thick, it contains a band of bony coal near its top (section 1, fig. 18). The coal opened at the mouth of Field Branch is referred to this horizon. It probably belongs in the group lying close to the top of the Sharon conglomerate, as is indicated by the section obtained in crossing the ridge from Deer Creek to Little Fork. This section again illustrates the objections raised in this bulletin to numbering coals. On the west side of this ridge at least ten small coal beds appear, any one of which theoretically may be thick enough to be commercially valuable at some place. On the east side of the ridge seven coal beds were counted, the lowest of which is the one referred to above as outcropping near the mouth of Field Branch. This coal has been opened by Walter Field, Robert Rucker, and others, the openings being at

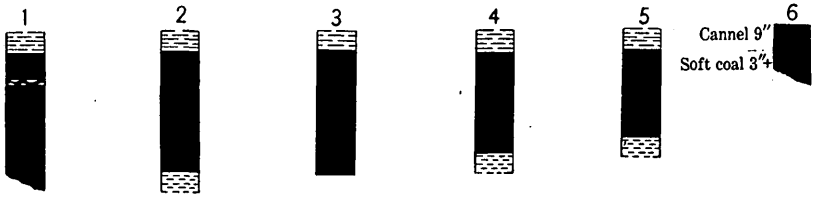


FIG. 18.—Sections of Barrett Creek coal. 1, William Herbelan, Deer Creek; 2, Mrs. Rebecca Tackett, Deer Creek; 3, Walter Field, Field Branch; 4, Robert Rucker, Field Branch; 5, R. T. Berry, Blaine; 6, J. W. Sparks, Sarah. Scale, 1 inch = 5 feet.

the base of the hills, but a few feet above the flood plains. At Mr. Rucker's coal bank about 2½ feet of excellent coal appears between a shale roof and fire-clay floor (section 4, fig. 18). At Mr. Field's over 3 feet of clean coal was seen, with a thin body of shale above, capped by a good sandstone. Mr. Field reports that some of the coal runs as high as 4 feet 4 inches, but that 3½ feet is a fair average. The position of this coal in the hills is such as to suggest the possibility of a large body of workable coal, the more so as it is believed that this coal may be the stratigraphic equivalent of that opened by Mr. Herbelan and Mrs. Tackett to the west of Deer Creek, which is known to be fairly persistent and of workable thickness. The position of this coal with reference to the railroad is favorable to its easy and cheap exploitation, and the slight westward rise of the beds in this vicinity should solve in large measure most of the difficulties encountered in the drainage of the mines.

The coal opened by R. T. Berry, southeast of Blaine and east of Hood Creek, may belong at this horizon. It measures 26 inches in

thickness and is worked for local use. The coals along Irish Creek, near its mouth, are referred to the lower horizons in the Pottsville. They are reported workable in one or two places, but the writer was not able to verify this information. These lower coals are here and there partly cannel. The coal measured by G. H. Ashley near drainage level at Sarah is considered to be near the base of the Pottsville; it was reported 28 inches thick, with a 12-inch bench of cannel 8 inches from its top.

The coal mined along Brushy Creek is one of the most important of the lower beds. It has been referred to at times as No. 1 or the Barrett Creek coal, but its position with reference to the Sharon conglomerate outcropping along Brushy Creek in the vicinity of Cordell leads to another interpretation. Below Cordell at the bank of A. J. Soard this coal is 180 feet above the top of the Sharon, a much greater distance than appears about the town of Blaine, or along Deer or Barrett creeks. It is strongly probable, therefore, that the coal on Brushy Creek is higher than the Barrett Creek bed. It may

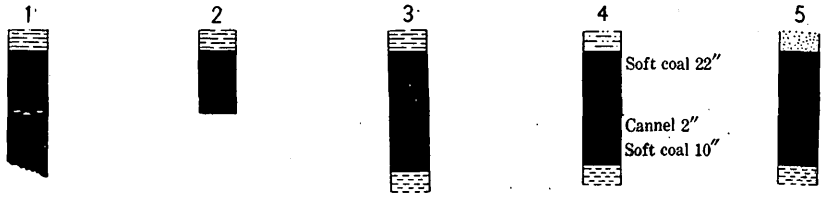


FIG. 19.—Sections of coal on Brushy Creek. 1, Two miles east of Blaine; 2, Simpson Steele, head of Brushy Creek; 3, Isaac Adams; 4, Garfield Moore; 5, near mouth of Big Branch. Scale, 1 inch = 5 feet.

correspond to No. 2 of the districts to the north, though without paleobotanic evidence such long-distance correlations have little value. Some of the coal along Brushy Creek contains a thin streak of cannel, as at the bank of Garfield Moore. It shows in general about 3 feet of coal, partly soft bituminous and partly splint. It appears to be persistent in the hills along Brushy Creek to the point where it disappears below drainage level about three-quarters of a mile above the mouth of Big Branch. It is an excellent coal for domestic purposes and furnishes all the inhabitants with fuel. The sections of this coal, measured by the writer, are given in fig. 19.

TECHNOLOGY OF THE COAL MINING.

Most of the mines in this quadrangle are small, none employing more than 75 men and very few averaging as high as 50 men daily throughout the year. The equipment is in most places comparatively simple. All the shipping mines are ventilated by means of furnaces, and drainage is usually natural, by means of ditches. In a few of the mines siphons are used for the drainage, and the occasional use

of hand pumps is reported. None of the mines were reported to be gaseous. In the majority the coal is picked with the ordinary hand picks, but machine mining is practiced at the Torchlight mine, Sullivan compressed-air drills being used.

The width of the entries, the distances at which rooms are turned, and the size of pillars left vary considerably in the different mines. The main headings are run usually 8 or 9 feet wide, and the cross headings are a foot or two narrower. Rooms are turned every 33 feet or thereabouts and vary in width, but most are from 20 to 25 feet wide. The custom seems to be to run the rooms 200 or 250 feet long. The pillars left are from 8 to 13 feet wide.

All the coal is carried from the mines by mules in cars with capacities ranging from 1,200 pounds to 1 ton. Most of the mines have the larger-size cars, but one mine reports the use of a car with a capacity of 1,300 pounds. All the mines are drifts. Most have the ordinary cradle tipple, but that of the Torchlight Coal Company is more elaborate, employing a shaking screen. Most of the coal is shipped as run-of-mine, but it is sometimes screened to suit the buyer. When this is done a small loss, usually not more than 5 per cent, is entailed.

Nearly all of the coal mined in the quadrangle is shipped to places along the local railroad lines. Much of that mined at Rush and Winslow goes to Ashland, where it is used at the furnaces or for domestic purposes. That mined on Lost Creek by the Eastern Kentucky Railway is likewise used along the line or by the railroad itself. The cannel mined by the Kentucky Cannel Company at Boghead and Hunnewell is shipped abroad, where it is used as a gas enricher. Some of the coal mined at the Torchlight mine is shipped to the Pacific coast and other western points.

STATISTICS OF COAL.[a]

The following figures give an idea of the magnitude of the coal industry in this area during the last five years. The figures represent tons of 2,000 pounds each.

Coal production in Kenova quadrangle, 1902–1906.

County.	Loaded at mines.	Sold or used locally.	Total.	Value.	Average price per ton.
1902.	*Tons.*	*Tons.*	*Tons.*		
Boyd	241,127	870	241,997	$193,479	$0.80
Carter	268,056	13,345	281,401	285,271	1.01
Miscellaneous[b]	3,686	586	4,272	5,335	1.25
	512,869	14,801	527,670	484,085	
1903.					
Boyd	245,491		245,491	220,686	.90
Carter	256,321	8,905	265,226	289,130	1.09
Miscellaneous	22,713	1,550	24,263	26,819	1.11
	524,525	10,455	534,980	536,635	

[a] Statistics were obtained from the records of the United States Geological Survey.
[b] Miscellaneous, in each year, includes Lawrence County, Ohio, and Lawrence County, Ky.

Coal production in Kenova quadrangle, 1902–1906—Continued.

County.	Loaded at mines.	Sold or used locally.	Total.	Value.	Average price per ton.
1904.	*Tons.*	*Tons.*	*Tons.*		
Boyd	69,067	28	69,095	58,304	.84
Carter	241,088	3,942	245,030	259,384	1.06
Miscellaneous	23,441	1,200	24,641	26,016	1.06
	373,596	5,170	338,766	343,704	
1905.					
Boyd	46,542	1,762	48,304	37,260	.77
Carter	138,135	7,034	145,169	144,448	1.00
Miscellaneous	10,310	100	10,410	9,750	.94
	194,987	8,896	203,883	191,458	
1906.					
Boyd	46,322	2,500	48,822	38,540	.79
Carter	154,482	4,266	158,748	144,899	.91
Miscellaneous	5,845	70	5,915	5,295	.90
	206,649	6,836	213,485	188,734	

Production at country banks only and for local trade.

County.	1905.			1906.		
	Tons of 2,000 pounds each.	Value.	Average price per ton.	Tons of 2,000 pounds each.	Value.	Average price per ton.
Boyd	516	$456		3,284	$3,931	
Carter	2,367	2,724		2,298	2,392	
Elliott	473	638		272	355	
Greenup	323	372				
Lawrence, Ky	7,621	8,658		2,612	2,348	
Lawrence, Ohio				2,020	2,525	
	11,300	12,848	$1.14	10,486	11,551	$1.10

According to the reports of the State inspector of mines of Kentucky, the production of cannel coal and of coke from 66 ovens in this area for the years 1901 to 1904 was as follows:

Production, in short tons, of cannel coal and of coke, 1901–1904.

	Cannel coal.		Coke.
1901	11,203	1901	23,320
1902	11,339	1902	23,075
1903	8,341	1903	22,323
1904	2,780	1904	17,980

CLAYS AND SHALES.

INTRODUCTION.

The clays of the Kenova quadrangle will be described by horizons, as some are scattered over the entire area, and the description by districts would involve needless repetition. All the clays of northeastern Kentucky have been deposited by the agency of water and are hence called sedimentary clays. They may be divided with regard to both their age and their adaptability into two classes—(1) clays which were deposited in Carboniferous time and are more or less closely associated with coal beds, and (2) recent clays, that is,

those occurring in the present river and stream valleys. The former are by far the more important. For descriptive purposes the clays may be regarded as either plastic or nonplastic; the latter variety is also known as flint clay.

On pages 14–21 of this bulletin will be found a somewhat extended description of the beds in which these clays are found and the way in which they are classified according to their relative ages. The reader is referred to this preliminary description for explanation of many of the terms used in the following discussion. On page 29 also will be found a brief description of the clays, to which the general reader is referred. The following notes are intended for the use of those who are more particularly interested in the clay resources of this region, and hence the description will be given with considerable detail and will be accompanied by sections and analyses. The columnar section on the economic map will show the position of the more important clay horizons.

CLAYS IN THE CONEMAUGH FORMATION.

The clays highest geologically are in the Conemaugh formation. As a rule the plastic clays in this formation are the under clays of coal beds. The Conemaugh coal beds are irregular, both in distribution and in thickness, and the same is true of the associated beds of clay. Clay has been noted at a few horizons, but it is not worked at any place so far as known.

The shales in this formation are abundant and widespread. So far as known these have not been utilized, but it is certain that they are adapted to the manufacture of some types of building brick. They are present in the hills about Ohio and Big Sandy rivers and are conveniently situated with respect to transportation.

CLAYS IN THE ALLEGHENY FORMATION.

CLAY ASSOCIATED WITH VANPORT LIMESTONE.

The clay bed associated with the Vanport ("Hanging Rock") limestone easily outranks all the other clays in the Allegheny formation in distribution, quality, and quantity. This clay bed occurs near the base of the Allegheny; it usually lies from 10 to 40 feet above the top of the Homewood sandstone, or Pottsville formation, between coals Nos. 5 and 6. In the absence of coal No. 5 it may lie even nearer the Homewood sandstone.

Extent.—This clay bed is above drainage level at Coalgrove and Forestdale, Ohio, but the dip to the east soon carries it below drainage level. It has been opened and worked in the hills both east and west of Ashland and also north of Catlettsburg. The dip toward the center of the basin causes its disappearance near the mouth of Big Sandy River, and it does not reappear north of Louisa. From Louisa it occurs in the hills in a great arc, following the outer edge of

the basin and coming back to Ohio River near Ashland. Its horizon is also above drainage level to the east and southeast of Cassville, W. Va.

This economic horizon, the beds at which contain clay, iron ore, and limestone, is indicated on the map (Pl. I) by a red line. It will be understood that the clay is not necessarily workable at all points on this line. The flint clay, which occurs in small amount associated with the plastic variety, will be found a great help in the field in locating these deposits, for, owing to its indestructible character, small fragments of the flint clay usually remain near the outcrops. Its position near the top of the massive Homewood sandstone should serve as an additional help in locating it.

Development.—The following firms work this clay: Petersburg Fire Brick and Tile Company, Coalgrove, Ohio; Ashland Fire Brick Company, W. T. Johnson, and O'Kelly Brick Company, Ashland, Ky.; Weaver Pottery Company, Catlettsburg, Ky.; Willard Fire Clay Company and Frailey & Rice, Willard, Ky. Besides the mines of the above firms, numerous small openings which had been worked in the past and many prospects were located by the writer during this investigation.

Physical character.—The clay at the horizon of the Vanport limestone is plastic, except for the small band of flint clay. The plastic clay is of two grades, the high (No. 1), and the low (No. 2). The flint clay is of slight economic importance owing to its thinness. The two following sections, one measured by G. H. Ashley 1 mile west of Ashland and the other by the writer at Willard, give an idea of the associated beds:

Section of clay bed 1 mile west of Ashland (Ashley).

	Ft.	in.
Sandstone, light brown	20+	
Coal	2+	
Shale, light drab	2	
Clay, light brown	6	
Clay, dark drab	1	6
Clay, drab, with scattered iron-ore concretions (Vanport limestone horizon)	2	
Shale, light drab, sandy	1	2
Shale, drab, ranging up to		8
Clay, dark drab to black, grading into light drab at middle	1	6
Clay, drab	3	
Flint clay		1–4
Clay, drab	3	6
Clay, dark drab, almost black		3
Clay, drab	8	

Four feet from the bottom of the lowest layer is about 1 foot of light-drab flint clay, similar to the best of the Pennsylvania flint clays.

Section of clay bed at Willard, Carter County, Ky.

	Ft.	in.
Fire clay		4
Coal		4
Flint clay, bluish (reported)		4
Clay, dark, plastic	4	
Clay, light, plastic, harder than the above	2	
Vanport limestone:		
Iron ore, red (2 to 4 feet) / Limestone (4 to 6 feet)	10	
Flint clay, thin band, formerly shipped to Olive Hill, Ky., and to Strasburg, Ohio.		

The Willard section differs from that at Ashland in having the workable clay above the limestone, and not both above and below, as in the section measured by Ashley and also in a section measured by the writer at the clay bank of William T. Johnson west of Ashland.

Section at the William T. Johnson clay mine, west of Ashland.

	Ft.	in.
Clay, dark	4	
Limestone ore (locally replaced by 4 feet of limestone), averaging		6
Bone, not always present		2
Clay, light drab	2	

The clay also occurs both above and below the limestone in the opening of the Petersburg Fire Brick and Tile Company at Coalgrove, Ohio, and the following section reported to the writer shows these conditions:

Reported section of clay bed at Coalgrove, Ohio.

	Ft.	in.
Clay, plastic	1	6–8
Clay, soft, plastic (No. 2)	5–6	
Limestone	4	
Clay (No. 1)	1	8

John Peters, president of the company, reports that the beds occupy these relative positions for several miles to the west. In the eastern part of Ashland, at the O'Kelly Brick Company's opening, the following section was measured:

Section of clay bed at the mine of the O'Kelly Brick Company, Ashland, Ky.

	Ft.	in.
Clay, upper, dark	4	6
Coal		4
Clay		3½
Coal		3
Clay	3	6

The siliceous clay given in the section (p. 117) at the base of the Allegheny formation near Louisa and Cassville probably belongs near this horizon. In the section measured at Cassville more than 6

feet of clay is shown, and in the section on the Chesapeake and Ohio Railway about 1 mile north of Louisa about 8 feet of very similar material was measured.

In some places clay at this horizon is suitable for making pottery. A section measured by P. N. Moore at Amanda furnace, about 4 miles northwest of Ashland, shows a layer of pottery clay. This section is as follows:

Section of clay bed near Amanda furnace.

	Ft.	in.
Soil	4	
Clay shale	6	
Coal		4
Clay (No. 2)	3	
Clay, pottery	4	
Clay (No. 1)	3	
Limestone ore		8
Top of Vanport ("Hanging Rock") limestone.		

The product mined near Amanda furnace was shipped to Cincinnati. The only company in this quadrangle using clay from this bed in the manufacture of pottery is the Weaver Pottery Company, located near Catlettsburg. Of the 6 feet of clay measured in the company's bank only the upper 3½ feet is worked, the lower part of the bed being too sandy to give satisfaction. The presence of limestone pebbles has also caused the company some annoyance. When subjected to the baking process the carbon dioxide in the limestone is liberated, causing little particles of the vessel to flake off, and thereby either ruining the vessel or making it of second grade.

Chemical character.—The character and color of the clay in the different benches is, as a rule, fairly uniform. The fracture is rather irregular, and the clay is somewhat hard, but becomes soft on exposure and afterward makes better brick. The following analyses indicate the chemical character of this clay:

Analyses of clay associated with the Vanport ("Hanging Rock") limestone.

	1.	2.	3.
Silica (SiO_2)	60.54	40.14	56.40
Alumina (Al_2O_3)	25.89	43.72	28.00
Ferric oxide (Fe_2O_3)	1.75	1.98	
Manganese oxide (MnO)	.26		
Lime (CaO)	.53	1.60	1.30
Magnesia (MgO)	.12		
Potash (K_2O)	1.85		
Soda (Na_2O)	.65		
Water (H_2O)	2.05	12.56	14.30
Loss on ignition	7.43		
Sulphuric anhydride	.12		
	101.19	100.00	100.00

1. Willard, Carter County, Ky. Analysis made at the structural materials testing laboratory, United States Geological Survey, St. Louis, Mo. C. H. Stone, analyst.
2. Upper stratum of clay at Vanport limestone horizon, Ashland, Ky. Robert Peter, analyst.
3. Lower stratum of clay in No. 2.
Analyses 2 and 3 were kindly furnished by the Ashland Fire Brick Company.

Applications.—As observed from the sections, most of the clay at this horizon is of No. 2 quality. It is used chiefly as a bond in the manufacture of fire brick and to a less extent for blast-furnace crucibles, boshes, coke-oven brick, etc. For the first-named purpose it is used by the brick companies at Ashland and Coalgrove. The product mined at Willard is shipped chiefly to Olive Hill, where it is mixed with flint clay to make a first-grade fire brick. The Willard fire brick is esteemed very highly by the clay men at Olive Hill. The Ashland Fire Brick Company has to import flint clay to make its high-grade refractory products. To make first-class refractory brick 67 to 80 per cent of flint clay is used, depending on the use to which the product is to be put, the remainder being plastic clay. For second-grade articles these proportions are reversed. It has been estimated that probably 500 to 700 pounds (according to the way the clay is used) will be sufficient to make 1,000 regulation 9-inch brick, when this clay is used alone as a binder. Its use in the manufacture of pottery has been referred to.

OTHER ALLEGHENY CLAYS.

Near North Kenova, Ohio, a clay was worked thirty years ago and hauled to Burlington and South Point, where it was used in making pottery. The old clay mines are now entirely fallen shut. The clay is 25 feet above No. 8 coal and directly below a massive sandstone, thus occupying a position near No. 9 coal. This correlation is strengthened by its distance of about 85 feet above the Sheridan coal. This is the only known occurrence in the area of a workable clay at this horizon.

At Cassville, W. Va., a flint clay has been prospected at a horizon lower than the above, in the hills north of the depot, by Frank Yates, of Louisa. It is found at an elevation of about 80 feet (barometric) above the tracks of the Norfolk and Western Railway, and about 100 feet below the base of the massive Mahoning sandstone near the top of the hill.

Section of Yates clay pit, Cassville, W. Va.

	Feet.
Cliff of brown, fine-grained, argillaceous sandstone.	
Shale, olive drab	5
Clay, drab, with numerous nodules of iron or lime, 2 to 4 inches in diameter, and distributed in lines	4½
Clay, drab, granular near crop, smooth farther back	1½
Clay, light drab, soft, plastic, smooth at back of pit, breaking with subflinty fracture, at crop apparently typical flint clay	2½
Clay, dark drab, hard, sandy	1
Clay, drab	3
Clay, brownish red	5

The same clay was also observed at a few points in the hills along Mill Creek and is reported 4 feet thick at one point. This flint-clay horizon is certainly worthy of very careful prospecting.

Other clays locally workable undoubtedly exist in the Allegheny formation. Many shale beds also appear promising and will probably be used in the future for paving bricks, sewer pipes, and other purposes where inferior material may be utilized.

CLAYS IN THE POTTSVILLE FORMATION.

SCIOTOVILLE CLAY.

In the Pottsville formation, as in the Allegheny, one clay bed stands preeminently above the rest as regards quality, distribution, and thickness. This is the Sciotoville fire clay of the Ohio Geological Survey reports, less commonly known as the Logan clay. It has been extensively mined at Sciotoville and Portsmouth, Ohio. It occurs a few feet above the Maxville limestone, but this limestone and the beds immediately above it are very sparsely distributed in this quadrangle. On the map (Pl. I) the red line drawn on Everman Creek, Carter County, just at the western edge, and the red line on Tygarts Creek indicate the extent of this horizon above drainage in this area and also where it may be looked for. On Everman Creek, a short distance above the residence of David Childers, 4 to 6 feet of nonplastic clay shows and has been mined. A short distance below Mr. Childers's house the limestone outcrops in the road, apparently directly below the massive Sharon sandstone. The clay was not observed here. It was reported to G. H. Ashley as being 5 feet thick and resting directly against the limestone on North Fork of Oldtown Creek, and as usually being present without the limestone in the hills east of Tygarts Creek. West of Tygarts Creek the limestone is reported as generally present, but little seems to be known of the clay.[a] This horizon may be looked for along the western outcrop of the coal measures, occurring, as it does, at the base of this series of rocks. Where present it will usually be found a few feet above the Maxville limestone or, in the absence of this bed, occupying a similar position above the sandstones of the Waverly. Though its outcrop area in the Kenova quadrangle is extremely small, a few miles to the west its horizon is above drainage level in nearly the entire valley of Tygarts Creek. At Olive Hill, in Carter County, it is now extensively worked by the Portsmouth Harbison-Walker Company and the Olive Hill Fire Brick Company, and it shows the following section at one of the openings of the former firm:

Section of clay bed at Olive Hill, Carter County, Ky.

	Ft.	in.
Coal		2–6
Clay, No. 3	1–9	
Clay, drab flint (No. 1)	1–9	
Clay, "semihard" (No. 2)	1–5	

[a] These statements refer to the territory within the Kenova quadrangle.

	Ft.	in.
"Pink eye"	3	
Shale, blue	1	6–8
Iron ore		4–8
Top of Maxville limestone.		

This order of superposition is usually maintained in this district. It will thus be seen that there may be four distinct varieties of clay present in this noted bed. Of these the nonplastic or drab flint clay is by far the most important and becomes the basis of refractory materials of the highest grade. The layer known as "semihard" is on a par with the clay at the horizon of the Vanport ("Hanging Rock") limestone, already described, though by some of the clay workers the Vanport limestone clay, at least at some points, is considered superior. The "semihard" is a plastic or No. 2 clay and is mixed with the flint clay in various proportions, depending on the desired quality of the product. No. 3 clay is also plastic, but of inferior quality to No. 2, while that called "pink eye" may be worked up into bricks, but the product is off color. The following analyses indicate the very high grade of the flint clay at this horizon, the percentages of silica and alumina approaching the theoretical values in kaolinite:

Analyses of Sciotoville flint clays of Kenova quadrangle.

	1.	2.	3.
Silica (SiO_2)	50.95	48.56	46.75
Alumina (Al_2O_3)	39.49	37.471	38.17
Iron oxide (Fe_2O_3)		Trace.	Trace.
Lime (CaO)		.112	.17
Magnesia (MgO)	.28	Trace.	Trace.
Phosphoric acid (P_2O_5)		.225	
Potash (K_2O)	.30	.289	Trace.
Soda (Na_2O)		.283	
Water (H_2O)	9.18	[a]13.030	14.03
	100.20	100.000	99.12

[a] Expelled at red heat.

1. Sciotoville fire clay. N. W. Lord, analyst; Ohio Geological Survey, vol. 7, 1893, p. 58.
2. Ridge between Grassy and Three Prong creeks, Carter County, Ky. Sample collected by P. N. Moore; Robert Peter, analyst; Report on eastern coal field: Kentucky Geol. Survey, vol. C, p. 10.
3. Near Olive Hill, Carter County. Analysis furnished by Ashland Fire Brick Company.

OTHER POTTSVILLE CLAY BEDS.

There are other clay beds below the Homewood sandstone, but they have not come into prominence. One of these is the clay associated with No. 4 coal, which lies under the Homewood sandstone. This coal and its underlying clay outcrop in the eastern part of Ashland, and the coal has been worked in a small way at many places on the road approaching the cemetery. In the summer of 1905 the O'Kelly Brick Company opened the coal and clay and began to utilize the clay at

its brick plant in the eastern part of the city with satisfactory results. The following section was measured at the opening:

Section of coal and clay below the Homewood sandstone in the eastern part of Ashland, Ky.

	Ft.	in.
Sandstone, massive.		
Coal	1	6–7
Clay		10
Coal		8–9
Clay	2½–4	

The same bed of coal, with its underlying clay and clay parting, also occurs on Catletts Creek, and there is no reason why this clay should not be exploited in connection with the coal here, unless it be its relatively great distance from transportation.

In the hills about the head of Johns and Field branches, Carter County, a few prospect holes have been made on a bed of clay lying a few feet below the Homewood sandstone. This position is similar to that of the clay occurring in the eastern part of Ashland and on Catletts Creek. On the land of Judge John W. Barber 4 feet of sandy clay was measured at a prospect which had not penetrated the bed far enough to reveal its real character and thickness. This bed should be further prospected in these hills.

RECENT CLAYS.

The recent clays are found in the flood plains of the rivers and small streams and are very common, many small streams having flood-plain deposits which extend well up to their heads. These flood-plain clays are very erratic in their distribution in the valleys of the larger streams, and there is no means of pointing out where they are most likely to occur. They range in thickness from 1 foot to over 4 feet. Often in working a clay bed a sandy clay is encountered, which makes "dead" brick. These streaks of sand are also utilized by the brick manufacturers, but for certain purposes this sand has been found unsuitable owing to the intermixture of particles of coal. The deposits worked at present are confined to the valley of Ohio River in the vicinity of Ashland, where there is a local market, cheap coal, and transportation facilities. The flood-plain clay is used chiefly for ordinary red building brick, though it is adapted to the making of tile, shingles, fireproofing, etc. It is made into brick at the Means-Russell plant, west of Ashland, and by the J. J. Gates Company and the O'Kelly Brick Company in the eastern part of the city. The smaller flood plains contain clays which perhaps will not compare in quality with those of the larger river valleys, but which may be worked up into material suitable for local country use. F. R. Bussey has utilized such material from the flood plain of Harriet Branch of Little Blaine Creek. The deposit is here only 4 feet thick, but it illustrates the possibilities existing on all the smaller creeks. Flood-plain

deposits along Big Sandy and Little Sandy have not even been prospected. Undoubtedly valuable deposits of clay exist along both these streams, and they may be utilized later for common and pressed brick, tile, paving brick, sewer pipe, etc. Experiments having in view the adaptability of these flood-plain clays to the various purposes enumerated above should certainly be carried out.

TECHNOLOGY AND STATISTICS.

All the clay mines in this area are drift mines, in which the workings are very irregular. The mines are drained either naturally or by siphon and pump, and ventilation is either natural or by furnace. In mining the clay the upper part of the bed is usually shot out by powder or dynamite and the lower part pried up. The clay is hauled from the mine in ordinary mine cars drawn by mules. The following table will give an idea of the magnitude of the clay industry in this region during the last five years:

Statistics of clay products in the Kenova quadrangle, 1902–1906.

Year.	Quantity of brick, including fire, vitrified, and common building brick.	Total value.[a]
	Thousands.	
1902	10,587	$133,633
1903	12,736	179,221
1904	14,861	92,354
1905	11,574	128,400
1906	12,826	152,631
	62,584	686,239

[a] These figures include values of pottery also. The figures were obtained from the files of the United States Geological Survey.

The seeming discrepancies in the above figures are due to variations in the amounts of fire brick and ordinary red building brick produced. For instance, the figures indicate a very unusual production of the more valuable fire brick in 1903, followed by a falling off in this commodity and an increase in the production of the less valuable ordinary red building brick in 1904.

It has been found inexpedient to separate the statistics of the fire brick and other varieties, owing to the small number of manufacturers of fire brick during some of the years. For the same reason it has been thought inadvisable to tabulate the statistics of the production of raw clay. The United States Geological Survey has figures for this product for only 1905 and 1906, and the industry is yet in its infancy. It is probable that it may never grow to great proportions, as most of the clay will continue to be worked up near the mines to satisfy home consumption. During 1905 and 1906, 20,168 tons of

clay, of 2,000 pounds each, valued at $11,855, were shipped from the clay mines. All this has come from the clay at the horizon of the Vanport ("Hanging Rock") limestone.

MARKET.

The market for the clay products of this area is rather local. Most of the red building brick is used at home or shipped to the neighboring towns in West Virginia and eastern Kentucky. The fire brick is either used locally at the furnaces in Ashland or shipped up or down Ohio River, along which there is considerable demand for such material.

LIMESTONES AND IRON ORES.

INTRODUCTION.

The iron ores of the Hanging Rock region of Kentucky were of great importance in the seventies and eighties, but owing to the introduction of cheaper ores from Alabama and the Lake Superior country, and to the gradual disappearance of the forests on which the charcoal furnaces depended, the iron industry of this region has declined, and at present no furnaces depending on the local ore supply are in operation. (See Pl. V.) The ore diggings are now fallen in, and in many places have entirely disappeared, so that it is not easy to trace them. The following descriptions are therefore necessarily brief, especially those relating to the block and kidney ores, which at present are not worked at all. For fuller descriptions of the iron ores as a whole the reader is referred to P. N. Moore's report in vol. C of the Kentucky Geological Survey, from which the writer has freely drawn.

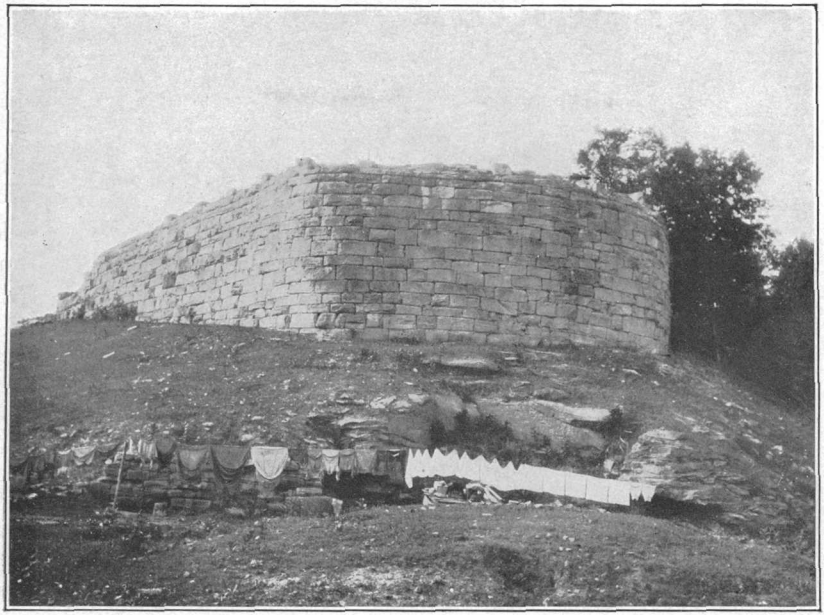
Where the iron ores are better known than their associated limestone beds the description of the limestones is made subsidiary.

IRON ORES.

GENERAL OUTLINE.

The iron ores of this region are chiefly earthy carbonates, spathic ores, or siderites, but on the outcrop and at variable distances in, depending largely on the porous or nonporous character of the roof, the ores have been altered to the hydrous ferric oxide, limonite. The ores may be classified as follows: (1) Limestone ores, (2) block ores, (3) kidney ores, (4) black band ores.

Limestone ores are those which occur upon or very near the top of a limestone stratum. In many localities they occupy a broader field than the limestone, but the term is still applied if the ore occurs



A. ABANDONED PRINCESS FURNACE.

B. ABANDONED BELLEFONT FURNACE, SHOWING RUINED HEAD WORKS.

near the stratigraphic position of the limestone. In eastern Kentucky these ores occur at two horizons—the lower associated with the Maxville and the higher with the Vanport limestone. Owing to their purity, uniformity, richness in iron, and ease in working they have been among the most highly valued of all the iron ores in this region.

Block ore and kidney ore are so called from their physical appearance. The former cleaves into more or less square or rectangular prisms when raised from its bed; the latter derives its name from its peculiar kidney shapes. Both varieties occur as unaltered carbonates or siderites, except where oxidized to limonites on or near the outcrop. The term "black band" is applied to beds of carbonate of iron with more or less bituminous and earthy matter associated.

Geologically these ores occur throughout the Carboniferous rocks in the Kenova quadrangle, but the most important are found in the two lower formations, the Allegheny and the Pottsville. These iron ores are all bedded deposits in the sense that they occur at fairly well-defined geologic levels, which are persistent over broad areas. The skeleton section (fig. 20) shows their relative position.

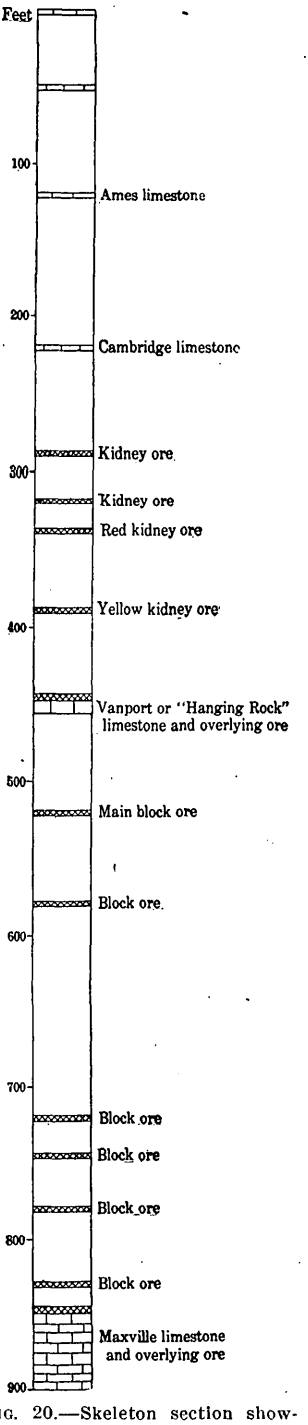


FIG. 20.—Skeleton section showing relative position of limestone and iron ores.

LIMESTONE ORES.

VANPORT LIMESTONE ORE.

Geologic position.—The higher of the important limestone ores is that associated with the Vanport ("Hanging Rock") limestone and hence known as the Vanport limestone ore. It is often known also as the red limestone ore and in the Kentucky Geological Survey reports as the "Ferriferous" limestone ore. It occurs from 10 to 40 feet above

the top of the Pottsville, between coals Nos. 5 and 6, the latter being known about Ashland as the "limestone coal" on account of this fact.

Extent.—The Vanport ore horizon is found in both Ohio and Kentucky. In Ohio its outcrop area is small in this quadrangle, but it is very extensive to the north and west. As it lies so near the top of the Pottsville, structure contours drawn on the latter hypothetical plane apply equally well for this ore horizon and for its associated limestone and plastic clay. Moreover, the red line drawn on Pl. I to represent the outcrop of the clay represents equally well the iron ore and limestone. Immediately south of Ohio River its western limit is beyond the border of this quadrangle and is reported by Moore as being about a mile below Amanda furnace, a few miles northwest of Ashland. The main western outcrop in the Kenova quadrangle appears at its northern edge in the hills between Little Sandy River and East Fork and continues southwestward to the point where the boundaries of Elliott, Lawrence, and Carter counties come together. From this point the general trend of the outcrop is southeastward beyond Big Sandy River. In Boyd, Greenup, and Carter counties much of the ore at this horizon has been removed along the outcrop, but good ore was seen in Lawrence County near the town of Blaine and in the hills between Adams and Prosperity.

Character.—Though the red line indicating the position of the Vanport limestone and its associated clay and iron ore has been drawn continuously on the economic map, this by no means indicates that the ore and limestone will be found continuously. On the contrary, it is known that the limestone and the accompanying ore are in many places not present, and where present are locally variable in thickness. The ore rests on the top of the limestone, and the bounding surface between ore and limestone, according to Moore, is very irregular, being full of little ridges and depressions. The limestone ranges up to 8 feet in thickness, but may be absent where the ore is present. The ore itself ranges from a few inches to a few feet in thickness, but may be pockety and the pockets may be several feet thick. The section of fire clay at Willard, Carter County, and at William T. Johnson's clay mine, west of Ashland, and Moore's section at Amanda furnace illustrate the thickness and associations of the ore and limestone.

The limonite ore occurring at the outcrop is usually brown or red, more commonly the latter, and in general dense and close grained. The red ore is the more valuable. The carbonate or unaltered ore is dense, close grained, and bluish or grayish in color, and therefore is known as the blue limestone or the gray limestone ore. Most of the furnaces used the limonite ore, as the furnace men were unable to produce a coarse-grained foundry iron from the carbonates. The

following analyses illustrate the character of both the limonitic and the sideritic phases of the limestone ore:

Analyses of limestone ores of Kenova quadrangle.

	1.	2.	3.	4.	5.	6.	7.
Ferric oxide (Fe_2O_3)	57.551	51.802	71.680	60.206	None.	65.395	31.544
Iron carbonate ($FeCO_3$)	----------	10.594	----------	----------	62.002	None.	30.708
Alumina (Al_2O_3)	6.017	4.523	4.155	1.044	2.900	3.484	1.779
Manganese oxide (MnO)	[a].130	----------	.090	Trace.	Not est.	Not est.	----------
Manganese carbonate ($MnCO_3$)	----------	Trace.	----------	----------	.553	----------	.060
Calcium carbonate ($CaCO_3$)	.150	7.480	.380	.285	6.880	8.580	2.730
Magnesium carbonate ($MgCO_3$)	.758	.440	.050	.381	2.243	[b]1,938	.141
Phosphoric anhydride (P_2O_5)	.057	.570	.084	.161	.149	.441	.421
Sulphuric anhydride (SO_3)	.105	.089	.270	.852	.302	.336	.491
Silica (SiO_2) and insoluble silicates	25.450	15.730	12.650	25.930	22.660	10.480	25.430
Combined water (H_2O)	10.300	8.772	10.800	[c]11.141	----------	9.346	6.523
	100.518	100.000	100.159	100.000	97.689	100.000	100.000
Metallic iron (Fe)	40.285	41.357	50.176	42.144	29.932	45.776	36.627

[a] Brown oxide of manganese. [b] Magnesia. [c] And loss.

1. So-called slate ore, occupying the place of the limestone ore, from ridge between Cane Creek and Wilson Creek. Hunnewell furnace. Kentucky Geol. Survey, vol. A, pt. 1, p. 114. Robert Peter and J. H. Talbutt, analysts.
2. Limestone ore from Hoods Creek near Bellefont furnace. Idem, p. 20.
3. Limestone ore from the Graham bank, near Willard, Carter County. Average sample from the stock pile. Idem, p. 55.
4. Limestone ore from Brush Creek, Pennsylvania furnace. Idem, p. 114.
5. Gray limestone ore, from J. P. Jones's drift near Ashland. Selected from the interior of the bank. Idem, p. 37.
6. Same as No. 5, but from exterior portion of the bank. Analyses 5 and 6 show well the changes which occur when the original ore is exposed to the atmosphere and surface waters.
7. Gray limestone ore from Mount Savage furnace, Carter County. Idem, p. 51.

Analyses 1 to 4 and 6 represent limonites; 5 and 7 carbonates.

The analyses given above will also be found in P. N. Moore's report on the iron ores of Boyd, Greenup, and Carter counties.[a] The samples were collected by Mr. Moore.

The following table shows more concisely the amounts of metallic iron, sulphur, and phosphorus in both varieties of ore at the principal limestone ore horizons:

Average iron, sulphur, and phosphorus content in limestone ores.

Name of ore.	Constituent.	Limonites.		Siderites.	
		Per cent.	Analyses averaged.	Per cent.	Analyses averaged.
Vanport ("Hanging Rock") limestone ore	Metallic iron	43.49	4	30.61	2
	Sulphur	.132	4	.15	2
	Phosphorus	.090	4	.174	2
Maxville limestone ore	Metallic iron	47.79	7	35.05	4
	Sulphur	.089	2	.81	3
	Phosphorus	.147	7	.20	4

The amounts of ferric oxide and iron carbonate in the analyses at the top of this page show the fundamental difference between the oxidized and unoxidized ores. The amount of metallic iron in the

[a] Kentucky Geol. Survey, vol. C, 1884, pp. 90, 92.

limonites ranges in general from 40 to 50 per cent, rarely going above or below these limits. In the unaltered ores the metallic content is much lower, ranging from 25 to 40 per cent. The remaining constituents are variable, but silica and insoluble silicates are high. Sulphur is low, except in analysis No. 4; phosphorus is in general high. The last table also indicates these facts.

MAXVILLE LIMESTONE ORE.

Geologic position.—The lower of the important limestone ores rests directly upon the Maxville limestone, as shown by the section obtained at Olive Hill, Carter County (pp. 118–119).

Extent.—The limestone itself is above drainage level in the valleys of Everman Creek, North Fork of Oldtown Creek, and Tygarts Creek, in the northwest corner of the quadrangle. It is of very scant extent in this area, but to the west and nothwest its outcrop is generally above drainage level. The red line on the map (Pl. I), representing the fire clay lying above the limestone, may be taken also to represent the top of the Maxville limestone and its overlying ore, where the latter is present.

Character.—Where exposed on Everman Creek the limestone is from 20 to 25 feet thick. West of the area it is much thicker, locally reaching 100 feet and more, but in some places it is entirely wanting. Many of the deeper wells drilled for oil and gas have penetrated this limestone and proved it to be very thick and generally persistent over all this area. Sections of these deep wells are given on Pl. VI. The limestone is the usual bright-gray variety, and has been burned and used for fertilizer, for which purpose there seems to be an ample supply. It is not improbable that it may also prove suitable for the manufacture of Portland cement.

The iron ore overlying this limestone is erratic in occurrence and thickness, and in these respects is like the ore associated with the Vanport (" Hanging Rock ") limestone. In quality it is comparable with that ore, and its content of metallic iron in its altered and unaltered phases is similar to that of the higher ore. It is apt to be more siliceous than the Vanport ore and in many places contains too much sulphur. On the whole it has proved to be one of the most valuable ores in this part of Kentucky.

ORIGIN OF LIMESTONE ORES.

An extended description of the origin of the limestone ores is hardly appropriate in this bulletin. For those interested in the theoretical side of the subject Moore's description[a] will be found most interesting and suggestive. As a result of studies made by the writer

[a] Kentucky Geol. Survey, vol. C, 1884, pp. 83–88, 94.

in the course of mapping this region in the summer of 1905, certain conclusions were reached which are summarized in an article in Economic Geology.[a]

BLOCK ORES.

Geologic position.—Most of the block ores are found in the Pottsville formation and in the lower part of the Allegheny formation. They have been separated by Moore into two groups with reference to their stratigraphic position—the upper block ores and the lower block ores. The former occupy the interval from 90 feet below the Vanport limestone to about 50 feet above it, and the lower block ores are confined to the lower 125 feet of the Pottsville. The skeleton section (fig. 20, p. 123) shows their relative positions.

Extent.—The area in which the block ores occur is along the western and southern edges of the quadrangle, chiefly west and south of the line of outcrop of the Vanport limestone. The lower block ores are mostly confined to the territory west of Little Sandy River, but the area occupied by them in this section of the quadrangle is a small part of their extent in this portion of the State. The upper block ores are more widely distributed in this particular area, their boundary extending to the east beyond that of the lower block ores and the Vanport limestone.

Character.—Like the limestone ores, the block ores occur both in the oxidized condition and as unaltered carbonates. They are characterized by being more persistent than the limestone ores and by more uniform thickness in individual beds, but they vary greatly in thickness and quality among themselves. Their most common impurity is sand. They are leaner ores, as a rule, than the limestone ores, and the lower block ores are inferior to the higher block ores. Their richness in iron apparently bears an inverse relation to their thickness, for it has been commonly observed that the leanest ores are the thickest, and vice versa. The following table shows their content in metallic iron, sulphur, and phosphorus:

Average iron, sulphur, and phosphorus content in block ores.

Kind of ore.	Constituent.	Limonites.		Siderites.	
		Per cent.	Analyses averaged.	Per cent.	Analyses averaged.
Upper block ores	Metallic iron	43.85	12	34.42	4
	Sulphur	.204	10	.444	4
	Phosphorus	.161	10	.229	4
Lower block ores	Metallic iron	33.48	10	29.74	4
	Sulphur	.137	9	.088	4
	Phosphorus	.238	9	.159	4

[a] Phalen, W. C., Origin and occurrence of certain iron ores of northeastern Kentucky: Economic Geology, vol. 1, No. 7, 1906, pp. 660–669.

KIDNEY ORES.

Geologic position.—Most of the kidney ores which have proved of value have been found in the lower part of the Allegheny formation. The more important range from about 40 or 60 feet to 100 feet above the Vanport limestone. In this interval there are from three to six beds of kidney ore of local importance. The lower of the more important ores has been called the yellow kidney ore. It lies about midway between the Winslow coal and the Coalton coal. Since most of the oxidized kidney ore has a yellow color, due to limonite, this name is not distinctive, but it has been commonly applied to the ore at this particular horizon. About 50 feet above the yellow kidney ore and 25 to 30 feet above the Coalton coal is another horizon of fairly persistent kidney ore called the red kidney ore, from the prevailing color of the weathered material. Other kidney ores occur in the Allegheny formation above the red kidney, but they are not so important as the two just mentioned.

Extent.—The western and southern boundaries of the kidney ores coincide roughly with the line representing the outcrop of the Vanport limestone and clay. Beyond this boundary, to the south and west, these ores are of minor importance. Within the arc formed by the outcropping Vanport limestone and clay these ores will be found in a zone of a mile or more in width. They occur in the hills along Ohio River and generally over the northern part of Boyd County, where they have been extensively benched. They are found in Carter County near Willard and also in the region between Little Sandy River and East Fork. In Lawrence County, as a rule, they have been very little explored.

Character.—The name of these ores is very suggestive of their physical appearance. Though occurring at perfectly distinct geologic levels, they do not form continuous beds or layers of ore, but are scattered through zones from 3 to 6 feet thick. Like the limestone and block ores they are found in all stages of transition from the pure carbonate ore, unaltered by atmospheric influences, to practically pure limonite on the outcrop. Their origin seems to be fairly obvious. It is quite probable that they have originated in much the same way as limestone and other concretions—that is, by the gradual accretion of ferrous carbonate from the surrounding beds. This segregation has probably been chiefly lateral, for otherwise the definiteness of geologic level, which is so common, would hardly persist, and the kidneys would be scattered throughout the shale and sandstones. The fact that the nodules coalesce into peculiar shapes strongly suggests such origin. Furthermore, the beds whence the nodules must have derived their ferruginous matter must have been rich in iron. These beds thus represent a period of deposition of

highly ferruginous sediments. Analyses of five samples of oxidized kidney ore collected in this region give the following averages: Metallic iron, 43.372; sulphur, 0.049; phosphorus, 0.166. These figures show that these ores are comparable with the limonite phases of the limestone and block ores.

BLACK-BAND ORES.

The term black-band ores is applied to beds of carbonate of iron with more or less bituminous and earthy matter associated. A notable occurrence of this ore is on the property of the Torchlight Coal Company on Levisa Fork, in Lawrence County. The deposit lies about 15 feet below coal No. 4 and is from 8 to 12 feet thick, consisting of layers of black or carbonaceous siderite, from 1 inch to 3 inches thick, alternating with thin layers of bituminous shale. The ore, which carries 55.12 per cent of iron carbonate, compares favorably with the Scotch black-band ores. An analysis of the ore from this locality follows, together with analyses of a similar ore from Perry County, Ohio, and of one from Scotland. These were kindly furnished by Col. Jay H. Northup, of Louisa.

Analyses of black-band ores.

	Threemile Creek, Kentucky.	Perry County, Ohio.	Scotch black band.
Iron carbonate ($FeCO_3$)	55.12		
Ferrous oxide (FeO)		43.37	
Ferric oxide (Fe_2O_3)	9.12	4.10	36.59
Manganese oxide (MnO)	2.90	1.50	2.70
Alumina (Al_2O_3)	3.26	6.05	.29
Lime (CaO)	6.12	3.00	3.24
Magnesia (MgO)	1.92	.25	1.92
Carbon dioxide (CO_2)		30.50	19.09
Phosphoric acid (P_2O_5)	Trace.	Trace.	
Sulphide of iron (FeS_2)	.78	1.56	1.63
Water (H_2O)		.58	.84
Organic matter	10.25	6.25	18.02
Insoluble residue	9.18	2.80	9.91
	98.65	99.96	94.23
Metallic iron	36.96	36.49	25.63

SUMMARY.

The ores of this part of Kentucky practically ceased to count as sources of iron some time ago. In spite of this fact it has been thought advisable to give a brief outline of their geology and occurrence. Though they have little value at present, they may be more important in the future. When the various ore beds were worked, the oxidized material at or near the outcrop was sought for, as the furnace managers were professedly unable to work the blue or gray carbonate and produce the desired coarse-grained foundry iron. The oxidized ore was obtained by benching or stripping, a process which,

though economical for ore occurring at the outcrop, could not be carried into the hills for any distance, and thus but an insignificant percentage of the ore bodies has been removed from the hills. The remaining ore is largely iron carbonate. It is very likely that when the cheaper ores now on the market become scarce and prices advance the higher grades of these ores will be worked. To reach satisfactory results the mining methods employed must be studied most carefully, but the fact that similar thin beds of iron ore have been successfully worked in Europe is significant.

LIMESTONES.

Brief descriptions have been given of two limestones, the Vanport ("Hanging Rock") limestone near the base of the Allegheny formation and the Maxville limestone underlying the Pottsville. The Conemaugh contains higher beds of limestone, a few of which are persistent and are hence of value in unraveling the stratigraphy. Some of these beds are also of local economic importance.

The lowest limestone in the Conemaugh is the most persistent of all. It usually lies very near the top of the Mahoning sandstone, or, rather, the group of sandstone lying at the base of the Conemaugh formation. It is very widespread, but not everywhere a typical limestone in its development. Along Big Sandy River it may be traced rather continuously from the mouth of Dock Creek to Roundbottom. At some points along this stretch it is a calcareous sandstone 4 to 5 feet thick, containing abundant crinoid stems and other fossils. About one-eighth of a mile below Lockwood on the Kentucky side it has much the same character, but here it is weathered and dark in appearance and crumbles easily under the hammer. In the hills back of Cassville it is a fossiliferous shale and is closely underlain by a thin bed of coal, called the Mason coal by I. C. White,[a] and probably correlating closely with the Brush Creek coal of western Pennsylvania. Throughout the southern part of Boyd County it is very persistent, but much of it is too sandy to burn for fertilizer. In the hills east and west of Willard and on most of the streams flowing into Little Fork from the east it is 4 to 5 feet thick. In this region it is siliceous and does not react with acid on the weathered surface, but on being broken it is found to contain much lime. At Willard it occurs 180 feet above the Coalton coal and about 230 feet above the Vanport limestone. When burned this limestone will probably yield a fairly satisfactory fertilizer. This limestone is probably the representative of one of the Cambridge limestones of the Ohio Geological Survey. The horizon is in many places char-

[a] West Virginia Geol. Survey, vol. 2, 1903, p. 280.

acterized by two calcareous beds lying a small distance from one another, as indicated in the following section:

Section of Cambridge limestone 1 mile west of Potomac on Whites Creek.

	Ft.	in.
Concealed.		
Sandstone, fossiliferous	4	
Shale	14	
Limestone, crinoidal		6
Shale, blue	1	

A short distance away, near the residence of J. L. Bowling, the following section was measured:

Section of limestone near residence of J. L. Bowling, west of Potomac, Ky.

	Feet.
Sandstone, massive	30
Concealed	15
Sandstone, laminated	2
Concealed	23
Sandstone, fossiliferous	4
Shale	23
Limestone	1
Shale	5

The fossiliferous sandstone and the limestone lying from 14 to 23 feet below may represent the upper and lower Cambridge limestones of Ohio.

About 80 to 100 feet above the Cambridge limestone is another limestone, also largely siliceous, which probably corresponds to the Ames of the Ohio and Pennsylvania surveys. It is seen at many places on the headwaters of East Fork of Little Sandy and is rather persistent in the hills east and southeast of Cassville, W. Va. In the latter region much of it is characterized by calcareous pebbles on its outcrop. This limestone is possibly valuable for fertilizer and may repay careful prospecting. Other limestones have been observed higher in the Conemaugh at 70 and 120 feet above the Ames. These higher Conemaugh limestones are generally characterized on their outcrops by the presence of a few limestone pebbles. Like the lower limestones, they may prove locally valuable.

BUILDING STONE.

The only rock suitable for building stone in this area is sandstone, and of this there is a great abundance. As a rule this rock will not bear the cost of transportation, but as a local building stone it has proved of value in the construction of culverts for the railroads which pass through the area and also in the construction of chimneys, fireplaces, etc., all through the country. Some of this sandstone has also been used in the construction of dwellings. Very little of it, if

any, can be cut into blocks of any considerable dimensions, but for rougher purposes it serves as a cheap and very accessible source of supply.

Most of the sandstone in this area is micaceous, much is feldspathic, and as a rule it contains iron oxide. It ranges from very fine-grained to conglomeratic, in which few of the quartz pebbles exceed an inch in their largest dimension. A large amount of this sandstone is friable, disintegrating readily to fine sand. Such rock was used in the construction of a residence and of a building in Ashland, and so far as known proved satisfactory. It would appear, therefore, that freshly cut blocks, even of this friable sandstone, season fairly well and become resistant.

In the Conemaugh formation the most important sandstone lies at its base and is known as the Mahoning sandstone. This sandstone is well exposed along Big Sandy River near its mouth, in both Kentucky and West Virginia. Near Kenova it appears to be thick bedded enough to supply dimension stone. At this point, besides being very massive, it is very coarse grained and locally conglomeratic. It has been used by the Norfolk and Western Railway in this locality. To the south, up Big Sandy River, it is above drainage level nearly to the mouth of Dock Creek in West Virginia and to Savage in Kentucky. In building the Norfolk and Western Railway and in the recent changes in grading the Chesapeake and Ohio Railway much of this rock has been used. A higher sandstone in the Conemaugh formation has been quarried for local purposes on Whites Creek, near Egypt. The Conemaugh also contains other sandstone beds which, though suitable for local purposes, are not sufficiently valuable to export.

Sandstone from the Allegheny formation has been used along Ohio River opposite Ashland. At this point the sandstone above the Coalton coal thickens abnormally and has been quarried by the Norfolk and Western Railway for use along its line. It has furnished much rock of fair dimensions.

The Pottsville formation contains many sandstones of considerable thickness, much of which has been used in the construction of the Norfolk and Western Railway along Tug Fork, and by the Chesapeake and Ohio Railway on Levisa Fork. The Homewood or upper sandstone member of this formation outcrops near Ashland and occurs as a very massive cliff between the eastern limits of the city and Cliffside Park. The rock has been used with very satisfactory results in the construction of dwellings. Lower sandstones of the Pottsville have proved locally valuable.

GLASS SAND.

Some of the sandstones in this quadrangle may be of sufficient purity to furnish raw material for making glass, but most of them appear to be too ferruginous for such a purpose. Some of the sand found in the flood-plain deposits may, when washed, also prove suitable. A deposit of the latter type was reported on the property of Samuel Ferguson, at North Kenova, Ohio. The Mahoning sandstone and the Homewood and other sandstones in the Pottsville appear to be of sufficient purity in places for glass making, but no definite statement can be made as to the suitability of this material at any particular point. The Mahoning near Willard and the Homewood near Mount Savage may repay careful prospecting for glass sand. Before pronouncing on the fitness of sandstone or loose sand for glass making it should be examined microscopically and chemical tests should be made to determine the amount of iron, which, if present in too large quantities, renders the glass opaque. Large amounts of aluminum and magnesia also have a deleterious effect. Better than either of these tests is a practical test of the material. It should be remembered also that some sandstones, though naturally too rich in iron for glass making, yield after crushing and washing a suitable raw product.

SALT.

Many years ago salt was obtained from wells sunk on Big Sandy River near Zelda. The old salt works have long since disappeared. South of Zelda, near Catalpa, some of the wells drilled for oil and gas have struck salt water, which is still running.

METALLIC ELEMENTS.

Numerous reports reached the writer, while working in the Kenova quadrangle, regarding discoveries of lead and other metals. Concretions containing small amounts of lead and zinc sulphides have been seen. It may be safely stated, however, that in this area the metallic elements, such as gold, silver, copper, lead, etc., occur in such small quantities that time and money spent in exploration for them will meet with but little return.

DIAMONDS.

Diamonds have been reported as having been found in Elliott County, in the peridotite described on page 21. The name of kimberlite has been applied to this rock owing to its resemblance to the diamondiferous rock of South Africa. The writer can not substantiate these reports. The peridotite is, however, characterized by the presence of numerous garnets of small size. None of gem quality,

so far as known, have ever been obtained, but it is by no means certain that they do not exist. The extent of the outcrops of peridotite is indicated on the economic map (Pl. I).

OIL AND GAS.

SUBSURFACE STRATIGRAPHY.

INTRODUCTORY STATEMENT.

In the pages dealing with the general stratigraphy of the various districts into which the quadrangle has been divided, brief descriptions have been given of the character of the rocks appearing at the surface. A knowledge of rocks lower than these has been obtained from the deep wells drilled in search of oil and gas. Some of the facts so obtained are merely supplementary to those already known, but much of the information is entirely new. It will be understood that the way in which our knowledge of these underlying rocks is obtained presupposes many factors which are liable to lead to error in attempting close correlations. First, a division of these lower rocks into well-recognized geologic units is based almost solely on variations in physical character, a standard which often fails entirely when applied to surface rocks. Second, the determination of lithologic distinctions is often left to persons incompetent to make such distinctions. Third, if measurements are not made with the steel tape other errors are likely to creep in. On the other hand, horizons at which, from a general knowledge of the underground stratigraphy of a given district, oil and gas are considered liable to occur are usually expected by the driller, and hence the position of their tops and bases is generally detected within very close limits.

CARBONIFEROUS SYSTEM.

PENNSYLVANIAN SERIES.

The base of the Pennsylvanian series, resting on the top of the Maxville limestone, has been chosen as a datum plane in arranging the deep-well records (Pl. VI). The Maxville limestone is present in all the sections except one shown by a well (No. 9, Pl. VI) drilled near the mouth of Blaine Creek, and serves as a convenient guide from which to reckon. The complete absence of this limestone in the Blaine Creek record is not easily explained, since the Horseford Creek well (No. 10), a mile and a half away, shows the limestone 140 feet thick. The limestone is probably present in the Blaine Creek well, but was called sandstone.

The well showing the greatest thickness of Pennsylvanian or coal-bearing rocks is the Horseford Creek well (No. 10), in which more than 1,000 feet of these rocks is represented. The explanation is that the well was started in Conemaugh rocks well up in this series. The

prevailingly sandy character of the lower part of the Pennsylvanian rocks is apparent. The line which has been drawn at the top of the lower sandstones of this series is not the top of the Pottsville, since from surface observations it is known that the Pottsville must be thicker than the intervals included between this line and the top of the Maxville limestone, as in the Shope Creek well, Summit well, Catletts Creek well, and others. This lower group of sandstones contains salt water and gas, and this fact has helped to determine the position of the correlation line at its top. It is probable that in several of the sections this lower group of sandstones may correspond to the Sharon conglomerate, which is known to consist of two members, as on Everman Creek, Carter County. The well showing the greatest thickness of Pottsville rocks is the Griffith Creek well (No. 19), which starts in rocks of this formation and reaches the Maxville limestone at a depth of 775 feet. In the southeastern part of the area, therefore, the Pottsville rocks are very nearly 1,400 feet thick, as compared with a thickness of 350 to 400 feet in the northwestern and western parts. The first figure, 1,400, added to the average thickness of Allegheny, Conemaugh, and higher rocks, makes the Pennsylvanian series in the Kenova quadrangle, in round numbers, about 2,000 feet thick. In certain sections the highest limestone plotted has not been regarded as the Maxville. In doing this each case had to be considered on its own merits in connection with the known surface geology of the immediate locality. At some points where limestone is shown on the surface on the plotted record, it is probable that sandstone has been designated as a limestone or lime by the driller.

MISSISSIPPIAN SERIES.

The Mississippian series includes the rocks from the top of the Maxville limestone to the base of the Bedford shale; no record shows the presence of red shale above the top of the Maxville. The series comprises the Maxville limestone and the Waverly group, in which is included at the base the Sunbury shale, Berea sandstone, and Bedford shale.

The Maxville limestone shows in all the sections except that of the Blaine Creek well (No. 9). It ranges in thickness from 60 feet in the Summit well (No. 3) to 345 feet in the Alum City Oil Company's Straight Creek well (No. 6) and the A. M. Holbrook well (No. 18). The latter thickness seems excessive, for near both the Straight Creek well and the Holbrook well other records show a thickness of 109 and 152 feet for this limestone. The fact that the unusual thickness of limestone is accompanied by a marked thinning of the underlying Waverly in both records is indirect evidence that the thickness of the limestone has been overestimated. The Richardson well (No. 5) shows the next lower measurement—about 270 feet. But this, too, may be excessive, for the Catletts Creek well, not over 3 miles away, shows

only 80 feet of limestone. The limestone shows great variation and no tendency to thicken regularly in any part of the area. Whether or not this is due to an unconformity at its top can not be stated, but it is known that an unconformity exists between the Mississippian and Pennsylvanian series in Pennsylvania and West Virginia. The Maxville limestone is the "Big lime" of the Pennsylvania drillers and corresponds to the Greenbrier of West Virginia.

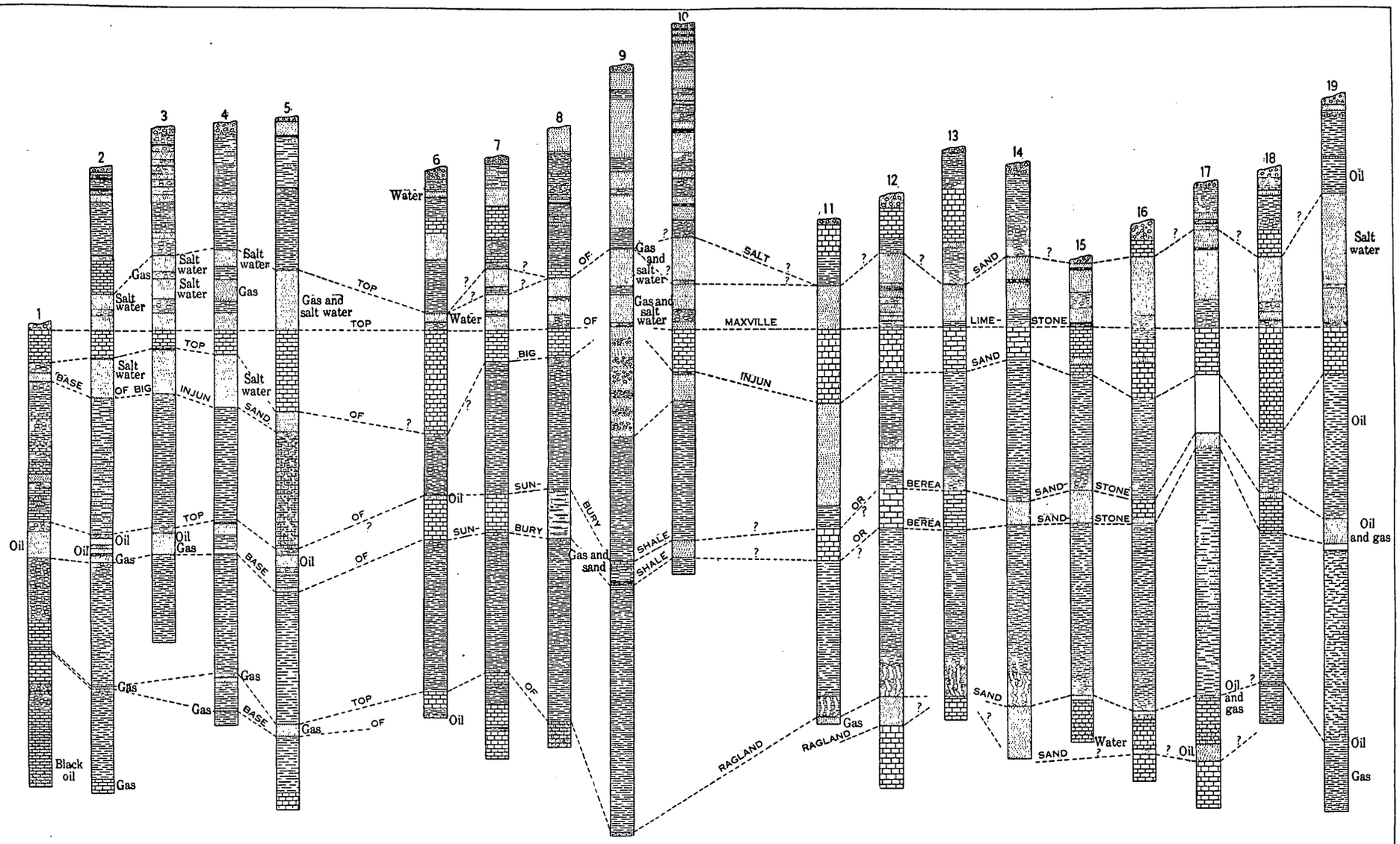
The Waverly group includes the Mississippian rocks below the Maxville limestone and above the Devonian shale. At the top of this group, in the wells studied in the northern part of the quadrangle, a persistent sandstone is present. It is in places overlain by a shale bed that is usually thin, but is 40 feet thick in the Joshua Kelly well (No. 1). At Straight Creek and on Glancy Fork no sandstone appears in this position, but the Horseford Creek well (No. 10) shows 95 feet. In the Blaine Creek section 370 feet of white sandstone and conglomerate are represented in this part of the section, and without doubt part of this thickness is the upper sandstone of the Waverly. In the wells in the southern part of the quadrangle it is usually absent, except in the Jason Boggs well (No. 11), where the sandstone in this position measures 345 feet, with the underlying shales only 75 feet thick. This interpretation of the lithologic character of the rocks is open to some question, as the shale below the sandstone is everywhere much thicker than the sandstone itself. In a carefully kept record of the Guffey well, north of Grayson, no typical sandstone is reported from this position. The complete record of the well, which seems to be the only one known in this particular part of the quadrangle, is given to show the character of the underlying formations in this part of Carter County.[a]

Log of Guffey well, just north of Grayson, Carter County, Ky.[b]

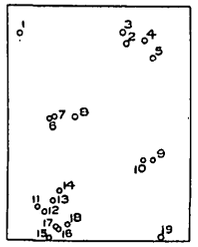
	Thickness.	Depth.
Carboniferous:	*Feet.*	*Feet.*
Quicksand	28	28
Slate, black	30	58
Sandstone	12	70
Slate, black	10	80
Limestone, Maxville	20	100
Shale, dark green, sandy	230	330
Slate, light gray, and sand shells	270	600
Sandstone and shale	50	650
Sandstone, slate, and shells	85	735
Slate, black (Sunbury shale)	22	757
Sand, Berea (oil and gas)	112	869
Slate, gray (Bedford)	25	894
Slate, red (Bedford)	6	900
Devonian shale:		
Slate, black	116	1,016
Slate, white	5	1,021
Slate, black	169	1,190
Slate, white	20	1,210
Slate, black	95	1,305
Slate, white	118	1,423
Limestone (oil and gas) ("Corniferous")	2	1,425
Silurian:		
Limestones, fine and coarse; strong flow of salt water at 1,475 feet	55	1,480

[a] Oil and gas: Kentucky Geol. Survey, Bull. No. 1, 1905, p. 74.

[b] The geologic units were identified by J. B. Hoeing.



1 Little Sandy Oil Co., Joshua Kelly farm, Euclid, Greenup Co.
2 Clinton well, George farm, Shope Creek, Boyd County
3 Summit well, Summit, Boyd County
4 Catletts Creek, 2 miles west of Catlettsburg
5 Richardson farm well, west bank of Big Sandy River, 1½ miles south of Catlettsburg (Longabaugh well)
6 Alum City Oil Co., Straight Creek, Carter Co.
7 New Domain Oil and Gas Co., Straight Creek, Carter County
8 New Domain Oil and Gas Co., L. C. Glancy farm, Glancy Fork, Carter County
9 Blaine Creek well, mouth of Blaine Creek, Lawrence County
10 Horseford Creek well, Lawrence County
11 New Domain Oil and Gas Co., Jason Boggs farm, Canes Creek, 6 miles northwest of Blaine, Lawrence County
12 New Domain Oil and Gas Co., John Boggs farm, Canes Creek, 4 miles northwest of Blaine, Lawrence County
13 New Domain Oil and Gas Co., J. F. Cooper farm, Lick Fork of Cherokee Creek, 5 miles northwest of Blaine, Lawrence County
14 New Domain Oil and Gas Co., J. A. Young farm, Cherokee Creek, Lawrence County
15 Laurel or Broas well, Lower Laurel Creek, Lawrence County
16 New Domain Oil and Gas Co., H. H. Gambill farm, Blaine Creek, 1 mile west of Blaine, Lawrence County
17 Berry well, mouth of Canes Creek, Lawrence County
18 New Domain Oil and Gas Co., A. M. Holbrook farm, ¼ mile northeast of Blaine, Lawrence County
19 Griffith Creek well, 7 miles southeast of Louisa, Lawrence County



VERTICAL SCALE IN FEET
0 200 400 600 800

DEEP WELL SECTIONS IN KENOVA QUADRANGLE.

In the record of the deep well near Central City, W. Va., the sandstone appears with a thickness of 177 feet, showing its continuation to the east of this quadrangle.[a]

Section of well on Fourpole Creek near Central City, W. Va.[a]

	Thickness.	Depth.
Carboniferous:	*Feet.*	*Feet.*
Conductor		26
Shale and lime (sand?)	94	120
Lime	7	127
Slate and fire clay	98	225
Sandstone	25	250
Shale	50	300
Sandstone	30	330
Slate, black	10	340
Sand, gray	60	400
Slate, black	10	410
Sandstone	85	495
Slate, white and blue	25	520
Sand and lime	20	540
Slate	20	560
Slate, black	175	735
Sandstone, gray	25	760
Slate, black and blue	75	835
Shale and lime	30	865
Sandstone	30	895
Slate, black	40	935
Limestone	5	940
Slate, black	30	970
Limestone (Maxville)	150	1,120
Slate	28	1,148
Sand, gray (Big Injun)	177	1,325
Shale, black	370	1,695
Limestone, hard	10	1,705
Slate, brown	25	1,730
Sandstone	25	1,755
Slate, black	10	1,765
Sand and lime	23	1,788
Slate	6	1,794
Shale, black	20	1,814
Sand, black (Berea)	97	1,911
Devonian:		
Slate	24	1,935
Slate, white	100	2,035
Lime and shale	9	2,044
Slate, black	211	2,255
Slate, brown	55	2,310
Sand and shale	45	2,355
Slate, black and blue	30	2,385
Sand, black	30	2,415
Slate, black	5	2,420
Sand, white	5	2,425
Slate, various colors	325	2,750
Sandstone	5	2,755
Limestone (part of this limestone may be upper Silurian)	215	2,970

[a] This well was drilled in 1898. The record was furnished by Thomas W. Harvey, owner.

The meager data available in this area as a whole indicate a tendency in this sandstone to die out to the south. It is the Burgoon ("Big Injun") sandstone of the Pennsylvania drillers, and probably represents the "Big Injun group" of the Kentucky Geological Survey and the Logan formation of the Ohio Survey. The thickness of the sandstone and shale ranges from 70 to 370 feet.

The underlying shales of the Waverly are from 370 to 470 feet thick across the northern part of the quadrangle, from west to east.

[a] Campbell, M. R., Description of the Huntington quadrangle: Geologic Atlas U. S., folio 69, U. S. Geol. Survey, 1900, p. 3.

In the wells in the central part of the quadrangle, except the Alum City Oil Company's well at Straight Creek (No. 6, Pl. VI), the thickness is rather uniform, ranging from 375 to 440 feet. It is fairly uniform also along the southern edge of the quadrangle, most of the wells showing about 400 feet. In most of the records the rocks are described as sand and shale, the latter usually light or gray in color, but in places dark or black. Local limestone layers are also recorded.

The Sunbury shale and Berea sandstone, near the base of the Mississippian series, consist of oil- and gas-bearing shale and sandstone from 60 to 200 feet thick. In the northern part of the quadrangle as a whole the Mississippian series averages very nearly 700 feet in thickness, but it shows a tendency to grow thinner toward the south.

DEVONIAN SYSTEM.

The records show, below the shales and sandstones at the base of the Mississippian series, a considerable body of shale, more or less calcareous, in the midst of which occurs a gas- or oil-bearing sand, probably the Ragland sand of the Kentucky drillers. In some wells this sand is underlain by a few hundred feet of black shale (Ohio shale), but in others the underlying rocks are more or less calcareous in part. It is probable that in the wells drilled in the southern part of the area (Nos. 11 to 19) Silurian limestones have been reached. They may also be reached in some of the wells near the northern edge of the quadrangle, as in that at Central City, where a part of the 215 feet of limestone at the base of the section may be Silurian. The basis for this statement lies in the fact that in the vertical section of Ohio rocks the limestones at the base of the Devonian do not exceed 75 feet in thickness at any point.[a] It is also possible that in the wells in the northern part of this area the considerable bodies of shale represented below the Ragland sand may be older than Devonian.

OIL AND GAS WELLS.

On the geologic map accompanying this report two classes of wells are represented by red and green symbols. Those in red indicate wells that are known to have produced gas in quantity; the other wells are shown in green. Nearly all the wells in this area were drilled in search of oil. In some of them oil was found, but in too small amount to pay the expense of prospecting, and some wells were practically dry. The rocks containing oil and gas are usually known to the drillers as sands. Those known to be productive in this area are described in the next section. The numbers in the accompanying list correspond to those used on the economic map (Pl. I).

[a] Rept. Geol. Survey Ohio, vol. 7, 1893, plate opp. p. 4.

Deep wells in the Kenova quadrangle.

1. Little Sandy Oil Company, Joshua Kelly farm, Euclid, Greenup County.
2. Clinton well, George farm, Shope Creek, Boyd County.
3. Summit, Boyd County.
4. Catletts Creek, 2 miles west of Catlettsburg.
5. Longabaugh well, Richardson farm, west bank of Big Sandy River, 1½ miles south of Catlettsburg.
6. Alum City Oil Company, Straight Creek, Carter County.
7. New Domain Oil and Gas Company, Straight Creek, Carter County.
8. New Domain Oil and Gas Company, L. C. Glancy farm, Glancy Fork, Carter County.
9. Mouth of Blaine Creek, Lawrence County.
10. Horseford Creek, Lawrence County.
11. New Domain Oil and Gas Company, Jason Boggs farm, Canes Creek, 6 miles northwest of Blaine, Lawrence County.
12. New Domain Oil and Gas Company, John Boggs farm, Canes Creek, 4 miles northwest of Blaine, Lawrence County.
13. New Domain Oil and Gas Company, J. F. Cooper farm, Lick Fork of Cherokee Creek, 5 miles northwest of Blaine, Lawrence County.
14. New Domain Oil and Gas Company, J. A. Young farm, Cherokee Creek, Lawrence County.
15. Laurel or Broas well, Lower Laurel Creek, Lawrence County.
16. New Domain Oil and Gas Company, H. H. Gambrill farm, Big Blaine Creek, 1 mile west of Blaine, Lawrence County.
17. Berry well, mouth of Cane Creek, Lawrence County.
18. New Domain Oil and Gas Company, A. M. Holbrook farm, one-fourth mile northeast of Blaine, Lawrence County.
19. Griffith Creek, 7 miles southeast of Louisa, Lawrence County.
20. Oil well, Catletts Creek.
21, 22. Forestdale, Ohio.
23. Frank Crank, Yatesville.
24. George Carter, near Yatesville.
25. Hannah Lackey, near Yatesville.
26, 27. Land & Carter, near Yatesville.
28. Keffer well, Upper Stinson Creek.

OIL AND GAS SANDS.

CARBONIFEROUS ROCKS.

Salt sand.—Fresh water is reported in the Summit well (No. 3), well up in the Carboniferous, 425 feet above the top of the Maxville limestone, and also in the Straight Creek well (No. 6), 441 feet above the same datum plane. The first prominent gas and salt-water horizon occurs in the interval of 250 feet above the Maxville, in the lower part of the Pottsville formation. This salt-water bed probably corresponds in places to the Sharon conglomerate. The oil and salt-water sands are either two or three in number, and may be regarded as the equivalent of the Salt sand to the north in Ohio, but in Washington and Monroe counties, Ohio, the name Maxton sand has been applied to the sand resting directly upon the Maxville lime-

stone. From this bed the old salt wells on Big Sandy River near Zelda obtained their salt water.

Big Injun sand.—The sandstone containing salt water lying directly below the Maxville limestone, or separated from it by a few feet of shale, belongs to the "Big Injun group," or Logan formation of Kentucky and Ohio. The term "group" is hardly applicable in the Kenova quadrangle, as most of the records show a single sandstone bed from 30 to 175 feet thick. In the Blaine Creek well (No. 4) 370 feet of sand and conglomerate are indicated in this part of the section, but, as has already been pointed out, some of this is probably the Maxville limestone. Nothing but salt water has been reported from this sandstone.

Berea sandstone.—In the rocks below the Big Injun sand an occasional show of oil is reported, but no persistent oil- and gas-bearing rocks are encountered until the drill reaches the Sunbury shale and Berea sandstone. Most of the records studied show between the shale of the Waverly above (Cuyahoga?) and the Devonian black shale below a group of sandstones with shale layers, which are referred to the Sunbury shale and Berea sandstone. In many of the sections the well-defined sandstone occurring below the black shale of the Waverly is without doubt the Berea sandstone proper, but in certain of the sections showing several sandstone bands the boundary has been drawn on the lowermost where there seemed no positive evidence to the contrary. Where a single layer of both shale and sandstone has been recognized in the driller's logs the thickness does not exceed 120 feet. Both oil and gas are reported from the Berea, but in no instance has the production been on a profitable scale.

DEVONIAN ROCKS.

Ragland sand.—The Devonian shale carries some oil disseminated through it, but the first persistent gas- and oil-bearing stratum in this rock is a sandstone band a few hundred feet from its top. Some of the records show this sandstone embedded in shale, as in the Clinton well (No. 2), the Catletts Creek well (No. 4), and the Richardson or Longabaugh well (No. 5); but in others it rests upon or is associated with limestone. It is barely possible that the Ragland sand of the southwestern part of the quadrangle, found resting upon limestone, may not be the same sandstone as the gas-bearing rock of the Catletts Creek and Clinton wells, but the presumption is strongly in favor of this correlation. The reason for this question lies in the fact that in the Clinton, Catletts Creek, and Longabaugh wells the gas-bearing sand is underlain by considerable bodies of shale, which are described in the Clinton record as black and white. In some wells (Nos. 6 and 19) the rock at the Ragland horizon is probably a lime-

stone. In the wells where this sandstone is underlain by shale (Nos. 2, 4, and 5) rocks earlier than Devonian may be represented. This gas-bearing sandstone, regarded as the Ragland, is in most places a very thin band, but at the John Boggs well (No. 12) and the J. A. Young well (No. 4) it is reported to be more than 100 feet thick. In Bath County in the Ragland field none of the records show a thickness of the oil-bearing stratum greater than 25 feet.[a] This sand furnishes the high-pressure gas on Catletts Creek, but there the sandstone occurs in two benches. At the Jason Boggs well on Canes Creek, Lawrence County, gas containing much hydrogen sulphide was encountered at this horizon, with a rock pressure of 350 pounds.

PRODUCTION.

Most of the wells drilled in this area report a small production of oil and gas, but so small as not to be profitable. Two gas wells are notable exceptions. The well drilled on Catletts Creek struck gas in a 9-foot layer of sandstone, thought to correspond to the Ragland sand, at a depth of 1,979 feet. The pressure recorded was 975 pounds. This gas is now piped to Catlettsburg. At the Jason Boggs well on Canes Creek, Lawrence County, gas was encountered in the interval from 1,672 to 1,697½ feet below the surface; also in the Ragland sand. The volume was reported to be 750,000 cubic feet per twenty-four hours when the gas was tapped, and the rock pressure to be 350 pounds. The gas was heavily impregnated with hydrogen sulphide.

TOPOGRAPHIC DATA.

TRIANGULATION STATIONS.

The topographic work for the map of the Kenova quadrangle is based on triangulation stations, two of which are found within the limits of the quadrangle and several outside of its borders to the north, south, and northwest. The stations north and northwest of the area, some of which are in the State of Ohio, were established by the Coast and Geodetic Survey, to which the writer is indebted for the information regarding them. The four triangulation stations represented south of the area in the accompanying figure were established by the United States Geological Survey. The two stations on this quadrangle are designated by the names Oakland and Buena Vista. Oakland, named from Oakland furnace, on Chadwick Creek, Boyd County, is situated at the highest point on the ridge at the head of Campbell Run and Laurel Creek. Buena Vista, so called from Buena Vista furnace, is situated on the ridge northwest of Straight Creek, on the dividing line between Greenup and Boyd counties. The accompanying figure (21) shows the relative positions of these triangulation stations. Descriptions of their exact locations follow.

[a] Kentucky Geol. Survey, Bull. No. 1, 1905, pp. 59, 60.

Geographic positions of stations.

[Locality, 39th parallel. United States standard datum. States of Ohio and Kentucky.]

Station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.
	° ′ ″		° ′ ″	*Meters.*
Round Top (1885)	38 36 35.371	1,090.7	83 12 37.795	914.5
Oakland (1884)	38 21 46.466	1,432.7	82 38 52.881	1,283.8
Buena Vista (1884)	38 23 44.026	1,357.5	82 48 21.664	525.7
Howland (1885)	38 37 47.115	1,452.8	82 59 20.415	493.7
Fradd (1885)	38 35 46.927	1,447.0	82 33 06.031	145.9
Gould (1885)	38 38 27.582	850.5	82 49 56.728	1,372.0
Scioto (1885)	38 45 47.719	1,471.5	83 03 03.622	87.4
Ironton, cupola of Kelly's house (1885) [a]	38 31 59.67	1,839.9	82 40 10.36	250.9

Station.	To station—	Azimuth.	Back azimuth.	Distance.	Log. distance.
		° ′ ″	° ′ ″	*Meters.*	*Meters.*
Round Top (1885)	Scioto	219 07 22.42	39 13 21.31	21,969.63	4.3418228
	Howland	263 23 19.14	85 31 36.82	19,416.44	4.2881697
Oakland (1884)	Gebhardt	241 41 35.15	61 56 19.22	39,117.34	4.5923693
	Davis	272 40 01.16	92 50 59.31	25,780.11	4.4112848
Buena Vista (1884)	Fradd	224 47 25.11	44 56 55.06	31,451.43	4.4976404
	Oakland	284 39 44.46	104 45 37.60	14,273.64	4.1545347
Howland (1885)	Gould	264 43 17.96	84 49 09.90	13,690.61	4.1364228
	Buena Vista	328 23 44.36	148 30 34.56	30,504.44	4.4843631
Fradd (1885)	Wray	271 00 59.69	91 04 23.75	7,917.68	3.8985980
	Gebhardt	285 51 33.48	106 02 43.60	27,068.65	4.4324666
	Oakland	18 00 13.70	197 56 37.88	27,244.57	4.4352799
Gould (1885)	Fradd	281 21 56.10	101 32 26.91	24,947.67	4.3970300
	Oakland	332 25 05.92	152 31 59.19	34,808.56	4.5416860
	Buena Vista	355 09 35.66	175 10 34.86	27,341.14	4.4368167
Scioto (1885)	Fradd	292 56 07.10	113 14 50.55	47,235.01	4.6742640
	Gould	305 26 57.47	125 35 09.49	23,361.24	4.3684959
	Howland	339 58 48.81	160 01 08.36	15,770.77	4.1978529
	Round Top	39 13 21.31	219 07 22.42	21,969.63	4.3418228
Ironton, cupola of Kelly's house (1885) [a]	Fradd	235 39 56	55 44 20	12,435.5	4.094663
	Oakland	354 19 06	174 19 54	19,000.8	4.278771

[a] No check on this position.

ROUND TOP.

Round Top station is situated in Lewis County, Ky., about 5 miles west of Quincy, on a hill just back of L. Johnson's house, well known in this locality as Round Top and as being the highest point along Ohio River between Pittsburg and Cincinnati. The whole top of the hill was cleared off, with the exception of two pine trees.

The station is marked by an earthen pyramid buried 3 feet in the ground. Above this and coming to the surface is a tile pipe 6 inches in diameter and 2 feet long. This is filled with cement and a nail in the center marks the center of the station. Four tile pipes 2 feet long and 4 inches in diameter, filled with cement, with a nail in the center, were put down as reference marks—north, east, south, and west—their tops being level with the surface of the ground. The following measurements were made with steel tape: From station to nail in pipe north (true), 5.88 feet; to nail in pipe east, 6.22 feet; to nail in pipe south, 5.95 feet; to nail in pipe west, 5.93 feet.

SCIOTO.

Scioto station is on the land of George Davis, about 1½ miles west of his distillery on the west side of Scioto River, which is about 1½

miles northwest of Portsmouth. A signal 96 feet high to the floor of the scaffold was erected here and theodolite No. 118 was mounted about 100 feet from the ground. Lines were opened to Peach

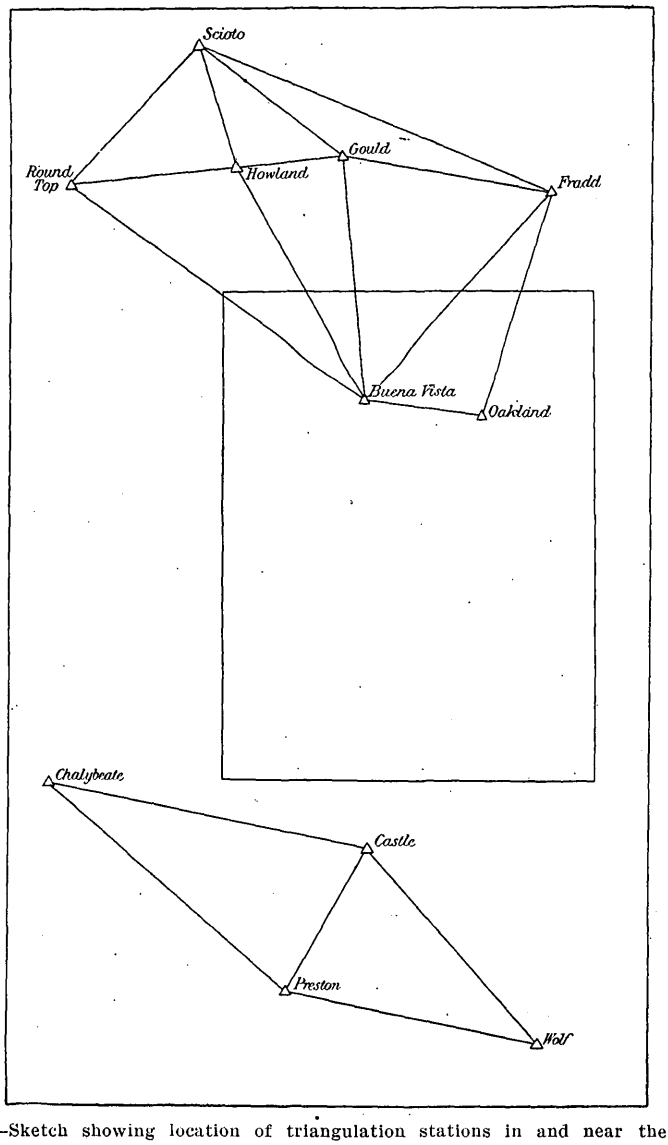


FIG. 21.—Sketch showing location of triangulation stations in and near the Kenova quadrangle.

Mount station (19 miles) by cutting on five ridges, and to Twin Creek station (13 miles) by cutting on two ridges. Fradd, Gould, Howland, Round Top, Springville, and the whole of the city of Portsmouth are open.

The station is marked as follows: A pottery pyramid was sunk below the surface, over which was placed a 6-inch draintile pipe, 2 feet long, filled with concrete. The center is marked by an iron spike. Reference marks consist of 4-inch pipes, as follows: North, 6.29 feet; south, 6.18 feet; east, 6.25 feet; west, 6.11 feet. These four pipes were filled with concrete, and a nail driven in each marks the center.

HOWLAND.

Howland station is situated in Greenup County, Ky., between Tygarts and Schultz creeks and between Right and Left forks of Beechy Creek, about 3½ miles west of Liberty, about 400 yards northwest of the house of James Howland, on a point of land belonging to James Howe, and about 100 yards west of the main county road that runs from Schultz Creek to the mouth of Brushy Creek. The signal is in sight from Mr. Howland's house. A 65-foot tripod and scaffold was erected here. Theodolite No. 135 was mounted on top of the tripod and the observations were made from it.

The station is marked by an earthen pyramid buried 2½ feet below the surface of the ground; above this is placed a draintile pipe 6 inches in diameter and 2 feet long, the top being just even with the surface of the ground. The pipe was filled with cement and a 6-inch spike in the center marks the station. Four tile pipes 4 inches in diameter and 2 feet long, filled with cement, with a nail in the center of each, were put down as reference marks. The following measurements were made: From station to nail in pipe north (true), 6.45 feet; east, 6.05 feet; south, 5.95 feet; west, 6.10 feet.

GOULD.

Gould station is situated on the hills east of Ohio River, about 1½ miles in an air line from the river at Franklin furnace landing. The land formerly belonged to O. B. Gould, but was sold in 1884 to Means, Kyle & Co., of Hanging Rock, Ohio. The hill is covered with large timber of second growth.

The station is marked as follows: The center by a pottery pyramid sunk 3 feet below the surface; above this is a piece of sewer pipe 6 inches in diameter, filled with concrete, with a nail in its center. Other pieces of sewer pipe, 4 inches in diameter, are sunk at the following distances and directions: North (true), 4-inch pipe, 6.08 feet; south, 4-inch pipe, 6.11 feet; east, 4-inch pipe, 5.78 feet. On the west is a brass rod, one-fourth inch in diameter, driven into the smoothed top of an oak stump and surrounded by a triangle of iron nails, distant 5.77 feet.

FRADD.

Fradd station is very near to the line between Lawrence and Aid townships, in Lawrence County, Ohio, about 100 yards south of the road running from Marion to Vesuvius furnace, about 3 miles from Marion, nearly a mile west of the white schoolhouse on the hill, on land belonging to Charles Fradd, who lives in the hollow about one-third of a mile southwest of the station.

The station was marked by an earthen pyramid, sunk 2½ feet in the ground; above this was placed a 6-inch tile pipe, 2 feet long and filled with cement; a 6-inch spike marks the station center. Four 4-inch tile pipes, 2 feet long, filled with cement, with a nail in the center, were put down as reference marks, their tops being level with the ground. The following measurements were made: From station center to nail in pipe north (true), 7.63 feet; east, 6 feet; south, 6.50 feet; west, 6 feet.

BUENA VISTA.

Buena Vista station is on the highest point of the narrow ridge about 2½ miles east of Hunnewell furnace, Greenup County, Ky. The county road from Hunnewell furnace to old Buena Vista furnace crosses the ridge, and the station is on the high point to the left of the road, called in the neighborhood the "high knob." When the ridge was cut off for charcoal a single large tree was left, in which a flag was put for use in reconnaissance. This tree was trimmed by cutting its lower branches and was left temporarily for a mark.

The station is marked at the center by a pottery pyramid sunk 3 feet below the surface. Above this was built a pier of concrete, about 4½ feet above the ground, on which was mounted the theodolite. The center of the pier above the station is marked 6 inches below the surface, at 15 inches below the top, at 6 inches below the top, and on the surface of the pier by iron spikes driven into the concrete accurately over the center of the station. A small pole was erected to observe on from Oakland, and was taken down when the pier was built. Reference marks: Two concrete piers, 6 by 6 inches and 2 feet long, with their tops even with the ground and nail in the center, one east, one west; for the north and south marks, oak stubs with nail in the top. The following are the distances: Station to nail north (true), 7.90 feet; east, 7.16 feet; south, 8.03 feet; west, 7 feet. The large chestnut oak in which the flag was placed was cut down and a pole was erected over the pier, with crotch 16 feet high and pole 12 feet above the crotch. The distance from the station to a blazed stump marked with a triangle of driven nails with a spike in the center is 17.3 feet.

OAKLAND.

Oakland station is on the highest part of the wooded hill at the headwaters of Chadwick Creek, on the land of Thomas Galligher, a few feet from the fence dividing his land from that of James L. Rucker.

The center is marked by a pottery pyramid, buried 3 feet. Over this is placed a section of 4-inch tile pipe 2 feet long, its upper surface level with the surface of the ground. This pipe is filled with and surrounded by concrete made of hydraulic cement and broken sandstone. The station center is marked on the top of the concrete by an iron spike 6 inches long, the center of the head of this spike being accurately plumbed under the center of the tripod head, on which was mounted theodolite No. 118. Reference marks consisting of 4-inch tile pipes 2 feet long, filled with concrete and sunk level with the surface of the ground, with a nail in the center of each, were placed at the following distances and directions: North (true), 5.98 feet; south, 5.02 feet; east, 6.02 feet; west, 6.06 feet.

WOLF.[a]

On sharp ridge at head of Wolf Creek, Martin County, Ky., 12 miles (air line) southwest of Warfield, on Tug Fork of Sandy River. Permanent mark: Large chestnut tree.

[Latitude, 37° 43′ 34″.4; longitude, 82° 34′ 20″.9.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Castle	138 37 03.8	318 28 31.8	4.489071
Preston	101 39 08.3	281 26 22.5	4.494856
Frazier	13 12 43.8	193 09 13.7	4.569316
Willard	342 01 58.8	162 08 53.3	4.735622

PRESTON.[a]

On northeast end of Long Knob, at head of Barnett and Jennie and Little Paint creeks, Johnson County, Ky., 7 miles southwest of Paintsville.

[Latitude, 37° 46′ 57″.3; longitude, 82° 55′ 11″.6.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wolf	281 26 22.5	101 39 08.3	4.494856
Quicksand	1 28 02.2	181 27 41.1	4.520126
Frazier	332 14 31.1	152 23 43.8	4.679871

[a] This description may be found in Bull. U. S. Geol. Survey No. 122, 1894, p. 82.

SPIRIT-LEVEL WORK.

During the course of topographic work in the Kenova quadrangle numerous bench marks were established, descriptions and elevations of which are given below.

The elevations in the following list are based on a bronze tablet at Kenova, W. Va., in the west side of the door sill at the entrance to the men's waiting room at the union station. The elevation of this tablet is accepted as 566.918 feet above mean sea level. The initial height from which these elevations are derived is that determined for bench mark 316 A of the Ohio River Survey, Corps of Engineers, U. S. Army, at Catlettsburg, Ky., by the 1903 adjustment of precise leveling. The leveling was done in 1900 under the direction of W. N. Morrill, topographer; by J. E. Buford and C. H. Semper, levelmen. All standard bench marks dependent on this datum are stamped with the letter "K" in addition to the figures of elevation.

HAVERHILL, OHIO, TO GREENUP, KY.; THENCE ALONG EASTERN KENTUCKY RAILWAY TO ARGILLITE.

	Feet.
Greenup County building, clerk's office; bronze tablet set vertically in stone step at right of entrance, stamped "538 I"	540.004
Riverton, 1.5 miles south of, railroad bridge 150 feet south of road crossing, on abutment at southwest corner of bridge; chisel mark	554.70
Argillite, 1,320 feet south of, east side of north end of Argillite tunnel, 8.86 feet higher than top of rail, in sandstone ledge; bronze tablet stamped "567 K 1900"	566.442

GREENUP SOUTHWARD TO MOUTH OF WHETSTONE CREEK.

Greenup, 2.5 miles southwest of, 750 feet southwest of log house, on north side of road, north of road center, in south end of sandstone bowlder 7 by 10 by 25 feet; bronze tablet stamped "578 I"	580.081

KENOVA ALONG CHESAPEAKE AND OHIO RAILWAY (BIG SANDY DIVISION) TO ROCKVILLE (BUCHANAN), KY.

Savage, 2.6 miles north of, on west side of highway or crossing 40 feet from center of track and 10 feet from center of highway, on sandstone ledge; chisel mark	552.44
Savage, 870 feet north of station, at southeast corner of highway bridge, on bridge seat; chisel mark	541.26
Savage, in front of station; top of west rail	547.1
Savage Branch station, 1 mile south of, at David Lockwood's house, in foundation on left side of front steps; bronze tablet stamped "586 K"	586.113
Lockwood, in front of station; top of east rail	544.3
Kavanaugh Church, in front of flag station; top of east rail	581.3

BOLTS FORK NORTHWARD VIA CANNONSBURG TO ASHLAND.

	Feet.
Bolts Fork, 600 feet north of post-office, highway bridge over Bolts Fork, at southeast corner bridge seat; bronze tablet stamped "652 K"	652.567
Mavity, 0.8 mile north of, at forks of road 105 feet south of log house, 51 feet south of sycamore, on abutment at southeast corner of bridge; chisel mark	605.08
Cannonsburg, post-office building, southeast corner of, 93 feet from railroad crossing; bronze tablet stamped "604 K"	604.871
Mead station, 0.5 mile south of, on Ashland Coal and Iron Railway, 200 feet southwest of house on west side of road, corner stone west end of culvert; chisel mark	590.92
Mead station, 1 mile north of, 81 feet north of small bridge, 15 feet east of center of road, in sandstone bowlder; bronze tablet stamped "638 K"	639.221
Ashland, Chesapeake and Ohio station, on Carter avenue, between Twelfth and Thirteenth streets, south side of building, 2 feet above ground; bronze tablet stamped "556 K"	556.531

ASHLAND ALONG CHESAPEAKE AND OHIO RAILWAY VIA CATLETTSBURG TO HAMPTON.

Ashland, 1.5 miles east of, on Chesapeake and Ohio Railway, girder bridge over electric railway, on top stone at south end of west wing wall; chisel mark	555.74
Catlettsburg, Louisa street, between Franklin and Clay streets, in court-house yard, at northwest corner of clerk's office, 1 foot above water table; aluminum tablet stamped "549 K 1900"	550.303
Catlettsburg, Big Sandy National Bank (U. S. Engineer's bench mark "316 A"), on window sill; chisel mark B $\frac{U}{S}$ M	548.690

BUCHANAN WESTWARD TO MAYHEW.

Buchanan, in front of station; top of east rail	558.3
Buchanan, 150 feet south of, overhead railway bridge (B. S. 189), in top stone at east end of north pier; bronze tablet stamped "554 K 1900"	554.231
Mayhew, 850 feet west of post-office, at northeast corner of bridge over Bolts Fork, 4 feet lower than bridge, on bridge seat; chisel mark	682.18

BUCHANAN SOUTHWARD ALONG CHESAPEAKE AND OHIO RAILWAY (BIG SANDY DIVISION) TO GALLUP.

Buchanan, 1.7 miles south of, trestle No. 206, in guard rail at southeast end; top of bolt	563.03
Fuller, 300 feet north of station, 5 feet west of railroad at east edge of highway, 30 feet north of white house, in sandstone ledge; bronze tablet stamped "572 K 1900"	570.874
Poters, in front of station; top of rail	573
Louisa, U. S. Engineers' bench mark No. 13 Big Sandy, at Lock No. 3, in engineers' office yard	569.081
Louisa County court-house, north face, west side, in foundation; aluminum tablet stamped "584 K 1900"	582.419

	Feet.
Gallup, at G. C. McClure's house, in stone step to house; bronze tablet stamped "591 K 1900"	589.370
Gallup, 0.6 mile west of, U. S. Engineers' bench mark No. 5 Big Sandy, 50 feet south of west end of trestle No. 403	590.289

GALLUP WESTWARD TO PROSPERITY.

Adams, 2 miles south of post-office, at M. R. Hayes's residence, in southwest corner of foundation; bronze tablet stamped "667 K 1900"	666.591

IRAD NORTHWARD 5 MILES, THENCE SOUTHEASTWARD VIA YATESVILLE TO LOUISA.

Yatesville, 3 miles northwest of, in field on south side of and 45 feet from center of road, 135 feet from southwest corner of Green Valley schoolhouse, in north side of large sand rock; bronze tablet stamped "598 K 1900"	596.856

MAYHEW WESTWARD TO DENTON, THENCE NORTHEASTWARD ALONG ASHLAND COAL AND IRON RAILWAY TO PRINCESS, THENCE EASTWARD TO CANNONSBURG.

Denton, 4.5 miles east of, on top of hill 60 feet north of road, at old road going north, old abandoned frame house, on foundation at southeast corner; chisel square	905.39
Denton, Chesapeake and Ohio Railway station, 200 feet northeast of, 16 feet east of center of main track, in top stone; chisel mark	669.84
Denton, 1.5 miles east of, 200 feet north of road crossing at southwest end of Means tunnel on Ashland Coal and Iron Railway, 15 feet west of highway, in sandstone ledge; bronze tablet stamped "787 K 1900"	787.794
Grant station, at southwest corner of girder bridge No. 11, 30 feet west of switch stand near station, on bridge seat; chisel mark	685.92
Geigersville, 800 feet north of Rush post-office, 600 feet south of coal dump, 330 feet south of road crossing, at southwest corner of railroad bridge No. 10, in bridge seat; bronze tablet stamped "639 K 1900"	639.442
Coalton station, west of tool house near, at northeast corner of railroad bridge No. 6, in bridge seat; chisel mark	615.03

ARGILLITE SOUTHEASTWARD VIA NAPLES TO PRINCESS.

Naples, 1,300 feet north of post-office, at southwest corner of overhead highway bridge across East Fork on or near Boyd-Greenup county line, in bridge seat; bronze tablet stamped "571 K 1900"	570.839
Princess, 3.25 miles northwest of, at northeast corner of highway bridge over Williams Creek, east of log house, on abutment; chisel mark	571.67

ARGILLITE SOUTHWESTWARD VIA OLDTOWN AND EUCLID, THENCE NORTHWARD TO HEAD OF CLAYLICK CREEK (SINGLE-SPUR LINE.)

Oldtown, Mrs. Womack's house, 350 feet north of Oldtown Creek bridge, on west side of road, in foundation stone on east side of house, 6 feet from southeast corner; bronze tablet stamped "558 K 1900"	556.843
Claylick Creek, head of, on ridge where road turns to right to go down creek, near site of former schoolhouse, on north side of road between J. H. Hally's and W. J. Hally's, in ledge; bronze tablet stamped "957 K 1900"	956.345

OLDTOWN SOUTHWARD TO HOPEWELL, THENCE SOUTHWARD ALONG EASTERN KENTUCKY RAILWAY TO GRAYSON.

	Feet.
Grayson, 0.4 mile west of railroad, at southeast corner of foundation of court-house; aluminum tablet stamped "686 K 1900"	684.996

GRAYSON EASTWARD VIA SENEY TO KILGORE.

Grayson, 5.6 miles east of, on north side of road, 15 feet from center, near top of Crib Hill, in sandstone ledge; bronze tablet stamped "834 K 1900"	832.874
Kilgore, 1.3 miles west of, in road between W. C. Hargio's residence and the old store of Norton Iron Works, on sandstone bowlder; chisel mark	661.34

GRAYSON SOUTHWARD ALONG EASTERN KENTUCKY RAILWAY TO WILLARD.

Grayson, 0.5 mile south of, at southeast corner of railroad bridge over Little Sandy River, on abutment; chisel mark	588.69
E. K. Junction, 0.5 mile east of, at southwest corner of Chesapeake and Ohio Railway bridge No. S442, on bridge seat; chisel mark	604.03
Willard, 3 miles north of, 6 feet from southwest corner of railroad bridge No. 9, on abutment; chisel mark	613.60
Willard, 1,400 feet east of station, at northeast corner of railroad bridge No. 15 over Dry Fork, in bridge seat; bronze tablet stamped "625 K 1900"	624.462

WILLARD SOUTHEASTWARD ALONG EASTERN KENTUCKY RAILWAY TO WEBBVILLE, THENCE SOUTHWARD ALONG PUBLIC ROAD VIA IRONTON HILL TO BLAINE.

Webbville, 5.8 miles south of, south of small house near south forks of road, on west side, 30 feet from center, in sandstone ledge; bronze tablet stamped "916 K 1900"	914.926
Cherokee, 0.5 mile north of mouth of Cherokee Creek, east of road, south of small house, in sandstone ledge; bronze tablet stamped "646 K 1900"	645.587

BLAINE WESTWARD ALONG BLAINE CREEK TO MARTHA, THENCE NORTHWARD VIA SARAH TO WILLARD.

Blaine, 0.3 mile west of, at northwest corner of highway bridge over Blaine Creek, on bridge seat; chisel mark	655.94
Martha, 0.4 mile north of, on east side of road, 25 feet higher than road, 36 feet north of oak tree on same side of road, in sandstone ledge; bronze tablet stamped "736 K 1900"	735.554
Fielden, 2 miles east of, at Pennington's store, mouth of Hurricane Creek, W. L. Pennington's house on south side of road, in foundation under northeast corner; bronze tablet stamped "698 K 1900"	696.921
Willard, 5 miles southwest of, on west bank of Little Fork, 0.5 mile north of Levi Pennington's, in sandstone ledge between public road and creek; bronze tablet stamped "650 K 1900"	649,725

BLAINE CREEK NORTHEASTWARD VIA PROSPERITY TO IRAD.

Irad, 2 miles west of, 0.25 mile east of log schoolhouse, on north bank of Blaine Creek, south side and 5 feet from center of road, west of house near, in large sand rock; bronze tablet stamped "630 K 1900"	629.784

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