DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

KENOVA FOLIO

KENTUCKY–WEST VIRGINIA–OHIO

BY

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WASHINGTON, D. C.
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GEOLOGIC ATLAS OF THE UNITED STATES.

The Geological Survey is making a geologic atlas of the United States, which is being issued in parts, called folios. Each folio includes topographic and geologic maps of a certain area, together with descriptive text.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds—(1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those of the most important ones are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the vertical interval represented by each space between lines being the same throughout each map. These lines are called *contour lines* or, more briefly, *contours*, and the uniform vertical distance between each two contours is called the *contour interval*. Contour lines and elevations are printed in brown. The manner in which contour lines express altitude, form, and grade is shown in figure 1.

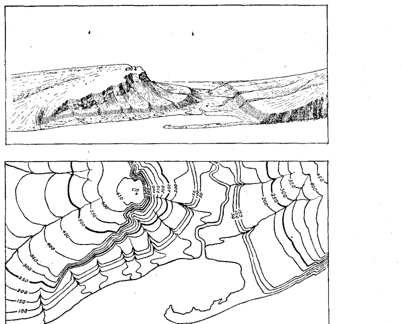


FIGURE 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly closed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle hill slope; that on the left is backed by a steep ascent to a cliff, or scarp, which contrasts with the gradual slope away from its crest. In the map each of these features is indicated, directly beneath its position in the sketch, by contour lines. The map does not include the distant portion of the view. The following notes may help to explain the use of contour lines:

1. A contour line represents a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contour lines are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above the sea—that is, this contour would be the shore line if the sea were to rise 250 feet; along the contour at 200 feet are all points that are 200 feet above the sea; and so on. In the space between any two contours are all points whose elevations are above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, and that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above the sea. The summit of the higher hill is marked 670 (feet above sea level); accordingly the contour at 650 feet surrounds it. In this illustration all the contour lines are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contour lines. The accentuating and numbering of certain of them—say every fifth one—suffices and the heights of the others may be ascertained by counting up or down from these.

2. Contour lines show or express the forms of slopes. As contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing around spurs or prominences. These relations of contour curves and angles to forms of the landscape can be seen from the map and sketch.

3. Contour lines show the approximate grade of any slope. The vertical interval between two contours is the same, whether they lie along a cliff or on a gentle slope; but to attain a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

A small contour interval is necessary to express the relief of a flat or gently undulating country; a steep or mountainous country can, as a rule, be adequately represented on the same scale by the use of a larger interval. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the interval may be 250 feet and for less rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. For a perennial stream the line is unbroken, but for an intermittent stream it is broken or dotted. Where a stream sinks and reappears the probable underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are represented by appropriate conventional signs in blue.

Culture.—The symbols for the works of man and all lettering are printed in black.

Scales.—The area of the United States (exclusive of Alaska and island possessions) is about 3,027,000 square miles. A map of this area, drawn to the scale of 1 mile to the inch would cover 3,027,000 square inches of paper and measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and a linear mile on the ground by a linear inch on the map. The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to the inch" is expressed by the fraction $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; they are $\frac{1}{250,000}$, $\frac{1}{125,000}$, and $\frac{1}{62,500}$, corresponding approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale of $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale of $\frac{1}{125,000}$, about 4 square miles; and on the scale of $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map of the United States is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ represents one square degree—that is, a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ represents one-fourth of a square degree, and each sheet on the scale of $\frac{1}{62,500}$ one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, though they vary with the latitude.

The atlas sheets, being only parts of one map of the United States, are not limited by political boundary lines, such as those of States, counties, and townships. Many of the maps represent areas lying in two or even three States. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet are printed the names of adjacent quadrangles, if the maps are published.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land and, by means of structure sections, their underground relations, so far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as *igneous*. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages to or nearly to the surface. Rocks formed by the consolidation of molten material, or magma, within these channels—that is, below the surface—are called *intrusive*. Where the intrusive rock occupies a fissure with approximately parallel walls it is called a *dike;* where it fills a large and irregular conduit the mass is termed a *stock*. Where molten magma traverses stratified rocks it may be intruded along bedding planes; such masses are called *sills* or *sheets* if comparatively thin, and *laccoliths* if they occupy larger chambers produced by the pressure of the magma. Where inclosed by rock molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. Where the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks that have solidified at the surface are called *extrusive* or *effusive*. Lavas generally cool more rapidly than intrusive rocks and as a rule contain, especially in their superficial parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows also are usually porous, owing to the expansion of the gases originally present in the magma. Explosive action, due to these gases, often accompanies volcanic eruptions, causing ejections of dust, ash, lapilli, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone disintegration, of volcanic ejecta deposited in lakes and seas, or of materials deposited in such water bodies by chemical precipitation are termed *sedimentary*.

The chief agent in the transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. Some of the materials are carried in solution, and deposits of these are called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the kinds of deposit named may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind, and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is loess, a fine-grained earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*, and rocks deposited in such layers are said to be stratified.

The surface of the earth is not immovable; over wide regions it very slowly rises or sinks, with reference to the sea, and shore lines are thereby changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land areas are in fact occupied by rocks originally deposited as sediments in the sea.

Rocks exposed at the surface of the land are acted on by air, water, ice, animals, and plants, especially the low organisms known as bacteria. They gradually disintegrate and the more soluble parts are leached out, the less soluble material being left as a *residual* layer. Water washes this material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it forms *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by various processes, rocks may become greatly changed in composition and in texture. If the new characteristics are more pronounced than the old such rocks are called *metamorphic*. In the process of metamorphism the constituents of a chemical rock may enter into new combinations and certain substances may be lost or new ones added. A complete gradation from the primary to the metamorphic form may exist within a single rock mass. Such changes transform sandstone into quartzite and limestone into marble and modify other rocks in various ways.

From time to time during geologic ages rocks that have been deeply buried and have been subjected to enormous pressures, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structures may have been lost entirely and new ones substituted. A system of planes of division, along which the rock splits most readily, may have been developed. This structure is called *cleavage* and may cross the original bedding planes at any angle. The rocks characterized by it are *slates*. Crystals of mica or other minerals may have grown in the rock in such a way as to produce a laminated or foliated structure known as *schistosity*. The rocks characterized by this structure are *schists*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are many important exceptions, especially in regions of igneous activity and complex structure.

FORMATIONS.

For purposes of geologic mapping rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, an alternation of shale and limestone. Where the passage from one kind of rocks to another is gradual it may be necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation contains one or more bodies of one kind, of similar occurrence, or of like origin. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics or origin.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a varied formation, such parts are called *members*, or by some other appropriate term, as *lentils*.

AGES OF ROCKS.

Geologic time.—The time during which rocks were made is divided into *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by the name of the time interval in which it was formed.

The sedimentary formations deposited during a period are grouped together into a *system*. The principal divisions of a system are called *series*. Any aggregate of formations less than a series is called a *group*.

Inasmuch as sedimentary deposits accumulate successively the younger rest on those that are older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or superposed by faulting, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossils, if present, may indicate which of two or more formations is the oldest.

Many stratified rocks contain *fossils*, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were washed into them, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. Where two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not that of their metamorphism.

Symbols, colors, and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern and is labeled by a special letter symbol.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system.

The symbols consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters.

The names of the systems and of series that have been given distinctive names, in order from youngest to oldest, with the color and symbol assigned to each system, are given in the subjoined table.

Symbols and colors assigned to the rock systems.

	System.	Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent, Pleistocene	Q	Brownish yellow.
	Tertiary	Pliocene, Miocene, Oligocene, Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ћ	Peacock-blue.
Paleozoic	Carboniferous	Permian, Pennsylvanian, Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		€	Brick-red.
	Algonkian		A	Brownish red.
	Archean		Æ	Gray-brown.

SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; waves cut sea cliffs and, in cooperation with currents, build up sand spits and bars. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are inseparably connected with deposition. The hooked spit shown in figure 1 is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is first built and afterward partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. Lakes or large rivers may determine local base-levels for certain regions. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the fairly even surface thus produced is called a *peneplain*. If the tract is afterward uplifted, the elevated peneplain becomes a record of the former close relation of the tract to base-level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—The map showing the areas occupied by the various formations is called an *areal geology map*. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any color or pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any particular formation, its name should be sought in the legend and its color and pattern noted; then the areas on the map corresponding in color and pattern may be traced out. The legend is also a partial statement of the geologic history. In it the names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the geologic formations is termed the *economic geology map*. The formations that appear on the areal geology map are usually shown on this map by fainter color patterns and the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of each mine or quarry and is accompanied by the name of the principal mineral mined or stone quarried. If there are important mining industries or artesian basins in the area special maps to show these additional economic features are included in the folio.

Structure-section sheet.—In cliffs, canyons, shafts, and other natural and artificial cuttings the relations of different beds to one another may be seen. Any cutting that exhibits those relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface and can draw sections representing the structure to a considerable depth. Such a section is illustrated in figure 2.

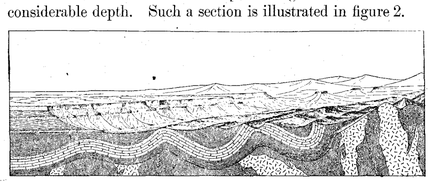


FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate patterns of lines, dots, and dashes. These patterns admit of much variation, but those shown in figure 3 are used to represent the commoner kinds of rock.

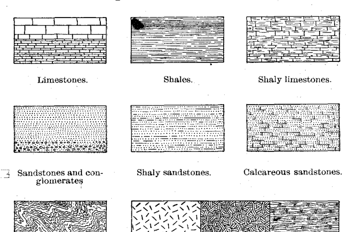


FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

The plateau shown at the left of figure 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction of the intersection of a bed with a horizontal plane is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

In many regions the strata are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets, the fact that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in figure 4.

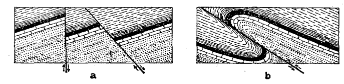


FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or by well-founded inference.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of sandstones and shales, which lie in a horizontal position. These strata were laid down under water but are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been uplifted. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata that have been folded into arches and troughs. These strata were once continuous, but the crests of the arches have been removed by erosion. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set shown at the left of the section. The overlying deposits are, from their position, evidently younger than the underlying deposits, and the bending and eroding of the older beds must have occurred between their deposition and the accumulation of the younger beds. The younger rocks are *unconformable* to the older, and the surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were folded or plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists were metamorphosed, they were disturbed by eruptive activity, and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in figure 2 are ideal, but they illustrate actual relations. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum that appears in the section may be measured by using the scale of the map.

Columnar section.—The geologic maps are usually accompanied by a *columnar section*, which contains a concise description of the sedimentary formations that occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures that state the least and greatest measurements, and the average thickness of each formation is shown in the column, which is drawn to scale. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest being at the bottom, the youngest at the top.

The intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

GEORGE OTIS SMITH,
Director.

May, 1909.

DESCRIPTION OF THE KENOVA QUADRANGLE.

By W. C. Phalen.

INTRODUCTION.

GENERAL RELATIONS OF THE QUADRANGLE.

The Kenova quadrangle lies in Kentucky, Ohio, and West Virginia, between parallels 38° and 38° 30′ and meridians 82° 30′ and 83°, covering 938 square miles, mostly in Kentucky. (See fig. 1.) It comprises Boyd County and parts of Lawrence, Carter, Greenup, and Elliott counties in Kentucky, part of Wayne County in West Virginia, and a little of Lawrence County in Ohio.

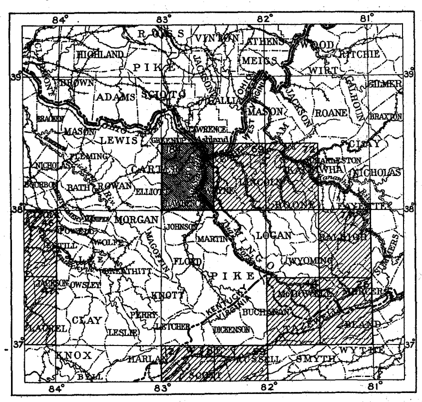


FIGURE 1.—Index map of the vicinity of the Kenova quadrangle.

The location of the Kenova quadrangle (No. 184) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: Nos. 12, Estillville; 26, Pocahontas; 44, Tazewell; 46, Richmond; 47, London; 59, Bristol; 69, Huntington; 72, Charleston; 77, Raleigh.

The chief towns in the quadrangle are Ashland, Catlettsburg, and Louisa in Kentucky, and Kenova in West Virginia. The name Kenova is made up of abbreviations of the names of the three States in which the area lies.

In its general geographic and geologic relations the Kenova quadrangle is a part of the Appalachian province, which extends from the Atlantic Coastal Plain to the lowlands of the Mississippi Valley and from central Alabama into eastern Canada. The Kenova quadrangle lies on the western side and just north of the center of the great bituminous coal field of the Appalachian province, which extends from north-central Alabama to northern Pennsylvania.

GENERAL GEOGRAPHY AND GEOLOGY OF THE REGION.

DIVISIONS OF THE APPALACHIAN PROVINCE.

With respect to topography and geologic structure the Appalachian province is divided into two nearly equal parts by a line extending along the northwest side of the Appalachian Valley, marked by the Allegheny Front in Pennsylvania, Maryland, and West Virginia and by the eastern escarpment of the Cumberland Plateau in Virginia, Kentucky, Tennessee, Georgia, and Alabama. These subdivisions are shown in figure 2. The rocks east of this line are disturbed by faulting and folding and are in consequence in places much metamorphosed; those west of this line lie nearly flat and are almost entirely unaltered. The few folds that break the regularity of the structure are so broad and open that they produce scarcely

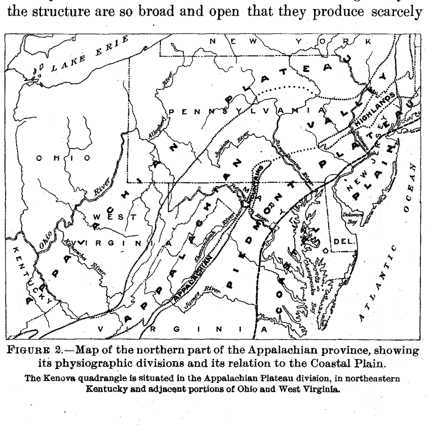


FIGURE 2.—Map of the northern part of the Appalachian province, showing its physiographic divisions and its relation to the Coastal Plain.

The Kenova quadrangle is situated in the Appalachian Plateau division, in northeastern Kentucky and adjacent portions of Ohio and West Virginia.

any appreciable effect on the topography. East of the Allegheny Front lies the Great Appalachian Valley, the surface of which is characterized by alternating ridges and valleys. The Appalachian Mountains, which outline the Great Valley sharply on the southeast, are made up of many large and small ranges bearing various local names. They merge, still farther east, into a deeply dissected upland, the Piedmont Plateau of the southern Atlantic States. The surface west of the Appalachian Valley is a dissected plateau, previously called as a whole the Allegheny Plateau but now known as the Appalachian Plateau. The different parts of this plateau have received distinct names. The plateau character is not easily seen in an area so small as the Kenova quadrangle, but when viewed broadly in comparison with the lowlands of the Mississippi on the the west and the alternating ridges and valleys of the Appalachian Valley on the east it is readily perceived.

THE APPALACHIAN PLATEAU.

Relief.—The Appalachian Plateau as a whole is a broad land mass, the surface of which slopes more or less uniformly northwestward from its southeastern escarpment to the lowlands of the Mississippi Valley. This surface is lowest at its southern margin, where it emerges from beneath a covering of Cretaceous sediments in north-central Alabama, at an altitude of about 500 feet. From this region it gradually rises toward the northeast to 4000 feet in West Virginia and then gradually descends to about 2400 feet in southwestern New York.

The plateau differs widely in character in different parts of the province, its nature depending on the character of the underlying rocks, the crustal movements that have affected them, and the drainage consequent to both of these factors. That part of it which lies in the southern part of the quadrangle is well preserved, as the conditions for its preservation have been almost ideal, but the part farther north is greatly dissected and its plateau character is correspondingly obscured. When viewed broadly from some elevated point, however, the summits of the highest ridges and hills are seen to reach about the same altitude and appear to merge in the distance into a nearly horizontal surface, which is approximately that of an old peneplain.

That part of the old surface that lies in the northeastern part of the plateau has been named the Schooley peneplain, from its typical development on Schooley Mountain, New Jersey. The tops of many ridges in Pennsylvania, especially those in the valleys of Allegheny and Monongahela rivers, represent another and younger peneplain, which stands at a lower level. This lower peneplain has been named the Harrisburg, on account of its excellent development near Harrisburg, Pa. A similar topographic feature found farther south in the Appalachian province has been called the Highland Rim. In Kentucky and Tennessee, where this later plateau has been best developed, it lies about 1000 feet above sea level and is separated from the Cumberland Plateau on the east by a more or less regular westward-facing escarpment. Its surface slopes gently westward. That part of it which lies in Kentucky has been called the Lexington Plain. The remnants of this old surface in the area north of the Ohio are obscure and are consequently difficult to trace exactly. In the Monongahela and Allegheny valleys the presence of divides at a common altitude about 100 feet lower than the Harrisburg upland points to the existence of an old surface at a stage of reduction later than that of the Harrisburg, when stream valleys were widened and the intervening areas of soft rocks were reduced to a common altitude. This surface has been called the Worthington upland, from its excellent development near Worthington, Pa.

Drainage.—The Appalachian Plateau, except its northeastern part, is drained into the Mississippi. The streams in its northeastern part flow either into the Great Lakes or directly to the Atlantic. The arrangement of the drainage of the northwestern part of the province has been determined largely by the positions and movements of ice sheets that existed during the Pleistocene epoch. It is supposed that all the preglacial streams north of central Kentucky flowed northward into the St. Lawrence or its tributaries, but the advancing ice sheet acted as a barrier, closing this northern outlet and establishing the drainage lines substantially as at present. A few of the westward-flowing streams in the southern half of the province have their sources at the summit of the Blue Ridge and flow westward across the Appalachian Valley and through the plateau into the Mississippi system.

Stratigraphy.—Most of the consolidated rocks of the plateau are of Carboniferous age. Lower Paleozoic rocks are exposed about the margins of the plateau and also where erosion has cut most deeply, and they extend under the Carboniferous rocks throughout the plateau. The Carboniferous strata are subdivided into three series—the Mississippian below, the Pennsylvanian in the middle, and the Permian above. The Permian and Pennsylvanian series are coal bearing; the Mississippian series as a rule is not. The rocks of these three series are chiefly alternating layers of shale and sandstone, although they comprise many layers of limestone, especially in the southwestern and southern parts of the plateau, where the Mississippian rocks include some thick limestone beds. The Pennsylvanian rocks cover the major part of the surface in the coal fields and contain most of the coal beds.

Structure.—Structurally the northern part of the Appalachian Plateau is a great trough or basin, the axial line of which extends southwestward from Pittsburgh across West Virginia to the Ohio at Huntington. The rocks southeast of this line generally dip northwest; those northwest of it dip southeast. The deepest part of the trough is near central West Virginia, toward which the beds generally dip. Around the northern and southern ends of the trough the beds outcrop in rude semicircular or elliptical bands. The Kenova quadrangle is situated at the extreme southwest end of this trough.

TOPOGRAPHY.

DRAINAGE.

General features.—The topography of the Kenova quadrangle is due to the long-continued erosion of rocks of different degrees of hardness. This erosion has been accomplished by streams.

The present drainage of the general region, including that of the Kenova quadrangle, is chiefly inherited from an ancient drainage and exhibits many features that indicate maturity, among the more notable being its pronounced dendritic character, which, with deep trenching, has produced a rugged topography but comparatively slight relief. Erosion has not yet rounded off the divides, which are generally rather sharp. Where the present streams do not follow the ancient channels these channels form belts of flat country, of which the "Flatwoods" near Ashland are a conspicuous example.

The Kenova quadrangle is drained either directly or indirectly into Ohio River, which crosses its northeast corner. The chief tributaries of the Ohio are Big and Little Sandy rivers and Twelvepole and Tygarts creeks, the last-named flowing across the extreme northwest corner of the area. Twelvepole Creek, entering from the Huntington quadrangle on the east, flows about 10 miles in a sinuous course in West Virginia and empties into the Ohio at Kellogg. Practically all the smaller streams flow into Big and Little Sandy rivers. Of these streams, Blaine Creek, a tributary of the Big Sandy that has an estimated length of about 70 miles, almost wholly within this quadrangle, and East Fork of the Little Sandy are the most important. Big Sandy River, which in conjunction with the Ohio is the main drainage channel of the area, is formed by the confluence at Louisa of Tug and Levisa forks. After flowing northward 27 miles it joins Ohio River at Catlettsburg. Levisa Fork is often referred to as Big Sandy River.

Asymmetry of drainage.—For an intelligent understanding of the present interesting arrangement of the drainage in the Kenova quadrangle it is necessary to go beyond the limits of the area. The causes of the asymmetrical drainage will be discussed in detail under the heading "Geologic history." In the Huntington quadrangle, on the east, Twelvepole Creek flows near the western margin of its basin, and the divide between it and Big Sandy River on the west is nowhere more than 3 or 4 miles distant, whereas the divide between it and Guyandot River on the east is from 12 to 15 miles away. Similar conditions prevail in the basin of the Big Sandy in part of its course in this area, but the difference between the width of the eastern and that of the western sides of its valley is not nearly so striking as is the difference along Twelvepole Creek. The basins of the Little Sandy and the East Fork of Little Sandy are symmetrical, for reasons that will be given later (p. 8). In the basin of Tygarts Creek, which flows across the extreme northwest corner of the quadrangle, the lack of symmetry is notable, but the asymmetry is opposite in kind to that in the basins of Big Sandy River and Twelvepole Creek. (See fig. 3.)

RELIEF.

The Kenova quadrangle lies near the western side of the Appalachian Plateau, in the lowland section, which contrasts with the upland section to the southeast, in West Virginia, southwestern Virginia, and western North Carolina. The plateau character within the area can now be realized only by broad general views from eminences within it. In these views the hilltops merge into what appears to be a continuous level plain. This ancient surface slopes gently from an altitude of 1200 feet along the southern edge of the quadrangle to a little above 1000 feet in its northwest corner.

The surface of the quadrangle, like that of most of the plateau, is decidedly irregular. It has been so much dissected that it now contains scarcely any level land except the flood plains of the larger streams. The extensive dendritic erosion, which is illustrated in figure 3, has produced sharp ridges, many of them barely wide enough for wagon roads, alternating with rather narrow V-shaped valleys having narrow flood plains

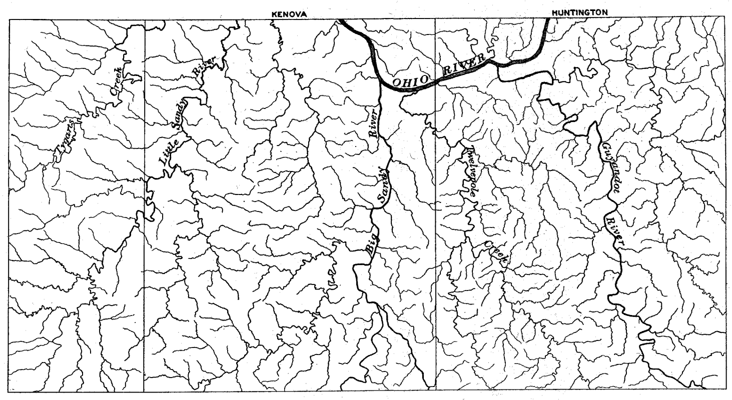


FIGURE 3.—Drainage map of the Kenova and Huntington quadrangles and adjacent area to the west, showing the asymmetry of the streams.

that reach well up to their heads. The relief though not great is pronounced, ranging from about 150 to 300 feet.

The lowest points in the quadrangle are those farthest downstream on Ohio and Little Sandy rivers and on Tygarts Creek. The flood plain of the Ohio slopes from about 560 feet above sea level at the eastern side of the quadrangle to about 530 feet at the western side. The flood plain of the Big Sandy has an elevation of about 600 feet at the south edge of the quadrangle and 550 feet where it enters the Ohio near Catlettsburg. It thus has a gradient of 1.1 feet per mile within the quadrangle. This is slightly less than the gradient of Little Sandy River.

The flood plain of the Ohio in this area averages three-fourths of a mile in width. On its margins are older gravel and silt terraces, splendidly developed in Ashland, Ky., and beyond the eastern limits of the area in Huntington, W. Va., these two cities being in part built on them. These terraces have not been shown on the map, owing to its small scale. The flood plain of the Big Sandy ranges in width from one-half to three-fourths of a mile. The flood plain of the Little Sandy from Grayson to Argillite is wider, but along the upper part of this river there is no flood plain, the stream flowing through a gorge in the Sharon conglomerate member of the Pottsville formation. The flood plains of both Big and Little Sandy rivers are terraced, the vertical distance between the terraces on Big Sandy River ranging from 8 to 10 feet.

Tight[a] has given a very complete description of many of the modifications of the drainage in this general area, and some of his descriptions apply closely to special localities in the Kenova quadrangle. Back of Ashland, for example, is a district known as the "Flatwoods." This can be readily made out on the topographic map from the absence of contours, which indicates a flat country. These flat lands represent ancient stream valleys. Similar remnants of old valleys occur along Big and Little Sandy rivers and are shown on the areal geology map as areas of high gravel deposits. Where the present streams follow the old valley floors they have cut narrow gorges. These old valley floors slope gradually from the heads of the rivers to their mouths, as do the valleys of the present streams. In Tight's account of the "Flatwoods" area and of Teays Valley, in the Huntington quadrangle, on the east, the gravel and silt deposits are minutely described.[b]

CULTURE.

Settlement.—The largest towns in the area are Ashland; Catlettsburg, the county seat of Boyd County; Louisa, the county seat of Lawrence County; Grayson, the county seat of Carter County, in Kentucky; and Kenova, in West Virginia. It is doubtful whether the combined population of the larger towns equals the strictly rural population.

Farming.—The area is under general cultivation. The flood plains of the streams are subject to periodical overflows and hence are very fertile. In the valleys of the larger streams some wheat is grown, but the principal crop is corn. Tobacco is cultivated on many of the hillsides in Carter County. The crops named and the usual garden crops constitute the principal products of the soil. The timber resources of the area are of little importance, most of the big timber having been removed during the days of the old charcoal iron furnaces, in the seventies and early eighties of the nineteenth century.

Roads.—Although the country is comparatively rugged, it is traversed by a network of fairly good country roads, the construction of which is facilitated by the softness of the rocks. In Boyd County the roads are notably well kept, and there are many miles of "pike," or macadamized roads.

Railroads.—The main line of the Chesapeake & Ohio Railway enters the area from Huntington, W. Va., crosses Big Sandy River at Hampton and follows the south bank of the Ohio. The Big Sandy division of this line runs along the west bank of Big Sandy River. The Louisville & Lexington division leaves the main line at Ashland and crosses the northwestern part of the quadrangle. The Ashland Coal & Iron Railway runs from Ashland to Denton; its tracks are used by the Louisville & Lexington division of the Chesapeake & Ohio. The Norfolk & Western Railway has recently built a line on the east bank of Big Sandy River which connects with its Twelvepole division and crosses the Ohio at Kenova. The Baltimore & Ohio Railroad has a terminus at Kenova. The Eastern Kentucky Railway, a short line constructed several years ago, runs from Webbville, Lawrence County, to Riverton, Greenup County, where it joins the Chesapeake & Ohio Railway.

River improvements.—Big Sandy River has been under improvement by the United States Government since 1878. In the Kenova quadrangle three locks have been built on this river below Louisa, one on Tug Fork at Saltpeter, and one on Levisa Fork at Chapman. The river will thus be made navigable the whole year instead of during only about eight months, and the present commerce will be largely augmented. The development of the thinner coals in the Kenova area and the thicker beds near the headwaters of the river will also be aided. The smaller streams, which are used chiefly in transporting logs and ties, are navigable during only a short season.

Relation of culture to topography.—The larger towns of the area are on the railroads, which naturally have been built along the easiest routes—the river valleys. In the valleys, also, erosion has cut deepest, and in them, consequently, the workable beds of coal and clay are best exposed. Only from such localities could these products be removed cheaply and expeditiously to market, and therefore the coal and clay of the area have been exploited chiefly along Ohio River, Williams Creek, and Little Sandy River.

The majority of the rural population live in the stream valleys, because most of the roads have been built along these valleys and because the only level lands in the area are the flood plains of the streams. The roads in the valleys have generally been built slightly up on the valley sides, to avoid washouts caused by the spring freshets. Though in a broad way they follow the gradients of the streams rather closely, yet they run up and down across many hills in their courses. As the area is much dissected by streams many of the other roads cross numerous divides, and in order to obtain easy grades most of them have been run diagonally over the ridges. Ridge roads—roads along or near the tops of ridges—are few and are as a rule long, tortuous, and poorly kept up, for few people live on the ridges.

The valleys are generally cultivated, but the hillsides have not been entirely neglected. In parts of the quadrangle—in Carter County, for example—even steep hillsides are planted in tobacco.

[a] Tight, W. G., Drainage modifications in southeastern Ohio and adjacent parts of West Virginia and Kentucky: Prof. Paper U. S. Geol. Survey No. 13, 1903, pp. 27 et seq.

[b] Idem, pp. 50 et seq.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

NATURE AND AGE OF THE ROCKS.

With one exception the rocks appearing at the surface in the Kenova quadrangle are of sedimentary origin—that is they were deposited in or by water. They include sandstone, shale, limestone, coal beds, iron ore, clay, and glass sand. Their total thickness is between 1100 and 1200 feet. The 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, which is of Recent age. The Mississippian and Pennsylvanian series of the Carboniferous system are represented in the rocks of this quadrangle. Each series comprises several formations, which in turn are subdivided into members, the various subdivisions being distinguished by their lithologic character and their fossils. The workable coals of the area are found in the Pennsylvanian series.

A knowledge of the rocks beneath those which outcrop at the surface has been obtained from deep wells drilled in search of oil and gas. Some of the facts thus obtained are merely supplementary to the knowledge obtained from the surface studies, but much of the information is entirely new. This method of obtaining knowledge of the lower rocks is likely to cause errors in correlation, for the following reasons: First, the division of these rocks into geologic units is based almost wholly on differences in physical character, distinctions which often fail when applied to surface rocks; second, the determination of lithologic characters is often made by persons incompetent to make such discriminations; and third, unless measurements are made with steel tape errors in determination of thickness of beds are likely to be made. On the other hand the horizons at which the driller's general knowledge of the underground stratigraphy of a given district would lead him to expect to find oil and gas are usually carefully watched for, and hence the upper and lower limits of the oil and gas bearing beds are as a rule rather closely determined.

ROCKS NOT EXPOSED.

DEVONIAN SYSTEM.

The records of deep wells show, beneath the shales and sandstones at the base of the Mississippian series, a body of more or less calcareous shale, 500 to 600 feet thick, at the base of which occurs a gas or oil bearing limestone, called the Ragland sand by the Kentucky drillers. This oil-bearing bed is a limestone and is believed to be the "Corniferous" limestone of the Kentucky Geological Survey reports. If this is correct the shales above the Ragland "sand" are Ohio shale. In some wells the Ragland is underlain by a few feet of black shale, but in others the underlying rocks are more or less calcareous. It is probable that the wells drilled in the southern part of the area (see well sections on the columnar-section sheet) reached Silurian limestone. This limestone may have been reached also in some wells near the northern part of the quadrangle, as in that at Central City, in the Huntington quadrangle, where a part of the 215 feet of limestone at the base of the section (see p. 3) may be Silurian. This statement is based on the fact that in Ohio, where these rocks outcrop, the limestones at the base of the Devonian are nowhere over 75 feet thick.[a]

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

The Mississippian series includes the Maxville limestone and the underlying rocks, its lower boundary being provisionally drawn by most geologists at the base of the Bedford shale. In some wells the Maxville limestone is overlain by thin red and green shales, which also belong to the Mississippian. The average thickness of the series is about 700 feet in the northern part of the quadrangle and somewhat less farther south.

The Berea sandstone and the Sunbury ("Berea") shale near the base of the series consist of oil and gas bearing sandstone and shale from 60 to 200 feet in thickness. Although these formations do not outcrop in the quadrangle, they have been identified by Foerste at Vanceburg, Ky., a few miles to the northwest.[b] In several of the well sections the Berea sandstone has been designated limestone in the driller's records, but it should probably have been called sandstone, for near the surface in the same wells beds that are almost certainly known to be sandstones are also given as limestones. (See well sections Nos. 2, 3, 5, 6, 7, 11, and 12 on columnar-section sheet.)

Upon the Sunbury shale lies a rather thick body of shales containing a few thin beds of sandstone, presumbly the Cuyahoga shale of Ohio. In the wells in the northern part of the quadrangle this shale ranges in thickness from 370 to 470 feet. In the wells in the central part of the quadrangle, except the Alum City Oil Co.'s well at Straight Creek (well section No. 2), its thickness is rather uniform, ranging from 375 to 440 feet. It is fairly uniform also along the southern edge of the quadrangle, most wells showing about 400 feet.

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

[b] Foerste, A. F., Jour. Geology, vol. 17, 1909, pp. 165, 166, 174.

In most of the records the rocks are described as sand and shale, the latter commonly light or gray, but in places dark or black. Local limestone layers are also recorded.

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

	Thickness.	Depth.
	Feet.	*Feet.*
Carboniferous:		
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 ("Berea" [Sunbury] shale)	22	757
Sand, Berea (oil and gas)	112	869
Slate, gray (Bedford?)	25	894
Slate, red (Bedford?)	6	900
Devonian:		
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, "Corniferous," (oil and gas)	2	1,425
Silurian:		
Limestones, fine and coarse; strong flow of salt water at 1,475 feet	55	1,480

Section of Carboniferous and Devonian strata in well on Fourpole Creek, near Central City, W. Va.

	Thickness.	Depth.
	Feet.	*Feet.*
Conductor [sand and gravel]	26	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
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 Silurian]	215	2,970

In the wells in the northern part of the quadrangle there is a persistent sandstone beneath the Maxville limestone. In places it is overlain by a shale bed, commonly thin but 40 feet thick in the Joshua Kelly well (well section No. 1, on columnar-section sheet). At Straight Creek and on Glancy Fork no sandstone was recorded at this horizon, but the Horseford Creek well (No. 18) shows 95 feet of it. In the Blaine Creek section (No. 19) 370 feet of white sandstone and conglomerate are reported at this horizon, and undoubtedly part of this thickness is the upper sandstone of the Logan formation. The remainder may be sandstone of Pennsylvanian age, the intervening Maxville limestone being locally absent, or it may be limestone erroneously called sandstone. The sandstone is generally absent from the wells in the southern part of the quadrangle, except the Jason Boggs well (No. 5), where it is said to measure 345 feet, the underlying shale measuring only 75 feet. This determination of the lithologic character of the rocks is open to question, as the shale below the sandstone is elsewhere 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 horizon. The complete record, which seems to be the only one known in this part of the quadrangle, is given above to show the character of the underlying formations in this part of Carter County.[a]

In the record of the deep well near Central City, W. Va., the sandstone, overlain by 28 feet of shale, is recorded as 177 feet thick, showing that it extends eastward beyond this quadrangle.[b] The well was drilled in 1898. The record given above was furnished by Thomas W. Harvey, owner.

The meager data available in this quadrangle indicate that this sandstone thins out southward. It represents the Burgoon sandstone (the Big Injun sand of the Pennsylvania drillers), the Big Injun group of the Kentucky Geological Survey, and the Blackhand and Logan formations of the Ohio Geological Survey. Its thickness ranges from 70 to 370 feet.

ROCKS EXPOSED.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

LOGAN FORMATION.

About 100 feet of the upper part of the Logan formation is exposed in the Kenova quadrangle. It is best seen in the valley of Tygarts Creek, on the hills about Warnock. The rocks are shale, shaly sandstone, and sandstone, and form a part of the sandstone and shale just described as occurring beneath the Maxville limestone in the deep wells.

MAXVILLE LIMESTONE.

Upon the Logan formation lies a massive limestone, the Sub-Carboniferous limestone of the Kentucky Geological Survey, which has been correlated with the Maxville limestone of Ohio. Its outcrops in the Kenova quadrangle are small and are confined to its northwestern part, two appearing in the valley of Everman Creek in Carter County, close to the west edge of the quadrangle, and another on the North Fork of Oldtown Creek. Its thickness in this quadrangle is less than 25 feet. In the Everman Creek area it is overlain by a thin bed of iron ore.

The Maxville limestone is recorded in all the deep well sections except one (No. 19), near the mouth of Blaine Creek, and it serves as a convenient key horizon. Its apparent absence in the Blaine Creek well is not easily explained, since in the Horseford Creek well, 1.5 miles distant, the limestone is reported to be 140 feet thick. It was probably encountered in the Blaine Creek well but was considered a sandstone. In other wells, notably Nos. 2 and 12, the Maxville limestone seems abnormally thick. It is possible that the lower part of this limestone as recorded is either sandstone or shale, for it is reasonably certain that in these wells, as in others drilled in this area, some sandstone has been reported as limestone.

PENNSYLVANIAN SERIES.

The top of the Maxville limestone marks the base of the Pennsylvanian series, unless the overlying red shale encountered in some well borings should prove to be Mississippian. As in other parts of the northern Appalachian bituminous coal field, the Pennsylvanian series comprises four formations, the Pottsville, Allegheny, Conemaugh, and Monongahela, each made up of a number of members.

POTTSVILLE FORMATION.

Name, limits, and thickness.—The Pottsville formation takes its name from Pottsville, Pa. It is the lowest formation of the Pennsylvanian series. It rests unconformably on Mississippian rocks and comprises all the beds above the Mississippian to the top of the Homewood sandstone. It is distinguishable from the formations below and above by both its lithologic character and its fossils. The entire formation is exposed in the northwestern part of the quadrangle, where it has a thickness of about 400 feet. It is much thicker in the southern part of the quadrangle, where at least 600 feet of it are exposed and a well record shows it to be nearly 1400 feet thick.

Distribution and character.—Nearly one-half of the entire surface of the quadrangle is occupied by the Pottsville formation, which consists chiefly of sandstone but contains scattered beds of shale, iron ore, limestone, and coal. In the southeastern part of the quadrangle it is well developed and a nearly complete section of the exposed rocks was obtained along Levisa Fork and in the surrounding hills. This section is given in the next column.

It is probable that in places south of Louisa, where the sandstone called Homewood is very massive and apparently homogeneous throughout, it is not wholly of true Homewood age. Its lower part probably belongs under the Upper Mercer coal (No. 4 of Kentucky Survey), which was cut out in places by a thickening of the lower sandstone member. Only the upper part of the bed in these places should be regarded as the true Homewood sandstone.

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

[b] Campbell, M. R., Huntington folio (No. 69), Geol. Atlas U. S., U. S. Geol. Survey, 1900, p. 3.

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

	Ft.	in.
Sandstone, massive (Homewood)	40–60	
Coal (Upper Mercer, No. 4 of Kentucky Survey).		
Ore, black band	8–12	
Concealed	20	
Sandstone, massive	20	
Shale or sandstone	15	
Coal (Lower Mercer, No. 3 of Kentucky Survey).		
Probably shaly sandstone	50–60	
Coal (Quakertown?)		4–8
Probably 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
Shale and sandstone	5	
Coal bloom		6
Sandstone, conglomeratic, 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.		
Fire clay		8
Sandstone		1½
Concealed	20±	
Sandstone, shaly, micaceous	10	

The section shows several massive sandstones separated by bodies of shale and shaly sandstone, and also limestones, coals, and iron ore, the total thickness being 600 feet. The general sandy character of the formation is also noteworthy. The correlation of the members of this formation in this area with those in Pennsylvania is based on the studies of David White.

At least 250 feet of Pottsville rocks are exposed along East Fork of Little Sandy River near the northern boundary of the quadrangle. Farther east, nearer the center of the basin, the Pottsville dips below drainage level and, except along Ohio River, the area occupied by it east of the Ashland Coal & Iron Railway is very small. West of this railroad, in the hills dividing the Little Sandy from East Fork, the Pottsville reaches well up toward the hilltops and its rocks are conspicuously exposed. Here the formation is prevailingly sandy but not quite so sandy as along Tug and Levisa forks.

The following section, compiled from barometric measurements made along the northern margin of the quadrangle from Argillite eastward to Hood Creek, gives a general idea of the Pottsville formation in this part of the area:

Section of Pottsville formation 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 (Lower Mercer, No. 3 of Kentucky Survey), 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	

In the general region traversed by Little Sandy River the Pottsville covers a larger area than any other formation and is economically the most important. The formation is exposed in its entire thickness in this region, resting on the Maxville limestone below, with the Homewood sandstone member at its top. It is prevailingly sandy but contains some shale beds.

The important beds of the Pottsville formation are given in the columnar section. They will be described in the order of their occurrence, beginning with the lowest.

Sciotoville fire clay.—The lowest bed that is of stratigraphic importance in the Pottsville formation is a valuable and persistent fire clay lying a few feet above the Maxville limestone. It outcrops on Everman, Tygarts, and Oldtown creeks and is from 4 to 6 feet thick. It is correlated with the Sciotoville or Logan fire clay of the Ohio Geological Survey.

Sharon(?) coal and Sharon conglomerate member.—According to David White the coal underlying the massive sandstone that is prominent back of Chapman, W. Va., is thought to represent the Sharon coal in this part of the quadrangle. At Gallup the sandstone below this coal is provisionally correlated with the Sharon conglomerate member. The sandstone is here 50 to 60 feet above railroad grade and a short distance north of the store it is 50 feet thick. The section below the sandstone is characterized by dark shales and gnarly "cauda-galli" flags and includes limestones and coals of various thicknesses.

In the valley of Little Sandy River the supposed Sharon conglomerate is found about 20 to 30 feet above the base of the Pottsville. It is one of the most important members of that formation in this part of the area. In the reports of the Kentucky Geological Survey it is often referred to as the "conglomerate formation" or "conglomerate rock." On Everman Creek there are two conglomeratic sandstones separated by a thin black shale which in places contains coal. The fossils obtained from this shale indicate that the coal is equivalent to the Jackson Shaft coal of Ohio and the Sharon coal of Pennsylvania. If this provisional correlation is correct, the lower of the two conglomerates represents the Sharon conglomerate of Pennsylvania.

In the southwestern part of the quadrangle the Sharon attains in places a thickness of 100 feet and is unusually massive and conglomeratic. It appears in the valley of Little Sandy River, along Brushy, Hood, and Lower Laurel creeks, and on Field Branch.

Barrett Creek or "Little Cannel" and associated coals.—Most of the coals of the Pottsville formation are locally workable. They were numbered by A. R. Crandall[a] and the numbers given by him appear in the section along Levisa Fork given on page 3. According to David White, the reference of the group of thin coals, of which the "Little Cannel" is one, in the section along Levisa Fork, to the Sharon coal does not appear to be fully sustained by paleobotanic evidence. This group of coals, which occurs within a height of 33 feet near railway level just north of Torchlight, may be at a horizon higher than the Sharon. The "Little Cannel" coal corresponds with the Barrett Creek coal of the northwestern part of the quadrangle, which is coal No. 1 of the Geological Survey of Kentucky.

Quakertown (?) coal.—What appears to be the Quakertown coal occurs in the northern part of the quadrangle, between Argillite and Hood Creek, where it lies 110 feet below the Homewood sandstone member. It is locally known as the "Clod" seam and has been extensively opened but only for local use.

The Mercer coals.—The main coal worked at Torchlight, Ky., has been correlated by David White with the lower coal worked at Boghead, Carter County. The next higher coal of importance at Torchlight corresponds with the upper coal worked at Boghead. The lower and upper coals worked at Boghead, on Stinson Creek, correspond to coals Nos. 3 and 4 of the Geological Survey of Kentucky, and according to White they are to be correlated with the Lower and Upper Mercer coals, respectively, of western Pennsylvania. The positions of these two coals in the geologic column and their relation to the other important members along Levisa Fork are shown in the section on Levisa Fork south of Louisa, given on page 3. It will be observed that the Upper Mercer coal occurs directly below the Homewood sandstone. The Lower Mercer coal is found 30 to 75 feet below the Upper Mercer coal.

Homewood sandstone member.—The Homewood sandstone is the top member of the Pottsville formation. In the southeastern part of the quadrangle it is massive and ranges from 40 to 60 feet in thickness. In Ohio it is seen near Coalgrove depot, but here it is not prominent, for it is not fully exposed. Along the Ohio near Ashland and Cliffside Park the sandstone commonly assigned to this member is unusually massive, attaining a thickness in some places of 75 feet. It is a question, however, whether all this sandstone is really of Homewood age, for west of Ashland it apparently forms one massive cliff reaching nearly to the base of the fire clay at the horizon of the Vanport ("Hanging Rock") limestone member of the Allegheny formation. It is possible, therefore, that the upper part of this sandstone may belong to the Allegheny and not to the Pottsville formation. Farther southwest, toward Princess, Coalton, and Rush, it dwindles to a shaly sandstone, nowhere exceeding and in few places reaching 10 feet in thickness. Taken as a whole, however, it is the most prominently exposed bed of the Pottsville formation along or near the East Fork of Little Sandy River. In the western part of the quadrangle this member ranges in thickness from 25 to 50 feet and in the southwestern part it is locally a very important member, attaining in places a thickness of 100 feet.

ALLEGHENY FORMATION.

Name and limits.—The Allegheny formation takes its name from Allegheny River in Pennsylvania, along which it is conspicuously exposed. As it is the lower of the two series of strata containing many valuable coals, it was formerly known in western Pennsylvania as the "Lower Productive Coal Measures."

[a] Crandall, A. R., Reports on the eastern coal field: Rept. Kentucky Geol. Survey, vol. C, 1884, pp. 11–25.

The Allegheny formation overlies the Pottsville and is in turn succeeded by the Conemaugh. It includes the beds from the base of coal No. 5 of the Kentucky Survey, which, according to Stevenson,[a] corresponds to the Brookville coal of Pennsylvania, to the top of the No. 7 or Waterloo coal of Ohio, which is believed to correspond to the Upper Freeport coal of Pennsylvania. The formation is distinguished from the Pottsville by a difference in lithologic character, and its fossil plants also are different from those of the Pottsville.

Thickness.—In the northern part of the quadrangle, including the part in Ohio, the average thickness of the Allegheny formation is about 180 feet. In the western and southern parts of the quadrangle the thickness is less and is far from uniform. Along Big Sandy River north of Louisa the thickness is about the same as in the northern part of the area near Ashland, Ky., and Coalgrove, Ohio, namely, 160 to 180 feet. Along the Chesapeake & Ohio Railway and in the region drained by East Fork of Little Sandy River and its tributaries, the Allegheny ranges from 180 to 200 feet thick. Near Willard, Carter County, the formation generally ranges in thickness from about 120 to 200 feet, but in places it is less than 120 feet thick, for on one side of a hill near the town it measures about 130 feet and on the other side less than 100 feet. In general it may be said that the formation is thinner where the underlying Homewood sandstone member of the Pottsville is thicker.

Distribution and character.—In the Kenova quadrangle the number of coals in the Allegheny formation is commonly not more than six and in many places four or less. In this part of Kentucky the formation contains also a valuable clay deposit and beds of sandstone, shale, limestone, and iron ore. It is less conspicuously sandy than the underlying Pottsville.

In Ohio the Allegheny formation, except the Brookville coal at its base, is fairly well developed, as will be observed from the section near Coalgrove given below. It outcrops in all the hills in Upper and Perry townships, but its easterly dip causes it to disappear near North Kenova just east of the Norfolk & Western Railway bridge.

A section of the formation may be observed along the road northwest of Louisa from a point near the confluence of Canes Branch and Twomile Creek. In this region the Allegheny loses some of the distinctiveness that characterizes it in the northern part of the quadrangle, and its upper limit is somewhat doubtful. Southward from the region around Louisa the rise of the beds causes the gradual disappearance of the Allegheny from the hills. North of this locality the formation gradually descends to the center of the basin, and at Zelda the highest coal in the formation disappears beneath the flood-plain deposits. The rise in the beds brings the Allegheny above drainage level again north of Savage. The formation is partly or wholly exposed in nearly all the hills in the southern third of Big Sandy Valley and also near the mouth of the Big Sandy.

A section west of Willard, Carter County, gives a good idea of the Allegheny formation in the southwestern part of the quadrangle. Not all the beds in the Allegheny observed in this section appear everywhere in the southwest corner of the area, for the formation is variable. The section represents the average of two distinct barometric determinations.

Section in hill west of Willard, Carter County, Ky.

	Feet.
Top of hill.	
Conemaugh formation:	
Sandstone, massive, and sandstone débris	45
Limestone, massive, drab, fossiliferous	4–5
Partly concealed with sandy débris and sandy shales	60
Sandstone, massive, white to light brown	25
Allegheny formation:	
Coal (Upper Freeport).	
Fire clay	2–3
Shale, sandy, and shaly sandstone	20
Coal (Lower Freeport).	
Concealed and sandy	15
Limestone, yellow	$1\frac{1}{2}$+
Shale, drab	15
Coal, workable (Middle Kittanning).	
Sandstone, laminated	20
Ore, limestone.	
Concealed	10
Coal (Lower Kittanning).	
Shale (fire clay at top)	15
Coal, two small blooms 6 inches apart.	
Shale and fire clay	20
Coal (Brookville).	
Pottsville formation:	
Sandstone, laminated (Homewood)	10
Sandstone, massive (Homewood)	20
Coal bloom; coal has been worked.	
Fire clay.	
Sandstone and shale	15
Coal bloom; coal has been worked.	
Sandstone	10±
Base of hill.	

Along the Chesapeake & Ohio Railway and in the region drained by East Fork of Little Sandy River and its tributaries practically all the important beds of the Allegheny shown in the section near Willard are exposed at one place or another. In a general way the formation occupies a surface zone extending from northeast to southwest in the region under discussion. West of the Ashland Coal & Iron Railway the Allegheny forms the tops of the hills, but east of the railroad the dip causes the formation to occupy lower and lower positions in the hills and to disappear near the head of East Fork and Straight Creek.

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

The Allegheny formation in the valley of Little Sandy River is confined chiefly to the hills east of the stream, but its base is exposed in the tops of some of the highest hills on the west between Little Sandy River and Tygarts Creek. Its general characteristics are similar to those it exhibits in the region on the east along the Chesapeake & Ohio Railway.

In the valley of Little Sandy River the Allegheny formation includes at least three valuable coal beds that are workable in different places, at least one valuable fire clay, and some deposits of iron ore, but the bulk of the formation here as elsewhere 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 southwestward to the southern edge of Carter County, and thence trends southeastward. Many of the hilltops west and south of the main Allegheny belt are formed by the rocks of this formation. Roughly it covers about one-third of the surface in the southwestern part of the quadrangle.

The principal beds of the Allegheny formation are described below in the order in which they were deposited. The columnar section shows that in general the beds of stratigraphic importance are or have been of economic importance.

Brookville coal.—The Brookville coal is the lowest bed of the Allegheny formation and is generally of workable thickness. This coal corresponds to No. 5 of the Kentucky Geological Survey. In Ohio the Allegheny formation is fairly well developed, as will be seen from the section given below. The coal at the base of the section corresponds to the Brookville. It does not outcrop, or at least was not observed, in Ohio in this quadrangle, but in parts of the quadrangle in Kentucky it is of great stratigraphic as well as economic importance.

Vanport limestone member.—The next higher important member of 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 regarded as equivalent to the Vanport ("Ferriferous") limestone of western Pennsylvania and that name will be used in this folio. Its relations in the Kenova quadrangle are well displayed at Coalgrove, Ohio, opposite Ashland, where the following section was measured:

Section near Coalgrove depot, Ohio.

	Feet.
Conemaugh formation:	
Sandstone, laminated	25
Shale, red and green	25
Limestone, fossiliferous	1
Sandstone, laminated	20
Shale	10 ±
Sandstone, laminated	36
Allegheny formation:	
Coal bloom (Upper Freeport coal, No. 7 of Ohio Survey).	
Concealed	50
Position of Lower Freeport coal (No. 6a of Ohio Survey).	
Concealed and shaly sandstone	44
Coal (Middle Kittanning, No. 6 of Ohio Survey).	
Sandstone, massive	33
Coal (Lower Kittanning, No. 5 of Ohio Survey).	
Sandstone, massive	40
Clay, massive flint	$1\frac{1}{2}$–$1\frac{2}{3}$
Clay, plastic	5
Limestone (Vanport or "Hanging Rock")	4
Fire clay	$1\frac{2}{3}$
Concealed	5
Probable position of Brookville coal (No. 4 of Ohio Survey).	

The Vanport limestone member in most places lies from 10 to 20 feet above the top of the Homewood sandstone. It ranges in thickness from 4 to 6 feet. On a map with 100-foot contour intervals, such as the map in this folio, it is impossible to show separately the line of outcrop of this limestone and its associated fire clay and that indicating the base of the formation. The limestone in many places rests directly on the Homewood sandstone, especially where the Brookville coal is absent. An important clay bed is generally associated with it, and its horizon on this account has an economic interest. In Ohio this clay and limestone occur together capped by a massive 40-foot sandstone, shown in the section above.

Lower Kittanning coal.—At the top of the sandstone just mentioned is found the Lower Kittanning coal. This coal corresponds with coal No. 6 of the Kentucky Geological Survey and with coal No. 5 of the Ohio Geological Survey. In Kentucky it is also known as the Limestone, the Keyes Creek, and the River Hill coal, and in Ohio as the Newcastle coal. It is commonly found 20 feet above the Vanport limestone, but in Ohio it lies about 40 feet above. Northwest of Louisa, near the confluence of Canes Branch and Twomile Creek, the Lower Kittanning coal is present in workable thickness 30 feet above the top of the Homewood sandstone, which is well exposed here in the road bed at drainage level. Between the Lower Kittanning coal and the next higher important bed, the Middle Kittanning coal, is found a bed of stratigraphic importance known as the yellow kidney iron ore. This iron ore is

[a] Rept. Ohio Geol. Survey, vol. 3, pt. 1, 1878, pp. 885 et seq., 992 et seq.

20 to 25 feet above the Lower Kittanning coal and about the same distance below the Middle Kittanning coal. It was formerly of economic importance, but it is not now worked.

Middle Kittanning coal.—The next higher bed of importance is the Middle Kittanning coal. This is coal No. 7 of the Kentucky Geological Survey, the No. 6 or Sheridan coal of the Ohio Survey, and the celebrated Nelsonville coal of the Hocking Valley. It lies from 25 to 45 feet above the Lower Kittanning coal and from 40 to 50 feet below the next higher coal in this formation. In Ohio the interval between it and the Lower Kittanning is occupied by a massive sandstone 33 feet thick. It is generally also overlain by a massive sandstone, which serves as a clue for locating it. Above this massive sandstone is a thin bed of red or purple shale, which is well exposed on the county road east of Summit. About midway between this coal and the next higher coal bed is a bed of limestone, in places altered to iron ore, commonly known as the red kidney ore. This ore is at present of no economic importance but serves as a convenient stratigraphic marker. From the top of the sandstone overlying the Middle Kittanning coal to the base of the next higher formation the beds are prevailingly shaly and include the Lower and Upper Freeport coals.

Lower Freeport coal.—The next higher beds of importance in the Allegheny formation are two coals. The lower of these is found about 45 feet above the Middle Kittanning coal and from 30 to 50 feet below the next higher coal. This lower coal is the Hatcher coal of both the Ohio and Kentucky geological surveys. In Kentucky it is No. 8 in the series and in Ohio it is No. 6A. E. McMillan has correlated it with the Lower Freeport coal of Pennsylvania.[a] This coal is workable in parts of the quadrangle, but as yet it is chiefly of stratigraphic and not of economic importance.

Upper Freeport coal.—Thirty to fifty feet above the Lower Freeport coal is the Upper Freeport coal, which, like the bed below it, is generally thin and only locally of workable thickness. This coal is of stratigraphic importance, for it marks the top of the Allegheny formation and occurs either at or a little below the base of the Mahoning sandstone member of the overlying Conemaugh formation. This bed is the Waterloo, Bayleys Run, or No. 7 coal of the Ohio Geological Survey.

CONEMAUGH FORMATION.

Name and limits.—The Conemaugh formation was formerly called the "Lower Barren Coal Measures." It received its present name from Conemaugh River, Pa., along which it is conspicuously developed and exposed. It includes the rocks above the Upper Freeport coal and below the Pittsburgh coal. As the correlation of the Upper Freeport coal in this area has been somewhat confused, details concerning its position and hence that of the base of the Conemaugh formation will be given here.

What is regarded as the Upper Freeport coal, with the overlying massive Mahoning sandstone member, is well exposed north of Louisa in the vicinity of Zelda and on Blaine Creek near Fallsburg. Above the sandstone, which forms the roof of this coal and which varies in thickness from 20 to 30 feet or more, the rocks are in marked contrast with the rocks below, both in the character and the number and importance of their coal beds.[b] The massive sandstone mentioned is probably the 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.[c] The position of the coal under consideration, which north of Louisa lies immediately beneath a massive sandstone (the Mahoning of Owen), indicates strongly that it corresponds 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 coal next below the Mahoning sandstone of Owen and asserts that this coal is commonly known as the Hatcher seam.[d] In another place[e] he states that above the shales containing coals Nos. 7 and 8 there is 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 of Kentucky,[f] interprets Crandall's generalized section of Greenup, Boyd, and Carter counties as placing coal No. 9 below the Mahoning sandstone; but in Plate I of his report Crandall places it well above the base of the Mahoning sandstone. In view of the evidence above outlined 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 or No. 8 coal of the Kentucky Survey. Normally, therefore, it would be No. 9 of the Kentucky Survey, but instead of coming within the Mahoning sandstone, where coal No. 9 was placed by Crandall, it occurs just below it, as in Pennsylvania.

Thickness.—The best section of the Conemaugh obtainable in the area is that seen along the tracks of the Norfolk & Western Railway in Wayne County, W. Va., from the mouth of the Big Sandy southward to and including the hill section along the private road near the mouth of Gragston Creek. A hand-leveled section exposed in the bluffs back of the town of Kenova to Cyrus, at the mouth of White Creek, is as follows:

Section of Conemaugh formation between Kenova and Cyrus.

	Feet.
Sandstone (Saltsburg? or Morgantown?)	35 – 40
Interval	95 –109
Limestone, fossiliferous, with abundant crinoid stems and brachiopods (Ames?)	5 – 10
Interval	32½ - 50
Massive sandstone (Buffalo)	40
Interval containing a limestone (Lower Cambridge) near its middle and probably made up chiefly of shale, sandy shale, and shaly sandstone	79
Mahoning sandstone member	46±

The Mahoning sandstone, as already indicated, outcrops in a bluff just back of Kenova. Here it is about 45 feet thick and probably not all present, for there seems to be a local erosional unconformity at or near its base and the Upper Freeport coal does not show. This coal, however, is present along the railroad farther to the south, near Columbia siding, and also outcrops and has been worked on Miller Creek not far away.

The 5 to 10 foot fossiliferous limestone at or near the top of the above section was observed in the road that ascends the hill at the mouth of Gragston Creek, at a point where the Pittsburgh coal is mapped on the areal sheet. This coal, the original identification of which as the Pittsburgh is due to I. C. White, is by barometer 310 feet above the limestone and by hand level 325 feet above, making the Conemaugh along Big Sandy River in this section approximately 550 feet thick. This is not the maximum thickness of the formation, as the Mahoning sandstone member is thicker than the above figure (46 feet) east of Kenova and along Twelvepole Creek. The thickness given for the lower part of the Conemaugh below the upper limestone in the above section (215 feet) is greater than that found in other parts of the quadrangle, even in West Virginia. In Ohio the interval from the base of the Mahoning sandstone to the base of the sandstone correlated with the Buffalo in the above section is 92 feet instead of 125 feet, the thickness along the Big Sandy; and at Cassville, farther south in West Virginia, the interval from the base of the Mahoning to the top of the Buffalo is 90 feet instead of 165 feet, the thickness near the mouth of the Big Sandy. This minimum figure, 90 feet, combined with the minimum interval between the top of the Buffalo and the limestone observed on Miller Creek, makes the thickness of that part of the Conemaugh below the fossiliferous limestone 122½ feet. If the part above the fossiliferous limestone is taken at 325 feet the entire thickness of the Conemaugh is approximately 450 feet. To summarize, therefore, the maximum thickness of the Conemaugh in the Kenova quadrangle is probably between 500 and 600 feet and the minimum thickness about 450 feet and possibly less.

The section of the Conemaugh formation obtained by the Ohio geologists in Lawrence County is only 420 feet thick, suggesting a westward thinning of the formation, which is in full accord with the westward thinning known to occur from Pennsylvania across the panhandle of West Virginia into Ohio. In the Kenova quadrangle the Conemaugh is probably thinner than it is on the northeast at Huntington but thicker than the Ohio geologists found it. West of Big Sandy River a definite thickness can not be assigned to the formation, as its top is not present. A general and detailed view of the Conemaugh where the formation is fully developed in this quadrangle, however, sustains the belief that its normal thickness is close to the figure given by the Ohio geologists.

Distribution and character.—In Ohio only the lower part of the Conemaugh is exposed. The section near Coalgrove (see p. 4), which gives an excellent idea of the lower part of the formation, is typical of this part of the Conemaugh except that the basal sandstone is particularly massive. Its massive character is well shown near the Norfolk & Western Railway bridge near North Kenova and on the county road joining the river pike west of Burlington. This sandstone forms prominent cliffs all along Ohio River in this area and in West Virginia. 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 the Ohio. They consist chiefly of red shale and sandstone with local beds of limestone and coal beds that are in few places of workable thickness. In Fayette Township the surface of the country is occupied chiefly by shales of the Conemaugh and by local sandstones and small and unimportant coal beds.

The whole thickness of the Conemaugh formation is not exposed anywhere west of Big Sandy River so far as known. Along the Louisville & Lexington branch of the Chesapeake & Ohio Railway and farther west, lower rocks occupy most of the surface. Southeast of this railway, however, the eastward dip brings the Conemaugh rocks lower down in the hills and finally below drainage level, and for several miles north of Fallsburg and Olioville they are the only rocks exposed west of the Big Sandy. The massive Mahoning sandstone member at the base of the Conemaugh formation in this part of the area is well shown west of Alley in the hills bordering Pigeonroost Creek and along the Chesapeake & Ohio Railway. At distances above the sandstone that vary from place to place but rarely exceed 40 feet lies a fossiliferous limestone, either the Lower Cambridge or the Upper Cambridge, which is closely overlain by another massive sandstone. Thus the lower 100 feet of the formation is generally sandy and is accordingly comparable with the lower part of the Conemaugh at the mouth of Big Sandy River. The upper part of the formation contains massive sandstone in places but is mainly shaly, the shale being reddish and purple and including local green layers. Much of this shale would be of commercial value if it were situated near lines of transportation. No commercial coals have been found in the Conemaugh formation in this region.

As the beds rise toward the west the Conemaugh formation is practically absent in the hills bordering Little Sandy River. In the south-central part of the quadrangle, however, Conemaugh rocks outcrop; and east of Willard, in one of the deeper parts of the basin, the surface is occupied entirely by this formation. Just west of Willard and in a few isolated areas on the hilltops west of Dry Fork Conemaugh rocks are also seen. They are well exhibited in the hill east of the mouth of Thompson Fork and along Lost Branch, Belle Trace Creek, Beetree Fork, and Straight Creek east of Denton. Between 300 and 400 feet of the Conemaugh, consisting of sandstone, shale, limestone, iron ore, and coal streaks, is exposed. The coal in the formation is too thin and pockety to be of more than local importance. There are three or four thin beds of limestone, the most persistent being a siliceous bed, 4 to 5 feet thick, near the base of the formation, 180 feet above the Middle Kittanning coal. This limestone corresponds to the Lower Cambridge limestone member. Some massive sandstones are scattered through the formation, particularly in its lower 100 feet.

The most important members of the Conemaugh formation are the Mahoning sandstone, the Brush Creek coal, the Lower Cambridge limestone, the Buffalo sandstone, the Ames (?) limestone, and the Saltsburg (?) or the Morgantown sandstone. The stratigraphic succession shown in the sections of northern West Virginia, western Pennsylvania, and eastern Ohio is lacking in most of the upper part of the Conemaugh formation in this area, and there is some question as to the exact equivalence of the bed in this quadrangle with the Ames limestone and the Saltsburg sandstone or the Morgantown sandstone of the regions on the north and northwest.

Mahoning sandstone member.—At the base of the Conemaugh lies the Mahoning sandstone, which is persistent and thus serves as a valuable guide in tracing this formation. In some parts of the quadrangle, notably near the mouth of Big Sandy River, it is unusually thick and massive, attaining near Kenova a thickness of 70 feet. It is continuous, though it includes a few intercalations of shale, eastward to Ceredo, south of which it becomes 100 feet thick. In Ohio this member forms prominent cliffs along Ohio River. On the headwaters of the East Fork of the Little Sandy it is also massive. It is well exposed west of Alley, in the hills bordering Pigeonroost Creek. In the western part of the area it is not prominent and in some of the sections it hardly appears at all.

Brush Creek coal.—Above the Mahoning sandstone there is usually a small coal, which is correlated with the Brush Creek coal of Pennsylvania. This is an unimportant bed, though it has been worked in the hills back of Cassville, W. Va., and along Twelvepole Creek a few miles above Ceredo.

Lower Cambridge limestone member.—The lower limestone given in the preceding section is the Lower Cambridge. The interval, however, between it and the top of the Mahoning is much greater than in the section at Cassville, where it is separated from the top of the Mahoning by only a few feet of shale and coal. It is very persistent and is a most valuable guide in tracing the rocks of the Conemaugh. Back of Cassville it occurs as a highly fossiliferous and calcareous shale lying upon the Brush Creek or Mason coal. In the western part of the quadrangle it is found about 180 feet above the Middle Kittanning coal, but the interval in places may be slightly less. Throughout the western part of the area where it is present it is highly siliceous and withstands weathering very well. It thus has a very characteristic appearance, which, with its persistency, makes it a valuable stratigraphic guide.

Buffalo sandstone member.—The next higher sandstone, the Buffalo sandstone member, is 40 feet thick in the section near the mouth of Big Sandy River. It is 28 feet thick in the hills back of Cassville, W. Va., and its average thickness is between 25 and 30 feet. The distance between the base of this sandstone and the Lower Cambridge limestone ranges from 10 to 40 feet, but averages about 35 feet. The Buffalo is usually a massive and coarse-grained sandstone and is very prominent in most of the area where it outcrops.

[a] Rept. Ohio Geol. Survey, vol. 5, 1884, p. 122.
[b] Rept. Kentucky Geol. Survey, vol. C, 1884, p. 60.
[c] See section by E. McMillan, Rept. Ohio Geol. Survey, vol. 5, 1884, p. 122.
[d] Rept. Kentucky Geol. Survey, vol. C, 1884, p. 24.
[e] Idem, pp. 9 and 10.
[f] Bull. Geol. Soc. America, vol. 17, 1906, p. 128.

Ames (?) limestone member.—Strictly according to the sequence of members, the next overlying limestone should be the Upper Cambridge limestone member. This limestone in the region south from the mouth of the Big Sandy first appears near railroad level almost opposite the mouth of Savage Branch. It is well exposed at the mouth of Dock Creek, where the following section was measured:

Section at mouth of Dock Creek.

	Feet.
Limestone	8–10
Massive shales with concretions	8–9
Coal and bone	1–1½
Green and gray clay shales	17
Railroad level.	

The limestone may be traced almost continuously from Savage Branch to Cyrus, where it is 32½ feet above the top of the next underlying massive sandstone (Buffalo). Here it is capped by approximately 10 feet of shale, 2 feet of which, at the base, is reddish. The question has been raised whether this limestone is the Upper Cambridge or the Ames. Its position in the Conemaugh sequence indicates that it is the Upper Cambridge limestone, but the fact that it is decidedly fossiliferous and contains abundant fragments of crinoid stems indicates that it is the Ames or "Crinoidal" limestone. It lies, however, well below the middle of the Conemaugh formation as exposed east of the Big Sandy, even if the maximum thickness is assigned to those members that occur below it. A study of its fossils may determine its identity, but until that study shall be made it can not be definitely placed.

Morgantown (?) sandstone member.—The interval between the Ames (?) limestone and the next higher sandstone is occupied chiefly by shale, whose thickness varies but rarely exceeds 100 feet. The next higher sandstone is massive along Big Sandy River, particularly in West Virginia, where it is 35 to 40 feet thick. Its correlation as the Morgantown sandstone member depends on the next lower limestone in the section being the Ames. If it proves to be the Upper Cambridge limestone, the sandstone should be correlated with the Saltsburg.

Upper part of the formation.—The remainder of the Conemaugh formation is prevailingly red shale, with here and there bands of shaly sandstone and a few beds of massive sandstone.

MONONGAHELA FORMATION.

The highest rocks of Pennsylvanian age in the Kenova quadrangle belong in the Monongahela formation. This formation, named from Monongahela River in Pennsylvania, was formerly termed "Upper Productive Coal Measures," as it includes several workable beds of coal.

In accordance with I. C. White's correlation, the coal bed at the top of the hills east of Lett, W. Va., near the mouth of Gragston Creek, is accepted as the Pittsburgh coal, marking the base of the Monongahela formation.[a] This is the only place in the quadrangle where rocks of this formation occur. The Pittsburgh coal is the most important bed of the formation and is capped by the Pittsburgh sandstone member, which is about 30 feet thick and very massive. The remainder of the formation is composed of reddish shale with sandy beds. About 100 feet of the formation is preserved in the hills.

QUATERNARY SYSTEM.

PLEISTOCENE DEPOSITS.

HIGH GRAVEL DEPOSITS.

Location.—The Kenova quadrangle lies outside the glaciated area, but it contains deposits that are held to be of Pleistocene age. In the "Flatwoods" district, back of Ashland, the hilltops are flat and do not rise more than 700 feet above sea level. These flat lands are covered with deposits of sand and gravel and with quartz and chert bowlders, the largest bowlders 12 inches in diameter. Deposits of sand and gravel similar to those back of Ashland occur also along Big Sandy River and some of its tributaries, as indicated on the areal map. Similar material occurs along Little Sandy River, and though the correlation of the deposits has not been attempted it is probable that the gravel along the Little Sandy, when traced up the Ohio, will merge with that along the Big Sandy. Silt associated with quartz pebbles has been discovered at lower altitudes along the Little Sandy, indicating periods of slack water and deposition before the present period of downcutting. The sequence of these changes is stated under the heading "Geologic history."

Derivation.—These high gravel deposits are derived from the old crystalline rocks of the Blue Ridge, on the east. The deposits in places occupy drainage valleys through which streams long ago ceased to flow. This is proved chiefly by the peculiar lithologic characteristics of some of the transported river débris, namely, the rounded pebbles of Kanawha black flint of the valley of Kanawha River near and above Charleston, W. Va. This material, about whose identity and source there is no question, has been found in Teays Valley and back of Ashland, thus proving that the Kanawha must have flowed through this territory during some period of its history.

Distribution.—The details of this ancient drainage problem are many and can not all be given here. The deposits have been traced from the "Flatwoods" area to the eastern border of the Kenova quadrangle, and from Ona, in Teays Valley, 13 miles east of Huntington, as far as Teays, the type locality. Throughout this course the deposits generally agree only in having a bowlder pavement. This pavement slopes from Hurricane to Ashland through a vertical distance of about 50 feet. In some places a mere handful of bowlders remains to mark the floor of the ancient valley, especially where erosion has been severe and the country is deeply dissected and where the land forms are not particularly well adapted to the preservation of the gravel. This is the case in the parts of the Kenova quadrangle in Ohio and West Virginia. Near Culloden, which is east of this area, the surface is less dissected than farther west and the bowlder pavement is preserved. It consists mainly of well-rounded bowlders of quartz, sandstone, and flint, the last being of various colors but chiefly black. The largest bowlders are about 3 feet in diameter, but most of them are smaller. The pavement is nowhere more than a few feet thick, but exact measurements of its thickness are not easily obtainable, as bowlders loosen from time to time and roll downward from their original positions. In the "Flatwoods" the material above the bowlder pavement is fine sand and silt mixed with gravel, and its thickness depends on its location. Its greatest measured thickness is 45 feet, but there is no means of telling how much has already been removed where this measurement was made. In many of the deposits seen in railroad cuts east of Ona the bowlder pavement is overlain by a deposit of sand of irregular thickness, cross-bedded and laminated.

In Teays Valley the bowlder deposit passes under cover just west of Culloden station on the new alignment of the Chesapeake & Ohio Railway. Above it is a deposit, 8 or 10 feet thick, of coarse-grained and compact sand, containing rounded quartz pebbles, the largest a quarter of an inch in diameter. About a mile east of Culloden the railroad begins to descend, and a shallow cut exposes fine laminated deep-red clays 15 to 20 feet thick, overlain by sand containing quartz pebbles. Just east of Hurricane station and opposite the flour mill the following hand-leveled section was measured:

Section on Chesapeake & Ohio Railway east of Hurricane, W. Va.

	Ft.	in.
(Original surface higher.)		
Gravel and fine sand	7	
Laminated clay	15	
Iron ore		1
Sand, cross-bedded in places (obscure above the bowlder pavement and up to railroad level, 19½ feet, but soil is sandy)	24	
Rounded pebbles embedded in sand and silt (bowlder pavement)	2-3	

East of Hurricane for about 1½ miles the clay and sand are interbedded, but still farther east little is seen along the railroad, for the new line as well as the old is located well up on the old valley wall and the cuts are chiefly in bedrock. The deposit east of Teays station must be fully 40 feet thick and is composed of some gravel and much fine silt or clay. It is laminated and the laminæ show well when the material is dry. Probably the other sections when studied will be found to differ from those given above.

Origin.—The high gravels are very similar to the material of the present flood plain of the Ohio. The great thickness of fine silt at Teays, however, requires additional explanation. Such fine silts are found in the present flood plain of the Ohio, but their maximum thickness is not known. They indicate a quiescent state of the water resulting from local damming or from retardation of the current possibly caused by crustal warping. Evidence of crustal warping is apparently lacking; if such warping occurred it must have been reversed by other warping equal in extent but opposite in kind, which seems hardly credible. The fact that the deposits in a given horizontal stretch are irregular indicates that damming, if it occurred, must have been local, and that while it lasted the water was probably, to some extent, in motion.

LOW GRAVEL DEPOSITS.

It is possible that the older terraces along the present flood plains of the Ohio are of Pleistocene age. These terraces are remarkably well developed in Ashland and Huntington, these two cities being in part built on them. Because of the small scale of the map, they have not been separately indicated, but are mapped with the alluvium.

RECENT DEPOSITS.

The alluvium of the streams is the youngest bedded deposit in this area. It forms the flood plains of both the large and the small streams, extending well up to the heads of the latter. Ohio, Big Sandy, and Little Sandy rivers have alluvial deposits fully 50 feet thick. Along the Ohio the width of the flood plain averages three-fourths of a mile; on Big Sandy and Little Sandy rivers it is narrower. Most of the deposits are terraced, and the older terraces along the Ohio may possibly be of Pleistocene age. Two flood plains are well developed along the Big Sandy and are 8 to 10 feet apart vertically. The material composing the lower flood plain is constantly being cut out and redeposited at each period of high water.

IGNEOUS ROCKS.

PERIDOTITE DIKES.

Occurrence.—Igneous rock was noted in this quadrangle by A. R. Crandall many years ago. It occurs in the hills on each side of Ison Creek west of Stephens, about 8 miles southwest of Willard. A detailed account of its occurrence and petrography was given by J. S. Diller, who visited the locality in 1884.[a] The rock is peridotite and is of more than usual interest, first because it resembles the peridotite of South Africa, the mother rock of the diamond in the Kimberley district; second because of the relative scarcity of this type of rock in the Appalachian region; and third because of a possible relationship to the mica peridotite of western Kentucky.[b] In another publication Diller calls the rock kimberlite, from its resemblance to the South African rock.[c]

Extent.—The area occupied by the rock is very small—not more than a few acres. Its outcrops are not numerous, but the extent of its exposure may be easily determined by noting the presence of the characteristic minerals resulting from weathering. There is no apparent reason why the various isolated masses should not be considered to be parts of a single intrusion, for all appear to be identical in mineral composition.

Character.—The rock is porphyritic and has a compact grayish-black groundmass. It is plentifully specked with phenocrysts of olivine, which appear fresh and unaltered and give it a grayish tinge. It also contains garnet (pyrope) and ilmenite, by means of which the boundaries of the decayed ledges were traced in the field. The rock also contains some plates of biotite. Its chief constituents besides these minerals, which are readily detected in hand specimens, are enstatite and a small amount of apatite. In places the olivine has been altered to serpentine, which may be readily observed in hand specimens and which in thin section is seen to be associated with magnetite and some carbonate, presumably dolomite resulting from the alteration of the olivine.

Relations and age.—The sedimentary rocks through which the igneous rock has forced its way are traceable practically up to the contact and do not appear to have been flexed upward along the contact zone. Though the igneous rock has broken off and inclosed masses of shale, these are surprisingly fresh and unaltered, resembling the ordinary black shale of the Pennsylvanian series. Only a few inclusions show distinct metamorphic effects. Some of the baked shale contains considerable secondary mica. The shale has been somewhat reddened and the sandstone fragments inclosed by the igneous rock have been metamorphosed.

The strata in which the bulk of the igneous rock is found belong to the Pottsville formation, but as some igneous rock is found in the Allegheny the intrusion is of Allegheny or later age. It was forced into the carbonaceous shale and coal beds of this formation, and, owing to the fact that the Kimberley diamonds of South Africa occur in peridotite penetrating carbonaceous shale, unusual interest attaches to the peridotite found in Elliott County. This interest has led to the prospecting of streams in the vicinity and to the sinking of a shaft 70 feet deep, which at the time of the writer's visit (October, 1905) was filled with débris. In 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 REPRESENTATION.

The dip of the beds or their angle of inclination from a horizontal plane is measured in the field with a clinometer if the inclination is great enough. In but few localities in the Kenova quadrangle, however, is the dip sufficient to permit this mode of measurement. Where it is not applicable, the altitude above sea level of a given bed on two hills a mile or so apart is determined, and the slope of this particular bed in feet per mile may be at once obtained. The contour lines for any bed are drawn on the map by connecting points of equal elevation on that bed. For instance, the 600-foot contour line on the structure sheet indicates all points in the area where the top of the Homewood sandstone member of the Pottsville formation lies 600 feet above sea. The other contour lines represent altitudes separated by vertical intervals of 50 feet.

The top of the Homewood sandstone was selected as a datum horizon in this area on account of the ease with which it may be followed, owing to its persistence and its relations to other well-known beds. Where it did not appear above drainage level, its distance below other known beds was used in the mapping, it being assumed that the distance is constant within the area where this means was employed. On the other hand, where the dip was so great that it would carry the top of the Homewood above the hilltops, its distance above known beds was used. Great precision is not obtainable in

[a] Rept. West Virginia Geol. Survey, vol. 2, 1903, pp. 191-193.

[a] Peridotite of Elliott County, Ky.: Bull. U. S. Geol. Survey No. 38, 1887.
[b] Williams, G. H., Am. Jour. Sci., 3d ser., vol. 34, 1887, p. 137.
[c] The educational series of rock specimens collected and distributed by the U. S. Geological Survey: Bull. U. S. Geol. Survey No. 150, 1898, pp. 290-294.

this way, for the intervals assumed are not uniform throughout the region, especially in areas underlain by the formations above the Homewood. Furthermore, the altitudes were determined with aneroid barometers, which are subject to sudden variations and have to be checked repeatedly by spirit-level determinations. 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 be generally taken as equal to a contour interval, but where, as in this area, the beds are not of uniform thickness it may be more. This mode of presentation, in addition to showing the structure of the beds, enables one to estimate the depth to the top of the Homewood sandstone where it is below drainage level. For example, near Zelda the 400-foot contour line was drawn. The elevation of Zelda is 580 feet; therefore the top of the Homewood sandstone should be at a depth of 180 feet. The distances of the several coal beds above or below the top of this sandstone being known, the depth of each bed below the surface at this place may be estimated in like manner.

DETAILED DESCRIPTION OF STRUCTURE.

The Kenova quadrangle lies at the southwest end of the great trough formed by the coal-bearing rocks of the northern Appalachian field. The axis of this trough extends southwestward from a point near Pittsburgh, Pa., crosses Ohio River a little east of the quadrangle and reaches Big Sandy River 8 or 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. The trough is deepest in central West Virginia and thence southwestward becomes gradually shallower, pitching upward within this quadrangle 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 in most of the area are not very steep. In the northern two-thirds of the quadrangle, with a few exceptions, they do not average as high as 50 feet to the 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 & Western Railway are the lower sandstone members of the Conemaugh formation; thus there is a dip of more than 50 feet to the mile between these points. Near Willard and southwest of this town in Carter County the dips are above the average, being close to 100 feet to the 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 to the mile. Near Adams and on Right Fork of Blaine Creek the rocks in places dip 300 feet to the 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°, and near this point two small faults were discovered, but their throws are probably not great enough to affect the structure contours materially.

A few minor flexures are involved in the main syncline. In the region near Irad and Osie, Lawrence County, the Homewood sandstone thickens rapidly toward the west causing a slight arch in the overlying beds, but west of this district the sandstone is somewhat thinner and allows a slight depression. West of Cherokee Creek, near 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 toward the Cincinnati arch. West of this quadrangle the beds gradually rise to the apex of this arch, and this rise is indicated in the contours west of Little Sandy River.

GEOLOGIC HISTORY.

ANCIENT LANDS AND SEAS.

When the rocks of the Kenova quadrangle were laid down an interior sea existed over that part of North America which extends from the Gulf of Mexico to Canada and from the Blue Ridge westward beyond the Mississippi Valley. The land east of this great mediterranean sea has been called Appalachia.

Most of the exposed rocks of pre-Cambrian time were schists and igneous rocks, the wearing away of which furnished the sediments deposited in the interior sea. These sediments constitute the present land mass in the region then covered by this sea. The surface separating the older schists and igneous rocks from the overlying sediments derived from them has been by some writers termed a basal unconformity.

As already mentioned, the Paleozoic sedimentary rocks of this area belong to the Carboniferous period. The early land mass known as Appalachia underwent many fluctuations before this period began. Changes also took place in the inclosed sea on the west. Cool water at times gave place to warm and shallow water, which was occupied by abundant animal life, resulting in the accumulation of vast deposits of limestone. Many of these beds of limestone were succeeded by deposits of shale, pointing to a change from clear to muddy water. New forms of life, adapted to such changes in physical conditions, came in, and the fossil remains of these forms serve as a basis for a division in geologic time. Beds of sandstone were also deposited with the shale and limestone, so that the early Paleozoic rocks of this section of Kentucky are made up essentially of calcareous, argillaceous, and arenaceous sediments.

MISSISSIPPIAN EPOCH.

The outcropping Mississippian rocks in the Kenova quadrangle are sandstones and shales belonging to the Logan formation and the Maxville limestone. The difference between the type of rocks in the lower and that in the higher formations represents possibly an alternation of shallow and deep water.

PENNSYLVANIAN EPOCH.

Pottsville time.—A very decided change in physical conditions must have occurred after the Maxville limestone was deposited. The land was elevated and the beds thus brought above sea level were eroded. Thus the Maxville limestone near the northern end of the basin was removed. Subsidence then followed, with elevation on the east, by which the streams were rejuvenated, and these streams brought in immense quantities of the arenaceous sediments so characteristic of the Pottsville in this area. It is probable that subsidence was more rapid in the southern and southwestern parts than in the western part of this area, for it is in the former regions that the greatest thickness of Pottsville sediments is accumulated. The coarser sediments constituting the bulk of the formation are composed of clear quartz and do not represent material derived directly from rock waste but material that has been worked and reworked along coastal plains. During the period of subsidence there were short periods of relative stability, when conditions were favorable for a luxuriant growth of vegetation, which furnished material for the coal beds. The Pottsville deposition is of interest because in Pottsville time those conditions began which resulted in the deposition of the coal in Kentucky, Ohio, West Virginia, and Pennsylvania.

In the southern anthracite and West Virginia coal fields the Pottsville formation is much thicker than in the Kenova quadrangle, where only the upper part of the formation is present. It was formerly supposed that the difference in thickness was due to differential deposition—in other words, that as much time was required to deposit the considerable thickness of sediments in West Virginia as to lay down the few hundred feet of Pottsville in the western part of the Kenova quadrangle. The studies of David White[a] have shown, however, that this is not the case, and that while the earlier Pottsville beds were being deposited in the Pocahontas coal field, for example, much of the country farther west was above water and subject to denudation. The surface thus denuded is now marked by the unconformity at the base of the Pottsville. Hence the lower part of the Pottsville was never laid down in the Kenova quadrangle, the Pennsylvanian series in the western part of the area beginning practically with the Sharon conglomerate, which is the basal member of the formation in Ohio and in parts of Pennsylvania as well as in the northwestern third of the Kenova quadrangle. The proof of this lies in the fact that the thick sections along the eastern border of the Appalachian coal region contain floras older than those in the lowest beds of the sections farther west. Furthermore, the characteristic floras of the thinner sections occur in only the upper parts of the thicker sections; in other words, the lower Pottsville beds were not deposited in this part of Kentucky nor in parts of the bituminous coal fields of West Virginia, Pennsylvania, and Ohio. These facts are well brought out in the map and articles by David White already cited.

Allegheny time.—Judging from the resemblance of the sediments in the lower part of the Allegheny formation to those of the Pottsville in the Kenova quadrangle, the physical conditions governing the Pottsville deposition extended well into Allegheny time, certainly until after the deposition of the Lower Kittanning coal. In the Hanging Rock district of Kentucky and Ohio this coal is both underlain and overlain by massive sandstones, essentially like those of the Pottsville in a large part of this quadrangle. Even after the deposition of the Middle Kittanning coal a massive sandstone was deposited.

The most notable fact deduced from a study of the Pottsville and Allegheny sections is the frequent recurrence of the peculiar physical conditions necessary for the formation of coal beds. Accompanying the coal beds are shales, sandstones, and limestones, in irregular succession. These are of widely different extent, thickness, and composition, a fact which in connection with the irregularity of succession indicates unstable relations between sea and land during the periods between the deposition of the coal beds.

A study of the coal beds has thrown some light on their origin, and it seems quite probable that they represent vast marshes or swamps in which an ancient vegetation flourished. Whether the plants grew in fresh, brackish, or salt water can not be certainly determined in all places, but it is probable that for the greater part of the time the water was not salt in the regions where most of the coal was deposited. The remains of the vegetation, such as fallen tree trunks and leaves, were preserved from complete oxidation by a shallow covering of water. These great marshes were at least locally subject to incursions from the sea, for beds containing marine fossils are associated with some of the coals and occur in all the coal-bearing formations. The fact that the coals commonly contain clay partings or consist of several benches separated by bone or clayey material indicates relative movement even during the deposition of the coal bed, which was temporarily flooded by water that bore sediments. At times the inrush of sediments was rapid, closely accompanying or following the erosion of part of the coal bed; such an inrush is thought to have affected the Lower Kittanning in certain parts of Ohio and Kentucky, and similar inwashes of sand on the surface of the coal-forming organic matter are numerous in this area. Generally the inwash of silts and clays must have proceeded quietly, for only such a supposition can account for the extensive accumulations of the finest muds in layers so thin as those forming the partings in coal beds.

Conemaugh time.—The material deposited in Conemaugh time does not differ greatly from that deposited during Allegheny time. Not so many coals were formed during the Conemaugh as during the Allegheny, and those that were formed were not so thick nor important. In Conemaugh as in Allegheny time conditions were often favorable for the deposition of red beds, and beds of red shale were laid down close above the Middle Kittanning coal. Taken as a whole, the Conemaugh is made up practically of the same types of rocks as the Allegheny, namely, sandstone, shale, limestone, and some coal beds. It seems reasonable to suppose, therefore, that the physical conditions during this period of deposition were not far different from those of Allegheny time. The land was under water, possibly fresh water most of the time, but occasionally brackish or salt water, as marine fossils are associated with certain limestones and shales in the formation.

Monongahela time.—There is no reason to suppose that the physical features in this area during Monongahela time were much different from those that existed during Allegheny and Conemaugh time. The Conemaugh formation is separated from the underlying and overlying formations because it contains few workable coal beds, and for this reason it was formerly designated the "Lower Barren Coal Measures." But the facts that it does contain coal beds and that its sediments are essentially like those in the underlying formation indicate a continuation of earlier physical conditions up to the beginning of the Monongahela. The deposits of the Monongahela formation are separated from the underlying Conemaugh by the famous Pittsburgh coal, which outcrops west of Centerville, Wayne County, W. Va., in only a very small area in the hilltops.

Lithologically the beds of the Monongahela are like those in the two underlying formations, especially the Allegheny, for during Monongahela time many important coal beds were deposited. Hence the physical conditions of the Allegheny and Conemaugh continued into Monongahela time. During Monongahela time peculiar conditions necessary for the accumulation of coal beds reached their culmination. The coal beds overlying the Pittsburgh coal have long since been removed by erosion from the region included in the Kenova quadrangle.

POST-CARBONIFEROUS DEFORMATION.

Up to the close of the Carboniferous period the interior Paleozoic gulf had received sediments brought to it from the surrounding land. The sedimentation must have been accompanied by a relative subsidence of the sea bottom to accommodate the many thousands of feet of sediments deposited in it. This subsidence was by no means continuous, a fact that is shown by the character of the sediments and by the unconformities that occur between the Mississippian and Pennsylvanian series, also locally and on a minor scale within the Pennsylvanian itself. At the close of the Carboniferous the beds emerged from the sea and so far as known have been above sea level ever since in northeastern Kentucky and adjacent parts of Ohio and West Virginia.

Since the emergence of the land diastrophic movements have occurred and quite likely there were similar movements while Carboniferous sediments were being deposited, for they are indicated by the structure of the formations in the quadrangle. These movements may possibly have had a common origin with a series of folds or breaks in the earth's crust that took place many miles east of this area in a zone extending along the Appalachian Valley and Mountains. A flow of the

[a] Bull. Geol. Soc. America, vol. 15, 1904, pp. 267-282; Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 751-930.

sediments eastward against the land mass or a thrust of the land mass due to contraction may also have influenced the development of these structural features. Whatever may have been their origin it is known that they are most pronounced in the east and gradually diminish toward the west. Along the east side of the Great Valley the rocks were folded, faulted, and metamorphosed, so that in many parts of this zone the original character of the sediments has been partly obliterated. Farther west, in the great Appalachian Valley, the rocks are greatly folded and faulted, but not greatly metamorphosed. The effect of the movement died out in minor plications west of the Great Valley, where the Kenova quadrangle is situated.

INTRUSION OF IGNEOUS ROCK.

The time of the intrusion of the peridotite bodies is unknown. They cut beds of the Allegheny formation and were therefore intruded after those beds had been deposited. There are no indications of such deformation and metamorphism of the shales as would have occurred if the intrusion had taken place while the sediments were still unconsolidated; hence the peridotite was probably intruded long after the Allegheny strata had been laid down and after the deposition of a great thickness of overlying strata and the consolidation of the Allegheny sediments into hard rock. Owing to the poor exposures and the great amount of weathering it has been impossible to determine whether the intrusive bodies were probably involved in the post-Carboniferous deformation. From analogy with similar bodies of peridotite in other parts of the Appalachian province, which are believed to have been intruded since the post-Carboniferous deformation, it seems reasonable to conclude, in the lack of evidence to the contrary, that they were probably intruded early in the Mesozoic era. In any event the intrusion appears to have been confined to a very small area and to have been the merest incident in the geologic history of the district. Nothing has been discovered to indicate whether the intrusion was connected with surface eruptions, but presumably it was not.

MESOZOIC AND CENOZOIC EROSION.

Since the emergence of the land and while deformation was proceeding degradation of the surface has been in progress. The land has been worn down, and it is believed that the even sky lines observed in a general view from any high point within the area indicate the position of an old peneplain. This peneplain was probably formed during late Jurassic or early Cretaceous time, when the region was in a state of comparative quiescence.

That the region has been recently elevated seems evident from the youthful character of the streams. Many of the small valleys are gorgelike, and the larger streams, like the Big Sandy, are intrenching themselves in their present flood plains.

PLEISTOCENE DEPOSITION.

River deposits.—It has been stated that no part of the Kenova quadrangle lies within the glacial boundary, but that it contains mappable deposits of Pleistocene age. These are the low and high level river gravels along the Ohio and the Big Sandy and back of Ashland in the "Flatwoods." These deposits, which were described in detail (p. 6) under "Stratigraphy," were formed by rivers that abandoned their former courses as a result of the invasion of the neighboring region by the ice. The history of the changes in drainage has been studied by Campbell,[a] Tight,[b] Shaw,[c] and others.

According to Campbell, in preglacial time the Ohio and the Kanawha flowed in the high-level valleys in which the silt and gravel now occur. During the glacial epoch ice dams were formed at Ashland and near Milton, in the Milton quadrangle farther east. These dams ponded the water, which rose high enough to find new outlets through the present courses of the rivers. While the old channels were being filled with silt the new channels were being deepened. When the ice dams disappeared the new channels had been cut lower than the old, and the streams remained in them.

Shaw and others believe that the presence of ice dams is not necessary to explain the phenomena but that they may be the result of modified stream action.

History of ancient drainage.—There is abundant evidence that in no very remote geologic time the courses of some of the main drainage channels in this and the adjacent Huntington quadrangle were quite different from the present courses. It is conclusively proved that Kanawha River, which now turns northward at St. Albans, Kanawha County, and flows into the Ohio at Point Pleasant, once flowed westward across the Huntington quadrangle through Teays Valley, along or near the present Chesapeake & Ohio Railway. Entering the Kenova quadrangle this river followed closely the present course of the Ohio and joined the Big Sandy at or near Catlettsburg. The resultant stream flowed across the northeast corner of the quadrangle through the "Flatwoods" district, southwest of Ashland. After leaving the Kenova quadrangle the ancient stream probably continued westward in approximately the present course of the Ohio, turning northward at Wheelersburg through the valley of the present Little Scioto River, joining the main Scioto River at Waverly, Ohio, and thence flowing northward to the basin of the Great Lakes.

[a] Campbell, M. R., Huntington folio (No. 69). Geol. Atlas U. S., U. S. Geol. Survey, 1900, p. 3.

[b] Tight, W. G., Drainage modifications in southeastern Ohio and adjacent parts of West Virginia and Kentucky: Prof. Paper U. S. Geol. Survey No. 13, 1903.

[c] Shaw, E. W., High terraces and abandoned valleys in western Pennsylvania: Jour. Geology, vol. 19, 1911, pp. 140–156.

Deposits of sand and gravel similar to those back of Ashland may be traced up Big Sandy River beyond Louisa and are found along certain side streams, as indicated on the areal geology sheet. These gravels likewise mark the floors of ancient valleys through which a stream or streams long ago ceased to flow. Thus the Big Sandy has not always flowed in its present course but formerly meandered much more than at present. For example, the presence of river gravel along the courses of Dock Creek and Miller Creek, Wayne County, W. Va., indicates that the Big Sandy flowed at one time in a great meander east of its present channel.

History of modern drainage.—The asymmetry of the drainage in this and adjoining areas has already been noted and it has been stated that to understand the present arrangement of the drainage in the Kenova quadrangle it is necessary to go beyond its limits. The asymmetrical character of the drainage basin of Twelvepole Creek, in the Huntington quadrangle, on the east, has been discussed by M. R. Campbell.[a] This stream flows near the western margin of its basin, and the divide between it and Big Sandy River, on the west, is only approximately one-fourth as far away as is the divide between it and Guyandot River on the east. The conditions are similar in the basin of the Big Sandy, in part of its course in this area. Briefly, Campbell ascribes this lack of symmetry to an uplift of the land on the east at a time when the relief of this region was slight and the streams were in process of adjustment. By this uplift the streams flowing west were accelerated and were enabled to work headward (eastward) more rapidly than those flowing from the opposite side of the basin, and thus to encroach on the divides on the east and push them toward the area of uplift. The basins of the Little Sandy and its East Fork are symmetrical. The reasons for this will be given subsequently. In the basin of Tygarts Creek, which crosses the extreme northwest corner of the quadrangle, the lack of symmetry is notable but is opposite in kind to that in the basins of Big Sandy River and Twelvepole Creek.

It has already been stated that structurally the northern part of the Appalachian Plateau, of which the Kenova quadrangle forms a part, is a broad, shallow trough, the beds on either side of which dip toward its axis, partly as a result of uplifts about its margins. Campbell has ascribed to a later uplift, on the east, the lack of symmetry in the drainage basins of Twelvepole Creek and Mud River, in the Huntington quadrangle, and with these may be included the basin of Big Sandy River, in the Kenova quadrangle. The tributaries of Tygarts Creek from the east are insignificant compared with those from the west. Many of the eastern tributaries are so small that they remain unnamed. Lack of symmetry in a divide is well shown in that between Tygarts Creek and Little Sandy River. In view of the explanation given above for the asymmetrical basins of Big Sandy River and Twelvepole Creek, it is evident that an uplift on the west may sufficiently account for the lack of symmetry in the basin of Tygarts Creek and others farther west.

[a] Campbell, M. R., Huntington folio (No. 69). Geol. Atlas U. S., U. S. Geol. Survey, 1900.

The basin of East Fork of Little Sandy River and, either wholly or in part, that of Little Sandy River itself occupy the axial zone between the uplifts east and west of the area. These streams therefore show little or no tendency to asymmetry.

In the opinion of the writer, however, there is another possible explanation for the lack of symmetry in the drainage of the Huntington and Kenova quadrangles, namely, that it is dependent on both the present structure and the character of the rocks. The rocks are mainly sandstone, sandy shale, and shale. Except for the shale beds, which are somewhat clayey and consequently impervious, the strata are water-bearing. These water-bearing beds give rise to many springs, which in turn are feeders of surface streams. The underground currents producing such springs flow more easily with the dip than against it, particularly as they are commonly confined to layers overlain and underlain by relatively impervious shale. The movement of the currents and streams thus being mainly with the dip, erosion, surficial and possibly underground, proceeds up the dip, the springs and underground streams facilitating this action because they increase the flow of streams running toward the synclinal axis. Thus the main streams in this region tend to lengthen their tributaries flowing with the dip more rapidly than those flowing against it, and consequently to push the divides between trunk streams westward on the west side of the synclinal axis and eastward on the east side of the axis. In the region along the axis, which may be regarded as neutral ground, there is no tendency toward asymmetry. This explanation does not postulate an uplift later than that which produced the main Appalachian folding.

ECONOMIC GEOLOGY.

The mineral resources of the Kenova quadrangle are coal, flint clay, plastic clay, shale, limestone, iron ore, building stone, glass sand, salt, oil, and gas. The relations of the important economic beds and others of stratigraphic value are given in the columnar-section sheet.

COAL.

NOMENCLATURE.

In following the description of the coal beds the reader will find the subjoined table helpful in correlating the names used in this folio with those used in the reports of the Kentucky and Ohio Geological Surveys. The Pennsylvania names have been used in this text because, although the quadrangle lies in three States, in two of them, Kentucky and Ohio, local names for these beds have been used. Morever, in these two States the coal beds have been numbered, and the numbers do not correspond. The use of two sets of numbers together and of different sets of local names would lead to confusion in describing a large number of workable coal beds. The Pennsylvania names are generally better known than any other single set of names used in the eastern part of the United States, and they are employed to some extent in West Virginia and Ohio. Their use, therefore, coupled with the local names or numbers, at once gives the stratigraphic position of the beds as established in the well-known Pennsylvania section.

Relations of coals and other important beds described in this folio to subdivisions used by Kentucky and Ohio geological surveys.

System.	Series.	Formation.	Minor divisions.	Names used by Kentucky Survey.	Names used by Ohio Survey.
Carboniferous.	Pennsylvanian.	Monongahela.	Pittsburgh sandstone member		
			Pittsburgh coal		Pittsburgh coal.
		Conemaugh.	Saltsburg (?) sandstone member		
			Ames (?) limestone member		
			Buffalo sandstone member		
			Lower Cambridge limestone member	Lower Cambridge limestone	Lower Cambridge limestone.
			Brush Creek coal		
			Mahoning sandstone member	Mahoning sandstone. (Includes No. 9 coal.)	Mahoning sandstone.
		Allegheny.	Upper Freeport coal		No. 7 coal, Waterloo coal and Bayleys Run coal.
			Lower Freeport coal	No. 8 coal and Hatcher coal	No. 6a coal and Hatcher coal.
			Red kidney ore		
			Middle Kittanning coal	No. 7 coal, Coalton coal, and Chadwicks Creek coal.	No. 6 coal, Sheridan coal, Nelsonville coal, Straitsville coal, Carbondale coal, Mineral City coal, Lower Waterloo coal, and Ashland coal.
			Yellow kidney ore		
			Lower Kittanning coal	No. 6 coal, Limestone coal, Keyes Creek coal, and River Hill coal.	No. 5 coal or Newcastle coal.
			Iron ore		
			Flint and plastic clay		
			Vanport ("Hanging Rock") limestone member, including iron ore at top.	Ferriferous limestone	Hanging Rock limestone.
			Flint and plastic clay		
			Brookville coal	No. 5 coal, Cooksey Fork coal, and Pennington coal.	No. 4 coal.
		Pottsville.	Homewood sandstone member		
			Upper Mercer coal	No. 4 coal, "Big vein," "5-foot vein."	No. 3a coal.
			Iron ore		
			Lower Mercer coal	No. 3 coal, Torchlight coal, McHenry coal, and Turkey Lick coal.	Lower Mercer coal.
			Quakertown (?) coal	No. 2 coal, "Clod seam," and Danleyton coal.	Quakertown coal.
			Barret Creek or "Little Cannel" coal	No. 1 coal. (Crandall correlated this with Jackson Shaft coal.)	
			Sharon (?) coal		Jackson Shaft coal.
			Sharon conglomerate member		Sharon conglomerate.
			Salt sand	Maxton sand	Maxton sand.
			Sciotoville fire clay		Sciotoville or Logan fire clay.
			Iron ore.		
	Mississippian.	Maxville limestone.		Subcarboniferous limestone	Maxville limestone.

GENERAL CHARACTER.

Workable coal beds are scattered through nearly the whole thickness of rocks exposed in this quadrangle up to and including the Pittsburgh coal at the base of the Monongahela formation. The names, positions, and relations of these coals are given in the generalized section on the columnar-section sheet.

The coals differ somewhat in character but include most varieties of the bituminous class. The greater number belong to the harder bituminous variety and in many places they 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. In general they are unsuitable for coking, but some of them after washing give fair satisfaction. The Lower Kittanning coal (No. 6 of Kentucky Survey), which has been mined for several years at Winslow, has been washed and coked by the Ashland Iron & Mining Co. for use in the company's furnaces at Ashland and has always proved to be 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 transportation and stocking. The Middle Kittanning coal (No. 7 of Kentucky Survey), which ranks with and is stratigraphically equivalent to the Nelsonville coal of Ohio, has been used by the Ashland Iron & Mining Co. in its blast furnace.

Ordinary bituminous coal is 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 locally the method of occurrence with the Lower Kittanning coal, the bottom bench of which is usually of the soft bituminous variety, and the upper two benches of the harder splinty type.

Certain beds in small areas contain benches of cannel coal; for example, the coal now being worked by the Kentucky Cannel Coal Co. at Boghead and Hunnewell. It is reported that the cannel layers are erratic in their occurrence. 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 hill. On Hilton Branch, southwest of Willard, a rather thick bed of cannel has been worked in a small way. The coal on Brush Creek in Lawrence County also contains a cannel layer. Besides these beds there are others containing sufficient volatile hydrocarbons to class them with the cannel coals. Certain layers in the Lower Mercer coal (No. 3 of Kentucky Survey) of Levisa Fork, in Lawrence County, fall within this class; and the "Little Cannel" bed, lying 140 feet below the Lower Mercer beds, contains a band whose analysis shows 55 per cent of volatile matter.

In the following descriptions only the chief facts regarding the important coals of the area will be given. For details the reader is referred to Bulletin 349 of the U. S. Geological Survey, on the economic geology of the Kenova quadrangle. For convenience in describing the coals and giving their relations the quadrangle is divided arbitrarily into five districts, as shown in figure 4, and all the coal beds are described according to their occurrence in those districts.

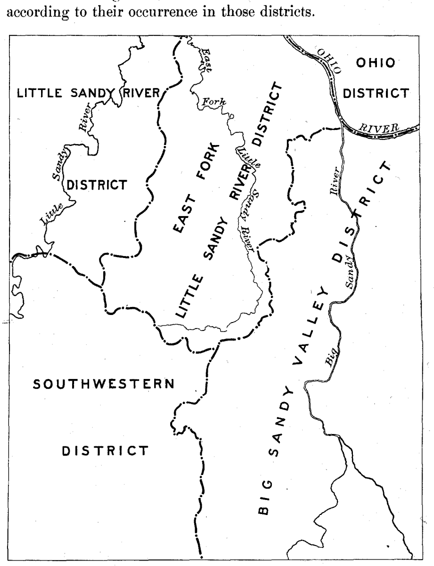


FIGURE 4.—Diagram of the Kenova quadrangle, showing the division into coal districts used in this folio in describing the coal resources.

BIG SANDY VALLEY DISTRICT.

The lowest coal beds exposed in the Kenova quadrangle appear in the region west of Gallup, in Lawrence County. As will be seen from the section of the Pottsville formation given on page 3, four small coals lie below what is regarded as the Sharon conglomerate member. None of these coals has been worked in this quadrangle, though one of them is at one place 24 inches thick. Between the conglomerate and the next massive sandstone above is about 50 feet of shale, in which are two small coal beds. The higher of these beds has been worked near a sharp bend in the railroad south of Torchlight. Where measured on the outcrop this coal is 16 inches thick.

BARRETT CREEK OR "LITTLE CANNEL" COAL (NO. 1 OF KENTUCKY SURVEY).

Above the 40 to 100 foot sandstone given in the section on page 3 is a group of shale beds that include five thin coal beds. A detailed section of these 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 } "Little Cannel"	1	7
Parting } "Little Cannel"		½
Coal } "Little Cannel"		2
Sandstone, laminated	10	
Coal	1	
Shale, sandy, or fire clay	2-3	
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 in a considerable area in the southeast corner of the quadrangle and may be looked for about 140 feet below the Lower Mercer 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 is found 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, for it has not been opened, but west of the Left Fork of Little Blaine Creek it has been opened in a few places near creek level and is of workable thickness, though badly split up by bone and clay partings.

The "Little Cannel" coal has been opened near the head of Threemile Creek and at one time was mined and shipped from this locality. 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 Co. There are small openings north of the station and in the hills on the west side of Levisa Fork. Developments on Left and Right forks of Little Blaine Creek are of local importance only and supply the country trade. The coal lies above drainage level along the headwaters of Rich Creek.

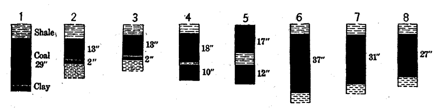


FIGURE 5.—Sections of lowest coals in the Pottsville formation.

1, "Little Cannel" coal, north of Torchlight; 2, "Little Cannel" coal, south of Torchlight; 3, John Duley, Wolfpen Branch of Everman Creek; 4, A. J. Womack, Righthand Fork of Everman Creek; 5, Near Samaria, Lost Creek; 6, Mrs. Rebecca Tackett, Deer Creek; 7, Robert Rucker, Field Branch; 8, R. T. Berry, Blaine.

Scale, 1 inch = 5 feet.

This coal is known at Torchlight as the "Little Cannel" bed 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 measured near Torchlight (fig. 5, secs. 1 and 2) show that this coal ranges in thickness from 20 to 30 inches. It is split into two benches by a parting of one-half to 1 inch of clay near the bottom. The cannel is not shown in these two sections but occurs near the middle of the upper bench and ranges in thickness from 3 to 6 inches. In appearance it resembles splint coal rather than true cannel. Perhaps the chief value of this bed in the future will be derived from this cannel band. It separates fairly readily from the bituminous coal above and below and breaks out in large blocks. The coal is moderately lustrous and gives a yellowish-brown streak. Its cleavage is laminated and its cross fracture is angular to subconchoidal. Analyses are given below.

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. Analyzed at the Department of Mines and Metallurgy, World's Columbian Exposition.
2. George R. Hislop, Paisley Gas Works, Scotland, analyst.

LOWER MERCER COAL (NO. 3 OF KENTUCKY SURVEY).

Nomenclature.—The next higher workable coal of the Pottsville formation in this district is perhaps the most important bed thus far developed on the upper waters of Big Sandy River in the quadrangle. In the Kentucky reports this coal is termed the No. 3, or McHenry's coal, the latter name being derived from that of the property on which the coal was first largely worked. In this folio it is called the Lower Mercer coal, for it is the same as the Lower Mercer coal of Pennsylvania. It is locally known as the Torchlight coal, as it has been most extensively worked at Torchlight, on the Chesapeake & Ohio Railway 6 miles south of Louisa.

Extent.—The Lower Mercer 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 Walbridge. In the hills between Threemile Creek and Levisa Fork it has been fairly well prospected, and also in the area between Levisa Fork and Lick Creek, on the west. It is found in the hills along Left and Right forks of Little Blaine Creek, but owing to a northward dip it disappears below drainage level not far north of the confluence of the forks.

Development.—This coal was first opened on Levisa Fork opposite Torchlight, where it is now being worked. Since then it has been developed on a commercial scale by the Torchlight Coal Co., at Torchlight. In the hills west of Levisa Fork this coal has been faced up in several places by the Louisa Coal Co. to ascertain its possibilities. It has also been opened 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. 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.

Character.—It will be seen from the sections of this coal presented in figure 6, that the coal bed is not everywhere alike.

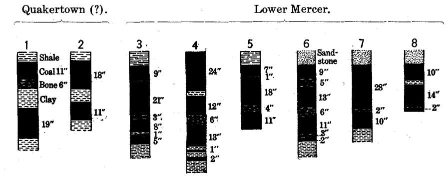


FIGURE 6.—Sections of Quakertown (?) and Lower Mercer coals.

1. Henry Branch; 2, A. W. Callahan, Danleyton Church; 3, Torchlight Coal Co., Torchlight; 4, Threemile Creek; 5, Left Fork of Little Blaine Creek; 6, Right Fork of Little Blaine Creek; 7, Kelly Frailey, Right Fork of Little Blaine Creek; 8, Andrew Hayes, Right Fork of Little Blaine Creek.

Scale, 1 inch = 5 feet.

In places it occurs as a single bench, but as a rule it consists of two or three benches, with a clay parting between the upper two. This clay parting is in general of knife-edge thinness, and is, perhaps, absent in some places (section 7). It rarely attains a thickness of an inch, though exceptionally it may exceed this measurement, for at an opening on Threemile Creek a parting of 3 inches was measured (section 4). The third or lowest bench ranges in thickness from less than 6½ to more than 14 inches and is separated from the middle bench by a persistent bone parting, averaging in thickness 3 to 4 inches.

The coal in this bed is of both the splinty and the soft bituminous variety. The topmost bench is generally 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, hard, dull, splinty coal. Analyses are as follows:

Analyses of Lower Mercer coal in valley of Big Sandy River.

	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. Talbutt, analysts.
2. Torchlight Coal Co.'s mine, second entry. Ricketts & Banks, analysts.
3. Torchlight Coal Co.'s property on Lower Gavitt Creek. Ricketts & Banks, analysts.
4. Torchlight Coal Co., Fivemile Shoal. Ricketts & Banks, analysts.
5. Crop coal from hill between Levisa Fork and Lick Creek property of the Louisa Coal Co. 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.

The roof of the coal bed is shale or massive sandstone. The shale ranges in thickness from a few feet to about 15 feet and in some places gives much trouble in mining. Above the layer of shale there is commonly a massive sandstone of irregular 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, which are separated from the main bed by a fire clay or bone parting (sections 3 and 4). The floor of the coal, as a rule, is clay.

UPPER MERCER COAL (NO. 4 OF KENTUCKY SURVEY).

Extent and development.—The Upper Mercer coal is 55 to 75 feet above the Lower Mercer coal in the valley of Big Sandy River. It is locally known as the "Five-foot vein" but is sometimes called the "Big vein." The area of its maximum development is in the hills east of Lick Creek and between Lick Creek and Levisa Fork. It has been prospected between Threemile Creek and Levisa Fork, where it is of workable thickness, and in this area it is about 60 feet above the Lower Mercer coal. Prospects have been opened on it on Donithon Branch, east of Threemile Creek, where it is also workable.

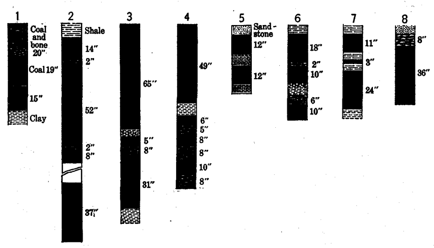


FIGURE 7.—Sections of Upper Mercer coal.

1, Torchlight Coal Co., Lower Gavitt Creek; 2, 3, 4. Louisa Coal Co., between Lick Creek and Levisa Fork; 5, Alex Chapin, Catletts Creek; 6, Boghead, Ky; 7, Hill west of Cane Creek, Carter County; 8, Mount Savage.

Scale, 1 inch = 5 feet.

Character.—Sections of this bed are shown in figure 7. The section measured at the head of Lower Gavitt Creek differs strikingly from the remaining three, obtained in test drifts between Lick Creek and Levisa Fork, just west of Torchlight. The upper 20 inches of the coal measured on Lower Gavitt Creek appears to be much broken. The lower bench, which averages about 15 inches where seen, is separated from the upper by a small clay parting. In places the upper bench consists of clean coal and there are three benches, as in the next bed below. The coal is reported with three benches also on the headwaters of Donithon Branch, where the upper bench is slightly thicker than either of the lower two.

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

West of Levisa Fork this coal thickens, as shown in figure 7, sections 2, 3, and 4. In general the coal in this vicinity is irregular but where observed consists of two main benches separated by a clay parting that ranges in thickness from a few inches to 5 feet. West of Lick Creek, about one-half mile above the mouth of Rhubens Branch, the coal measures about 2 feet.

Where the coal is of workable thickness it is of a bright, hard, bituminous variety, with a few bands of splint or semicannel coal. The upper of the lower two benches appears to be the more uniform, but in places the lower may probably be worked with it. Locally, however, the lower bench is badly split by bony partings. In many places between Levisa and Tug forks all three benches are workable. As a rule the roof of the coal is shale, but in some places the massive Homewood sandstone member extends down practically to its top. The following analyses indicate the chemical character of this coal:

Analyses of Upper Mercer 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. Northrup, of Louisa, Ky. Sample was collected at the head of Donithon Branch.
2. Furnished by A. C. Collins, of the Louisa Coal Co., Otto Wuth, analyst. Sulphur is included in the total.

The foregoing analyses show a good coal of the bituminous grade. On account of its hard and somewhat splinty character it will bear transportation and stocking well.

BROOKVILLE COAL (NO. 5 OF KENTUCKY SURVEY).

Position.—The lowest workable coal in the Allegheny formation in the valley of Big Sandy River occurs below the Vanport limestone member. This coal usually lies directly on the Homewood sandstone member. Crandall, in his general section of this part of Kentucky, located coal No. 5 of the Kentucky Geological Survey, to which he gave the names Cooksey Fork and Pennington, as the first below the horizon of the Vanport limestone,[a] and therefore it appears probable that his No. 5 or Cooksey Fork coal is the same as the Brookville coal of this folio.

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

Extent and development.—Around Louisa the presence of this coal is nearly everywhere 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, where it has been opened about $2\frac{1}{2}$ miles southwest of Louisa. In West Virginia, south of Cassville, this coal is usually present, but it is thin and, as in Kentucky, is rarely worked. A short distance south of Louisa it lies below the flood plain.

This coal is the most important bed on the headwaters of Cat Creek. Here and on the headwaters of Cherokee Creek and Dry Fork, farther west, it attains its maximum thickness in this quadrangle. Further details and an analysis of it are given in connection with the description of its occurrence on Cherokee Creek (p. 13). At the headwaters of Cat Creek it has not been mined on a commercial scale because of its remoteness from lines of transportation. Its outcrop in this locality is not large, as the northward dip carries the bed below drainage level near the mouth of Thompson Fork. On the economic geology map its outcrop line in the valley of Cat Creek is practically coincident with that of the clay bed at the base of the Allegheny formation. The following section was measured at an opening on Cat Creek:

Section of Brookville coal at bank of W. H. Moore, Cat Creek.

	Inches.
Shale, black.	
Coal	$1\frac{1}{2}$
Bone	$4\frac{1}{2}$
Coal	$17\frac{1}{2}$
Bone	$\frac{1}{2}$
Coal	24
	48

A thickness of 4 feet 10 inches to 5 feet is reported from other country banks near Cat Creek. 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 clay and bone partings that it will have little value except for country trade.

LOWER KITTANNING COAL (NO. 6 OF KENTUCKY SURVEY).

Though the Lower Kittanning coal 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 are now closed. Near the mouth of Twomile Creek and on Lick Creek it has been opened and worked on a small scale. It is reported to be of workable thickness in the hills north of Chapman on Threemile Creek, and a few old openings on it were seen in that vicinity. On Dry Ridge, south of Irad, it appears as a small coal not exceeding 2 feet in thickness.

South of Cassville, W. Va., an opening shows $32\frac{1}{2}$ inches of coal. The coal has also been opened on Mill Creek, and though the bed at this locality is somewhat impaired by bone and shale in its upper part it commonly contains a lower bench of bright lustrous bituminous coal of good quality, ranging in thickness from 2 to 3 feet.

UPPER FREEPORT COAL.

Extent and development.—In the valley of Big Sandy River the Upper Freeport coal has been prospected in many places. The rise of the beds up the river brings this coal above drainage near Zelda, where it has been opened on both sides of the river. Just south of Zelda the coal measured

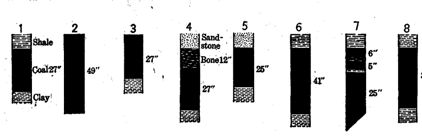


FIGURE 8.—Sections of Upper Freeport and Pittsburgh coals.

1, Clifton Dean, near Zelda; 2, Frank Yates, near Catalpa; 3, 1 mile north of Fallsburg; 4, 1 mile above mouth of Cat Creek; 5, C. C. Crank, Fallsburg; 6, Christopher Bellamy, Little Hurricane Creek; 7, Volney Artrip, head of Right Fork of Hurricane Creek; 8, James Adkins, hill west of Centerville, W. Va.

Scale, 1 inch = 5 feet.

27 inches (fig. 8, section 1). The Upper Freeport coal 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 48 feet above the railroad track, where it is a little more than 4 feet thick (fig. 8, section 2). This coal has been opened also near the mouth of Horseford Creek, where it 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 beneath it has not been opened, except near the heads of some of the shorter streams that flow into the Big Sandy from the west.

The rise of the beds toward the south brings this coal above drainage level on Blaine Creek at the mouth of Long Branch, about 1 mile north of Fallsburg. Here its thickness is indicated in figure 8, section 3. A short distance south, near the mouth of Cat Creek, an almost identical section (section 4) was seen. The following leveled section was measured east of Fallsburg:

Section east of Fallsburg.

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

This section shows well the character of the beds above the Upper Freeport 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 (fig. 8, section 5). West of Yatesville the thickness is from 2 to 3 feet.

In West Virginia, near the mouth of Big Sandy River, the basal sandstones of the Conemaugh formation are a conspicuous feature in the landscape, and in recent cuts along the Norfolk & Western Railway a coal bed occupying a position corresponding to that of the Upper Freeport coal was observed near the mouth of Miller Creek. Opposite Zelda the coal shows a thickness of nearly 40 inches. About Hubbardstown and along Hurricane Creek both this and the next underlying coal outcrop in several places. The lower of these two coals is rarely of workable thickness, but the higher has been opened at several places and shows a thickness of $2\frac{1}{2}$ to 3 feet or more (fig. 8, section 6). About a mile east of Hubbardstown the bed does not appear to be thick enough to work, but near the mouth and near the headwaters of Tabor Creek it has an average thickness of 3 feet and in places consists of two benches, instead of a single bench. Northeast of Cassville, on the headwaters of Right Fork of Hurricane Creek, and still farther northeast, on Trace Branch, this coal was measured at a few country banks. A good idea of its persistence and character may be obtained from figure 8, section 7. This coal has been opened also at one or two places on Mill Creek.

Character.—From the sections given in figure 8 it will be seen that the Upper Freeport coal 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 in many places is overlain by massive sandstone. It rarely exceeds $2\frac{1}{2}$ feet in thickness, for the measurement of 4 feet obtained southeast of Catalpa is apparently local. The coal is a lustrous, bituminous, semiblock coal, with splinty partings, and is highly esteemed for smithing and for domestic use. Its chief drawback is its thin section. Its quality apparently bears a certain relation to the thickness of the bed, for the thicker coal at the head of Little Hurricane and Tabor creeks is reported to be of poorer quality.

OHIO DISTRICT.

LOWER KITTANNING COAL (NO. 5 OF OHIO SURVEY).

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 held by Orton and the Ohio geologists to be the equivalent of the Lower Kittanning coal of Pennsylvania. (See columnar section.) As it is the first coal bed of importance above the Vanport ("Hanging Rock") limestone, it is called locally in Kentucky the limestone coal, a name that is applied to it also about Coalgrove, Ohio. It is found at various heights above the Vanport limestone, but it averages 40 feet above this bed and 30 feet below the next higher coal. From section 1 in figure 9 it will be seen that this coal lies below a heavy sandstone at Coalgrove. It has been opened in many places and is now mined on a commercial scale near the base of the hill northwest of Coalgrove depot. It is worked in several country banks near Forestdale, east of which it lies below drainage level.

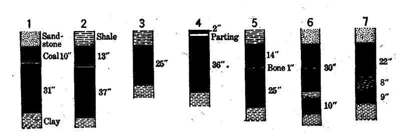


FIGURE 9.—Sections of coals of the Allegheny formation in Ohio.

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; 6, country bank north of Coalgrove; 7, Harry Smith, north of Coalgrove.

Scale, 1 inch = 5 feet.

Character.—Sections 1 and 2 in figure 9 illustrate well the character of this coal. The bed, however, usually occurs in three benches, which range in thickness as shown in the following section:

General section of Lower Kittanning coal near Coalgrove, Ohio.

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

The bed is irregular in thickness, and each of the maximum figures given above was obtained at only one place. The average total thickness is 3 to $3\frac{1}{2}$ feet. The massive sandstone that overlies the bed furnishes an admirable roof, so that little timbering is necessary. On the other hand, this sandstone rolls locally and in places cuts out the coal completely. The coal is dry, of good quality, and well adapted for heating. It does not yield a good grade of coke, for it contains a large amount of sulphur, but after washing it is suitable for coking.

MIDDLE KITTANNING COAL (NO. 6 OF OHIO SURVEY).

Extent and development.—The Middle Kittanning coal, which is the second bed above the Vanport ("Hanging Rock") limestone member, has been known and worked for many years in the Hanging Rock region. According to the Ohio Geological Survey reports, it is identical with the Nelsonville or Straitsville coal of the Hocking Valley.[a] Up to the present time it has proved to be by far the most important coal in this quadrangle. It is present in all the hills near Coalgrove, Forestdale, and Sheridan; in the hills well up on Little Ice Creek; and along the Ohio to a point about 2 miles above Sheridan. Beyond this point it is hidden by the flood-plain deposits, except, possibly, near North Kenova. At present the coal is of importance only for local use. It 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 the Ohio near Sheridan.

Character.—The coal generally ranges in thickness from about 3 to more than 4 feet. (See fig. 9, sections 3 to 7.) As a rule it has a bony parting, an inch or less in thickness, lying from 2 to 14 inches below the roof. The upper of its two benches is usually about a foot thick; the lower or main bench ranges from 2 to 3 feet. Southeast of Sheridan the two benches are represented by a single bench of 25 to 27 inches thick (fig. 9, section 3). The different measurements of the bed obtained in this field are given in figure 9. It is possible that a third bench exists in places in Kentucky.

The coal is hard and splinty, breaking along charcoal layers into slabs 6 to 8 inches thick. It is too high in sulphur to make a first-class coke, and has been used chiefly as a steam and domestic coal.

The roof of the coal is in some places massive sandstone and in others shale. The overlying and underlying sandstones are abnormally thick in places and almost cut out the coal, only a few stringers being left to represent the bed. This is its condition along the Ohio opposite the eastern suburbs of Ashland. For this reason the coal is not visible in many places where its horizon is exposed. It is reported to be absent just west of Forestdale.

UPPER FREEPORT COAL (NO. 7 OF OHIO SURVEY).

The upper coals in the Allegheny formation and the coals in the Conemaugh are of little or no importance in this part of Ohio. The Lower Freeport coal (No. 6A of Ohio Survey) and the Upper Freeport (No. 7 of Ohio Survey) have been opened in a few places on Lick Creek, about $1\frac{1}{2}$ miles east of Sheridan, and on Little Ice Creek.

EAST FORK OF LITTLE SANDY RIVER DISTRICT, INCLUDING ASHLAND.[b]

QUAKERTOWN (?) COAL (NO. 2 OF KENTUCKY SURVEY).

Extent and development.—The stratigraphic position of the Quakertown (?) coal bed is plainly indicated in the section between Argillite and Hood Creek (p. 3). It is known locally as the "Clod" seam owing to a clay parting that it contains. Openings on it have been made at many places near Argillite and Danleyton, and it has been called the Danleyton coal in the economic bulletin on this area. It lies 110 feet below the base of the Homewood sandstone member and from 30 to 40 feet below the horizon of an ore bed, which must have been of considerable importance near Danleyton, as it has been opened to a great extent. Farther west, about Hunnewell in the valley of Little Sandy River, the bed occurring about 110 feet above the road is probably the same coal. Beneath the coal here and at Danleyton there is an unusually massive sandstone and the distance below the base of the Homewood sandstone is about 100 feet in both places. The bloom of this coal shows on Black Branch of Little Sandy, east of Pactolus, and generally on the county roads east and southeast of Grayson, and it ascends the small creeks to their sources. On Upper Stinson Creek, near Stinson post office, a coal, presumably the Quakertown, lies 100 feet below the old workings of the Lexington Carter Co., which has been reported as having mined the Upper Mercer coal (No. 4 of Kentucky Survey). This would place the Quakertown coal about 70 feet below the Lower Mercer coal (No. 3 of Kentucky Survey). In the opening at this place it was reported 22 inches thick with two partings. It is present in the hills bordering East Fork of Little Sandy River between Danleyton and Naples, but south of Naples it lies below drainage level. Near Argillite it appears 150 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 Creek and Henry Branch, and nearly every farmer about Danleyton has opened this coal for his private use. A short distance east of Danleyton it goes below drainage level. Where opened its development is purely local.

Character.—Sections 1 and 2 of figure 6 (p. 9) indicate the character and the striking similarity in the general features of different exposures of this coal. The coal where seen is in two benches, separated by a clay parting. Each bench ranges from less than a foot to about $1\frac{1}{2}$ feet in thickness, and the clay parting ranges in thickness from 6 inches to more than a foot. The lower 4 or 5 inches of the upper bench is in places bony. Nowhere 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 generally more lustrous than the lower, but some of it is 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 will be serious hindrances to its commercial development so long as thicker coals remain in the region, although it is conveniently situated for transportation. It is reported to be an excellent stove and steam coal and is widely used by the farmers.

LOWER MERCER COAL (NO. 3 OF KENTUCKY SURVEY).

Extent and development.—The Lower Mercer coal occurs in workable thickness above drainage level in a small part of Boyd County only. Farther west and southwest, however, in Greenup and Carter counties, it is found above drainage level and is widely distributed near the western limits of the quadrangle. In this district it has been worked only on a small scale, owing to its thinness and to the fact that it is badly broken by partings, but along Cane and Stinson creeks, in Greenup and Carter counties, it is an important cannel coal. It is present in workable thickness in the ridge separating Little Sandy River from East Fork, but on the eastern flank of the ridge it is worked only at a few country banks. Its outcrop (where known to be workable) is indicated on the economic geology map. This bed has been best developed in the valley of Hood Creek, west of Ashland, where it directly overlies a massive sandstone. Though it has been opened in many places northwest of Pollard, every opening has been allowed to fall in.

Character.—Where seen the bed consists of two benches. The upper bench, which is the main workable bench, is all coal in many places and largely bone in others. 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.

UPPER MERCER COAL (NO. 4 OF KENTUCKY SURVEY).

Extent and development.—Although the Upper Mercer coal outcrops in a broad area along the Ashland Coal & Iron Railway, it has proved to be of workable thickness in very few places. Its outcrop if drawn on the economic map would come a little below that of the clay indicated by the green line.

In the eastern part of Ashland it has been prospected at many points on the road leading to the city cemetery. Farther up the Ohio between Sandy City and Catlettsburg, it was formerly worked. 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, and near the mouth of Shope Creek $3\frac{1}{2}$ feet of coal with an important fire clay below is reported. At Music it has been opened but is so badly broken by partings that it is not a commercial coal. So far as known it is not workable elsewhere in this district.

Character.—The reason for its slight exploitation is at once evident from an examination of its section (fig. 7, section 5). It is thin, and this, together with the clay parting near its middle, will probably bar it from the list of commercial coals of this district for some time to come. The two benches nowhere measure more than $2\frac{1}{2}$ feet together, and the clay parting is in places as thick as one of the benches. It usually has an excellent roof of massive sandstone, which makes it a safe and cheap coal to work. Its clay floor is important, for it is of workable thickness and of a quality good enough to serve as a bond in refractory brick. 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.

LOWER KITTANNING COAL (NO. 6 OF KENTUCKY SURVEY).

Extent.—The lower Kittanning coal 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 in any great area. It is particularly important about 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. This bed is present in all the hills between Little Hood and Catletts creeks, along the Ohio, and on Keyes Creek. In most places, however the operations are on a small scale. Most of the railroad mines are closed, but mining is in progress at mine No. 8 of the Ashland Iron & Mining Co. at Winslow.

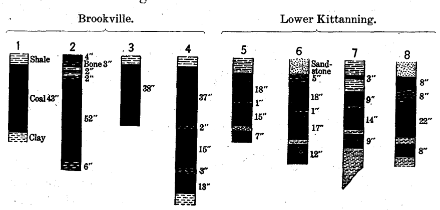


FIGURE 10.—Sections of Lower Kittanning coal (No. 6 of Kentucky Survey) and of Brookville coal.

1, J. C. Webb, Caney Fork; 2, J A. Young, head of Cherokee Creek; 3, James Wheeler, ridge east of Backbone; 4, James Adams, head of Johns Branch; 5, county road one-half mile east of Winslow; 6, Nancy McKnight, three-fourths mile northeast of Winslow; 7, John Gerard, near Oakview (Ashley); 8, in hills west of Ashland.

Scale, 1 inch = 5 feet.

Character.—Sections 5 to 8 in figure 10 give a fair idea of the thickness of the coal. From these sections it will be observed that it usually occurs in three benches, the upper two generally separated by a thin bone parting that is rarely more than $1\frac{1}{2}$ inches thick. These two benches together, without the bone parting, range from $2\frac{1}{2}$ 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 there are a few inches of dark shale. In places sandstone is thicker 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 in the upper two benches is splinty and is harder than that in the lower bench, which crushes badly in the pillars. Like the other coals in this district, the upper two benches readily break into blocks or slabs 6 inches or more thick. This coal bears stocking and transportation well.

The following analyses indicate the chemical nature of the coal.

Analyses of Lower Kittanning coal.

	1	2	3	4	5	6	7	8
Moisture	-------	-------	5.19	3.40	2.94	2.70	4.04	3.65
Volatile matter	43.52	42.95	41.86	32.50	32.50	36.70	33.60	36.59
Fixed carbon	50.54	52.10	47.69	55.40	56.70	52.60	53.34	52.62
Ash	5.94	4.95	5.26	8.90	7.74	8.00	9.00	7.11
Sulphur	1.83	2.54	1.40	1.23	1.97	1.71	1.31	1.71

1. Mine No. 12, Ashland Iron & Mining Co., Winslow, Ky.
2. West of Ashland.
3. Tunnel mines, near Ironton, Ohio, N. W. Lord, analyst. Ohio Geol, Survey, vol. 5, 1884, p. 1045.
4. Turkey Pen Hollow.
5. Keyes Creek.
6. Horse Branch.
7. Amanda furnace.
8. Average of first seven analyses.

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

The analyses show that this is a bituminous coal of high grade. The percentages of fixed carbon and volatile matter indicate a good gas coal, but of course a coal yielding only a second-grade coke would hardly be used for gas making. Coke from this coal has never been used alone in iron furnaces but has always been mixed with some standard coke, such as Pocahontas or Kanawha.

As a steam fuel the coal gives excellent satisfaction. Its average analysis, in column 8, shows a very close resemblance in composition to the next higher or Middle Kittanning coal in this region, which is highly valued as a steam coal. It contains less moisture than the Middle Kittanning coal but more ash. The sulphur averages about the same, and volatile matter and fixed carbon are present in nearly the same percentages in the two coals. The sulphur content of the Lower Kittanning coal is rather high.

MIDDLE KITTANNING COAL (NO. 7 OF KENTUCKY SURVEY).

Name.—The Middle Kittanning is the most important coal bed in the quadrangle. It was mined originally at Coalton, Ky., and is widely known under the name of Coalton coal.

Extent.—The zone of outcrop of the Middle Kittanning coal is about 10 miles wide in the northern part of the quadrangle, and follows the structure lines southwestward, gradually tapering as it approaches Willard and Webbville. (See map showing economic geology.) The rise of the beds southward, beyond these towns, soon carries this coal above the hilltops. It is present in all the hills southeast of Naples bordering Williams Creek and its tributaries, Straight Creek, and East Fork and its branches. It has been eroded from the hilltops in the "Flatwoods" area south of Ashland. Though present on Catletts Creek and Keyes Creek, it may not be so thick as in the region farther west. Its horizon is believed to be above

[a] Rept. Ohio Geol. Survey, vol. 3, pt. 1, 1878, pp. 917-918.

[b] This district corresponds to the Chesapeake & Ohio Railway district of the economic bulletin on this area (Bull. U. S. Geol. Survey No. 349).

drainage level also on Chadwick Creek. On Garner Creek it has been opened at a few country banks. In general the western limit of the outcrop of the Middle Kittanning coal coincides with the boundary between Boyd and Greenup counties and south of Greenup County follows the divide between Little Sandy River and East Fork.

Development.—Nearly every bed of this coal that has been found in the district has been worked or prospected. Southwest of Ashland, in the hills bordering Hood Creek, it is prospected 40 to 50 feet above the next lower coal. Near Winslow and Summit it has been opened on many farms but is reported to be 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 many 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 & 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 & Ohio Railway. With the exception of a little work done by the Ashland Iron & Mining Co. at Winslow, now abandoned, operations on this bed begin at Princess and extend as far south as Willard. The names of the companies that are now working the coal are given on the margin of the economic geology map. The present operations are mostly remnants of what were once very much larger and more important mines. In some of the hills the coal is reported as completely worked out.

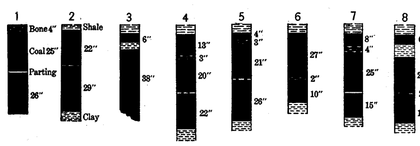


FIGURE 11.—Sections of Middle Kittanning coal (No. 7 of Kentucky Survey).

1, Princess Land and Mining Co., Princess; 2, Richard Jauchius, east flank of ridge between Mavity and Coalton; 3, W. W. Sexton, head of Pigeonroost Creek; 4, George Hull, Rush Creek; 5, John Runyon, North Fork of Trace Creek; 6, Equally Conley, west of Bellefont; 7, Straight Creek Coal Co., Straight Creek; 8, Morning Glory Coal Co., Grant.

Scale, 1 inch = 5 feet.

Character.—The sections in figure 11 give a fair idea of the thickness of this bed. It will be observed that the coal generally occurs in either two or three benches, which are separated by bone or clay partings. The measurements indicate that more commonly there are three benches. The thickness of the upper parting generally ranges from 1 to 5 inches and rarely exceeds 1 foot. In most places the lower parting is bone from half an inch to two inches thick. About Rush this parting is clayey 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 prevailing elsewhere, which changed after this clay was deposited, so that shale was laid down instead of coal.

As a general rule the upper bench is not mined, for two or more reasons—first, it is irregular in thickness; second, it is likely to contain much sulphur and bone, as it does at the openings along Straight Creek and near Denton. It varies greatly in size from place to place but seems to be of workable thickness in some localities, as at the mines on Rush Creek (fig. 11, section 4). The upper bench is fairly thick in the mine of the Straight Creek Coal Co., but the coal is too heavily impregnated with sulphur to be marketable (fig. 11, section 7). At the Morning Glory Coal Co.'s mine near Grant it is in places of workable thickness, but it grows lower and narrower so abruptly that it can not be depended on as a minable bed. At one place in this mine it measures 26 inches; at others it is absent. A similar condition was observed on Mile Branch.

The two lower benches are almost everywhere workable. They are mined together, the bony parting being separated by hand. They average very close to 20 inches each, the lower usually being slightly thicker than the other. The two benches together range from about 3 feet 3 inches to 4 feet, a fair thickness 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 thickness must be regarded as altogether exceptional. The operations on this bed near Coalton were long ago suspended, but the thickness measured in the hills on the east indicates a possible coalescence of the lower two or main benches. A similar condition was observed at the head of Pigeonroost Creek (fig. 11, section 3).

The roof of the bed is usually shale and is considered to be fairly strong. It ranges in thickness from a few inches to a few feet. In some places this shale is sandy; in others it is replaced by a massive sandstone and in such places the coal is very thin. Near the head of Rush Creek a few feet of cannel shale was seen above the coal. The cannel shale was observed also on North Fork of Trace Creek. This shale in laces 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. Rolls occur here and there in the floor of the coal but are not common. Faulting is rare and very slight.

The coal 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 common characteristic of 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. It is a dry-burning noncoking coal now widely used in this part of the State for steaming and for domestic use, and in the last three decades it has acquired a reputation as an iron-making coal.

The analyses of this coal show a rather high percentage of sulphur. The quantity of ash is somewhat variable, but in the amounts of volatile matter and fixed carbon the coal shows a very uniform character, as will be seen from the following seventeen analyses:

Analyses of Middle Kittanning coal from northeastern Kentucky.

	1	2	3	4	5	6	7	8	9
Water	4.80	5.00	4.06	4.40	3.30	7.70	6.40	6.60	6.06
Volatile matter	34.20	34.50	34.24	31.10	33.30	28.16	27.22	34.36	32.94
Fixed carbon	54.90	55.40	54.70	57.90	57.60	53.04	58.88	54.61	54.80
Ash	6.10	5.10	7.00	6.60	5.80	11.10	7.50	4.40	6.20
Sulphur	1.31	1.29	1.85	2.10	2.48	1.06	.97	.72	1.87
Coke	61.00	60.50	61.70	64.50	63.40	64.14	66.38	59.04	61.00

	10	11	12	13	14	15	16	17
Water	6.40	4.40	3.20	35.20	39.90	38.40	42.51	5.19
Volatile matter	31.40	38.00	35.06					32.87
Fixed carbon	57.66	52.86	54.40	43.30	53.30	54.75	52.06	55.57
Ash	4.54	9.14	7.34	21.50	6.80	6.85	5.43	6.57
Sulphur	1.67	2.20	2.63	1.30	2.05	2.05	1.32	1.68
Coke	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 Co. 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 Branch, 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 & Mining Co. at Ashland; being incomplete, these are not so good as the other analyses.

17. Average of first twelve analyses.

The analyses numbered 1 to 12 were made by Robert Peter and J. H. Talbutt, of the Kentucky Geological Survey. Some striking facts are brought out by the foregoing figures, the leading one being the remarkable uniformity displayed by the coal over the broad area from which the samples were collected. The average of Peter's and Talbutt's analyses is given in column 17, and a comparison with it shows how slightly most of the analyses deviate from the average.

LITTLE SANDY RIVER DISTRICT.

LOWER COALS.

A coal of importance in this area occurs between the two basal conglomerates outcropping on Everman Creek near its junction with Wolfpen Branch. Here a black shale lies 15 to 20 feet below the top of the upper conglomerate. In places this shale is coal-bearing and the thin coal found in it is probably the stratigraphic equivalent of the Jackson Shaft coal of Ohio and the Sharon coal of Pennsylvania. This coal has been worked on Barrett Creek almost at water level. On Crane Creek the lower conglomerate, the supposed Sharon conglomerate member, is very massive, and this coal again appears but is only 6 inches thick—too thin to be of value.

About 50 to 60 feet below the next higher main coal there is a single small coal bed and in places a second coal a few feet still lower. These are both thin beds lying above the Sharon conglomerate member, but, if the upper of the two basal conglomerates represents the Sharon conglomerate, the lower coal may be within the stratigraphic limits of the Sharon. Where only one of these coals is present the observer can not be sure which it is. One of them was exposed in an excavation below the post office at Grayson, and it appears in several places on the county pike south of the town. It was opened in the bed of Town Branch on the west. It rests immediately on a thin bed of quartzite or quartzite-like micaceous sandstone which, though not more than 5 or 6 feet thick, is fairly persistent 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. In the valley of Upper Stinson Creek directly east of Grayson two coals show just at the foot of the hill north of the road and at the edge of the meadow; the lower of these coals is 20 inches thick and has a bone floor and shale roof. Near the north end of the tunnel of the Eastern Kentucky Railway, south of Hopewell, this coal shows, but here it is too thin for working. The coal was noted also east of Pactolus, on the hills near Black Branch, where it is too thin for shipping though of some local importance.

BARRETT CREEK OR "LITTLE CANNEL" COAL (NO. 1 OF KENTUCKY SURVEY).

Correlation.—In the valley of Little Sandy River the equivalent of the "Little Cannel" coal corresponds to coal No. 1 of the Kentucky Geological Survey. In the economic bulletin on this area it is called the Barrett Creek coal. 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 the Ohio coal a little too high in the Kentucky section, for the coal associated with the black shale lying between the basal conglomerates on Everman Creek appears to contain a fossil flora similar to that of the Jackson Shaft (Sharon) coal of Ohio and hence is probably more nearly the stratigraphic equivalent of the Ohio coal than the bed 50 to 60 feet higher in the Kentucky section.

Development.—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 Crane Creek, about 2½ miles west of Hopewell station, it has been opened, and though reported thin is of excellent quality for smithing. Near Samaria on Lost Creek it has also been opened. It outcrops on Oldtown Creek and on 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 River the coal is not so extensively distributed above drainage level owing to the eastern dips. Between Argillite and Laurel it appears as a bloom in a few places on the pike along the Eastern Kentucky Railway but has not been opened so far as known. It is probably this coal that is opened in a few places on Cane Creek, south of Hunnewell, where it is about a foot thick. The coal has been opened at a few points on Deer Creek northwest of Willard. Its position, about 60 feet above the Sharon conglomerate, which is prominent along Little Sandy River in this region, serves to identify it. 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 to be workable in one or two places, but the writer was not able to verify this information. These lower coals are in places partly cannel.

Character.—Sections 3 to 8 in figure 5 (p. 9) give an idea of the thickness of the coal in the Little Sandy River district and in the southwestern district, near Blaine. The sections show that it is commonly of workable thickness, but at many points it falls below what might be regarded as the commercial requirement for this region, namely 2 feet. At most places on and near Barrett Creek it consists of two benches, an upper containing from 1 to 2 feet of coal and a lower ranging from 2 inches to a foot. It has near its base a clay, shale, or bone parting, in places 6 inches thick. The coal here is for the most part of the soft bituminous type, but in some places the lower bench is hard and splinty. It is of high grade and well fitted for local use and for smithing.

On Field Branch about 2½ feet of good coal appear between a shale roof and fire-clay floor (fig. 5, section 7). At one bank over 3 feet of clean coal was seen with a thin body of shale above, capped by a good sandstone. It is reported that some of the coal in this bank 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 probable existence of a large body of workable coal, and this is the more probable as it is believed that the coal may be the stratigraphic equivalent of the coal which has been opened just west of here on Deer Creek, and which is known to be persistent and generally workable. The nearness of this coal to the railroad is favorable to its exploitation, and the slight westward rise of the beds should make draining the mines comparatively easy.

LOWER MERCER COAL (NO. 3 OF KENTUCKY SURVEY).

Development.—The Lower Mercer coal in the valley of Little Sandy River has been extensively worked in the vicinity of Hunnewell furnace, and the cannel coal in it was said to range in thickness from 3 to 4 feet. It is present in all the hills east of Little Sandy River, lying higher in the hills toward the west. The area of its greatest development in the western part of the quadrangle is the irregular quadrilateral square included between Sandy River and its East Fork on the east, the Chesapeake & Ohio Railway on the south, and Little Sandy River on the west. In this area it is of fairly even thickness but is less uniform in physical character. At Boghead it is worked chiefly for its cannel bench, which occurs near the middle of the bed. On the waters of Upper Stinson Creek it has been opened in many places. Between this creek and Little Sandy River the coal bed seems to lose its cannel bench and to

[a] Rept. Kentucky Geol. Survey, vol. C, 1884, p. 11.

consist at most places 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 in several places and generally is of workable thickness. It is found in most of the hills west of Little Sandy River.

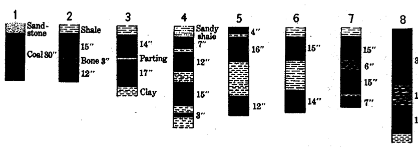


FIGURE 12.—Sections of Lower Mercer coal.

1, Hill east of Grayson; 2, Robin Run, 2 miles southeast of Grayson; 3, John Crawford, Robin Run; 4, 5, 6, Kentucky Cannel Coal Co., Boghead, Ky.; 7, Kentucky Cannel Coal Co. Hunnewell mine; 8, David Childers, Everman Creek.

Scale, 1 inch = 5 feet.

Character.—As will be seen from the sections in figure 12 the coal in some places consists of two and elsewhere of three or even four benches. Southeast of Grayson, at most country banks, it consists of two benches (fig. 12, sections 2 and 3) separated usually by a thin bone parting. Each bench ranges in thickness from about a foot to 15 inches. The coal differs in character in the two benches. In places there is a layer of cannel from 1 to 2 inches thick at the top of the upper bench, and at one bank a 6-inch layer of cannel was observed at the top of the lower bench. As a rule, the lower is more splinty and harder than the upper bench. This bed averages about $2\frac{1}{2}$ feet of excellent coal in the region southeast of Grayson. On Everman Creek (fig. 12, section 8) it contains more coal but also has a thick bony parting.

Where worked at Boghead and Hunnewell, the bed usually consists of three benches. The topmost 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 from the next lower cannel bench by a bone or clay parting, which is from $1\frac{1}{2}$ to 9 inches thick, being thicker near Hunnewell than at Boghead. The lowest bench is similar in character to the top bench. At Boghead it ranges from 12 to 15 inches in thickness, and at Hunnewell it is slightly thinner. It is separated from the middle cannel bench by an irregular clay parting, which at Boghead reaches a thickness of about 10 inches. The middle bench of cannel coal is the most valuable part of the bed at Boghead and Hunnewell and at both places is about 15 inches thick.

The cannel coals from the Hunnewell and Boghead mines have been examined by G. R. Hislop.[a] The results of the examinations made indicate that the cannel coals of this district, worked by the Kentucky Cannel Coal Co., are of high grade, the only drawback to mining being that they underlie only small areas, in which respect they are like most other cannel coals.

The following analyses, by Mr. Hislop, indicate the chemical character of this cannel coal:

Analyses of Lower Mercer coal.

	1	2
Moisture expelled at 212° F	1.21	2.75
Volatile matter	54.92	47.23
Fixed carbon	35.17	43.58
Ash	8.08	5.55
Sulphur	.62	.89

1. Boghead. 2. Hunnewell.

UPPER MERCER COAL (NO. 4 OF KENTUCKY SURVEY).

Extent and development.—The Upper Mercer coal is opened and worked at Boghead, where it occurs 30 feet above the Lower Mercer coal. It is present and as a rule is of workable thickness in most of the hills east of Little Sandy River. It is reported to be of workable thickness about Hunnewell, but is thickest 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. It is present in workable thickness over a considerable area between the heads of Cane Creek and Straight Creek. West of Little Sandy River it is present only near the tops of the highest hills.

Character.—The sections of this coal bed show that it is very irregular. The coal at Boghead is comparable with that measured west of Cane Creek. At both places the bed consists of three benches separated by either bone or black clay or shale partings. The coal in the upper bench ranges from 8 to 15 inches and in places has a few inches of bone over it. The middle bench ranges from $1\frac{1}{2}$ to 11 inches and is of soft bituminous coal, as is the upper bench. These two benches are separated by a parting of bone or black shale nowhere more than 6 inches thick. At Boghead the coal has a bottom bench of cannel ranging from 9 to 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 and 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 section 8 of figure 7 (p. 10), and in others several clay or shale partings. It has a roof of shale, clay, or massive sandstone. This coal is opened at many country banks near Mount Savage.

[a] Bull. U. S. Geol. Survey No. 349, pp. 89-92.

SOUTHWESTERN DISTRICT.

LOWER MERCER COAL (NO. 3 OF KENTUCKY SURVEY).

In the southwestern part of the quadrangle the Lower Mercer coal occurs 160 feet below the top of the Homewood sandstone member. It is found in this position along Right Fork of Blaine Creek and on the streams that flow into it from the north; also on the headwaters of Little Fork. Farther north it lies not so far below the Homewood sandstone. At the head of Field Branch this coal is not of workable thickness, but it is of more than ordinary interest from the fact that it consists largely of cannel. The coal here has a shale roof and measures approximately 2 feet thick. Near Backbone and Stephens it is found near the bed of the creek and has been worked on a small scale for local supply. South of Cherokee it is found near road level above the massive sandstone outcropping near the bridge over the creek. It has been opened in several places near Fielden and Sarah, where it is called the "mud seam." On Cains Creek, Rockhouse Branch, Knob Branch, Equal Fork, and in the vicinity of Willard sections obtained from this coal show it to be badly broken up. Except where the coal is of the cannel type it is of the same character as the rest of the coals in this district, namely, partly splint and partly soft lustrous bituminous coal.

BROOKVILLE COAL (NO. 5 OF KENTUCKY SURVEY).

Extent and development.—The Brookville coal is the most important coal in the southwestern part of the quadrangle. It reaches its greatest thickness along Dry and Caney forks, along Cherokee Creek, and in the hilltops northwest of Willard, at the head of Johns Branch. In this district it may be regarded with fair certainty as the western continuation of the coal that occurs on Cat Creek. It has been carefully prospected in the hills 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 north somewhat steeply, disappearing below drainage level before Webbville is reached. The same dip 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 bed of excellent coal. Its position is indicated by a bloom at many places in the ridge lying still farther west between Little Fork and Blaine Trace Branch. The southernmost point where its bloom was seen is in the hills just northeast of Blaine. 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.

Character.—Measured sections of this coal are given in figure 10 (p. 11). The sections obtained 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. The exposures seen along this stream probably average between 3 and 4 feet in thickness. As a rule the roof of the coal is shale.

At the heads of Dry Fork and Cherokee Creek and on the west at the heads of Perkins Branch and Equal Fork the coal attains its greatest development in this district. On a small creek entering the head of Cherokee Creek from the east more than 4 feet of excellent clean coal was measured in a single bench (fig. 10, section 2). At some places in the same bank a lower bench less than 1 foot thick is reported, but this is not everywhere present. As a rule the roof is shale and the floor bone passing into clay. In the ridge between Equal Fork and Blaine Trace Branch, a short distance east of Backbone, 38 inches of coal was measured. It was reported that the usual thickness is $3\frac{1}{2}$ feet. Thirty inches of coal was measured in the ridge west of Equal Fork.

The coal is the bright, lustrous bituminous variety, containing streaks of harder coal with probably some splinty layers. Without much doubt it will serve well for steaming and domestic use, but its efficiency as a coking coal has not yet been determined. From the fact that it may be removed from its position in rectangular blocks for the thickness of the entire main bench, it may appropriately be classed among the block coals. The following analysis shows its chemical character:

Analysis of Brookville coal from bank at head of Cherokee Creek.

Moisture	7.64
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 the ash is low. No sulphur is given, and this constituent was probably not determined, as it is quite certain that some sulphur is present.

LOWER KITTANNING COAL (NO. 6 OF KENTUCKY SURVEY).

Extent and development.—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, the Lower Kittanning coal is ordinarily from 45 to 60 feet above the Vanport limestone member, which in turn is near the top of the Homewood sandstone member of the Pottsville; hence there is nearly the same interval between the coal and the latter horizon. About Willard, near the fire-clay mine 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 Middle Kittanning coal. West of the town the bed is about the same distance below the latter coal and above the Vanport limestone.

Though it outcrops in all the hills about Willard, it has never been worked and nothing definite can be stated as to its character. It is probably too thin to be of any great value. Its bloom was noted in the hills on the south. In the hills north of Daniels Creek and west of San Branch it has been opened and worked on a small scale. On Brush Creek, south of the Elliott-Lawrence County line, this coal is sufficiently thick to be worked for local needs. In the hills north of Mount Savage also it seems to be fairly persistent.

Character.—This coal in the localities just described is fairly comparable with the same bed in the East Fork of Little Sandy River district. It contains three benches, separated by thin partings of bone or fire clay. The upper two benches are soft bituminous coal, and the lowest bench is hard splint. The roof is shale and the floor is clay. Sections obtained farther west also show three benches.

MIDDLE KITTANNING COAL (NO. 7 OF KENTUCKY SURVEY).

Extent and development.—About Willard and north of Webbville the Middle Kittanning coal has been opened and worked at many places. 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. Many country banks show this coal to be of fair thickness for about a mile above the mouth of Belle Trace Creek and for 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 toward the south. It has not 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 only in small bodies. It is found in the ridge between Equal Fork and Blaine Trace Branch and on the west in the ridge between Little Fork and Blaine Trace Branch, where $3\frac{1}{2}$ 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 coal is present only here and there in the tops of the highest hills.

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. This company formerly mined this bed extensively south of Willard, but at present all the old mines are closed.

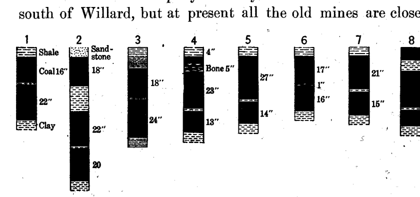


FIGURE 13.—Sections of Middle Kittanning coal (No. 7 of Kentucky Survey).

1, Alex McAlvin, Cobb Fork; 2, Ashland Iron and Mining Co., No. 10; 3, Mile Branch, northwest of Kilgore; 4, East Kentucky Railway mine, Partlow; 5, east of Willard; 6, near mouth of Lick Branch, west of Willard; 7, Lick Branch, west of Willard; 8, head of Davies Branch.

Scale, 1 inch = 5 feet.

Character.—The thickness of this coal may be learned from the sections in figure 13. On Lost Branch and at the head of Davies Branch, where measurements were made, three benches are present (fig. 13, sections 1 and 2). The top bench is from 4 to $7\frac{1}{2}$ inches thick and is not worked. In the immediate vicinity of Willard only two benches were noticed (fig. 13, sections 5 and 7). The upper bench is about 2 feet thick, grading into bony coal at the top. The lower bench is commonly 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, where measured, is only 15 to 21 inches in thickness, and the lower bench, which is about 16 or 17 inches thick, is comparable in thickness with this bench near Willard (fig. 13, section 7). 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 $3\frac{1}{2}$ 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 there are rolls in the roof or horsebacks.

The roof is as a rule fairly massive shale of irregular thickness, usually capped by a massive sandstone. The top of the coal is generally bony. The coal is bituminous. The upper bench is soft and full of charcoal partings; the lower bench is hard and splinty. The composition of this coal is indicated by the analyses given on page 12. These figures are for the most part those of coals collected 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 output of the Eastern Kentucky Railway mine at Partlow is used exclusively along the railway for steaming and domestic purposes.

COALS IN THE CONEMAUGH AND MONONGAHELA FORMATIONS.

BRUSH CREEK COAL (MASON COAL OF I. C. WHITE).

In the hills back of Cassville a small coal, called by I. C. White the Mason coal[a] but regarded as the same as the Brush Creek coal of Pennsylvania, is found above the Mahoning sandstone, the basal member of the Conemaugh formation. It is 2 feet thick. The same coal bed has been opened at points along Twelvepole Creek a few miles above Ceredo. It is as a rule so thin and so irregular 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. Except for this bed the Conemaugh formation is probably devoid of workable coals.

PITTSBURGH COAL.

In the tops of the hills near the center of the basin in West Virginia there is about 100 feet of the Monongahela formation. At its base is the Pittsburgh coal, which in this region is hardly comparable in thickness with that famous bed in other parts of West Virginia and in Pennsylvania. It is nevertheless a coal of excellent quality, and only its very small extent here prevents its commercial exploitation. In the hills east of Lett, at the mouth of Gragston Creek, it has been opened, and is found to range in thickness from $2\frac{1}{2}$ to $4\frac{1}{2}$ feet. It averages about 3 feet and usually has a thin but strong shale roof overlainby massive sandstone 20 to 30 feet thick. The section measured at one of the openings illustrates the character of this bed (fig. 8, section 8, p. 10).

CLAY AND SHALE.

DIVISION OF THE CLAYS.

All the clays of northeastern Kentucky have been deposited by water and hence are sedimentary clays. They may be divided with regard both to their age and to their adaptability into two classes: (1) Clays closely associated with coal beds and (2) Recent and Pleistocene clays, that is, those occurring in the present or ancient 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 4 to 6 there 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 ages. The columnar section shows the position of the more important clay horizons.

CLAYS IN THE POTTSVILLE FORMATION.

SCIOTOVILLE FIRE CLAY.

In the Pottsville formation one clay bed stands preeminently above the rest as regards quality, extent, and thickness. This is the Sciotoville fire clay (so named in the reports of the Ohio Geological Survey), less commonly known as the Logan clay. It has been extensively mined at Sciotoville, Ohio. It occurs a few feet above the Maxville limestone, but this limestone and the clay bed immediately above it are very sparsely distributed in this quadrangle. On the economic-geology map the green line on Everman Creek, Carter County, at the western edge of the quadrangle, and the one on Tygarts Creek indicate the theoretical extent of this horizon above drainage in this area, also where it should be looked for. On Everman Creek 4 to 6 feet of nonplastic clay shows and has been worked. It was reported as being 5 feet thick and as 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. This clay 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 underlying sandstones. Though its outcrop in the Kenova quadrangle is extremely limited, a few miles farther west its horizon is above drainage level in nearly the entire valley of Tygarts Creek.

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

OTHER CLAYS IN THE POTTSVILLE FORMATION.

There are other clay beds in the Pottsville formation, but they are not important. One of these is the clay associated with the Upper Mercer coal, which lies under the Homewood sandstone member. 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. The O'Kelly Brick Co. has opened the coal and clay and utilized 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 member in the eastern part of Ashland, Ky.

	Ft.	in.
Sandstone, massive.		
Coal	1	6–7
Clay		10
Coal		8–9
Clay	$2\frac{1}{2}$–4	

The same bed of coal with its underlying clay occurs also on Catletts Creek. 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.

CLAYS IN THE ALLEGHENY FORMATION.

CLAY ASSOCIATED WITH THE VANPORT LIMESTONE MEMBER.

Location. — The clay bed associated with the Vanport ("Hanging Rock") limestone member easily outranks all the other clays in the Allegheny formation in quality and quantity, and in extent of distribution. 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, the upper member of the Pottsville formation, and between the Brookville and Lower Kittanning coals. In the absence of the former coal it may lie even nearer the Homewood sandstone member.

Extent.—This clay bed is above drainage level near Coalgrove and Forestdale, Ohio, but its dip toward 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 general 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 southward it occurs in the hills in a great arc, following the outer edge of the basin and coming back to the Ohio near Ashland. Its horizon is also above drainage level east and southeast of Cassville, W. Va.

These beds of clay, iron ore, and limestone are indicated on the economic geology map by a green line. It will be understood that the clay is not necessarily workable at all points where this line is drawn. The flint clay, which occurs in small amount associated with the plastic variety, is a great help in the field in locating these deposits, for, owing to its indestructible character, fragments of the flint clay usually remain near the outcrop. Its position near the top of the massive Homewood sandstone serves as an additional help in locating it.

Physical character.—The clay associated with the Vanport limestone member is plastic, except for the small band of flint clay. The plastic clay is of two grades. The flint clay is of slight economic importance owing to its thinness. The two following sections give an idea of the associated beds:

Section of clay bed 1 mile west of Ashland.

[Measured by George H. 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 (horizon of Vanport limestone member)	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 member:		
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.

Section at the William T. Johnson clay pit, 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 at Coalgrove, Ohio, and the following section 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

It is reported that the beds occupy these relative positions for several miles toward the west in Ohio. In the eastern part of Ashland the following section was measured:

Section at the clay pit of the O'Kelly Brick Co., Ashland, Ky.

	Ft.	in.
Clay, upper, dark	4	6
Coal		4
Clay		$3\frac{1}{2}$
Coal		3
Clay	3	6

The sandy clay (p. 15) 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 & Ohio Railway about a 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 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.

[Measured by P. N. Moore.]

	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 member.		

The only manufacturer in this quadrangle using clay from this bed is the Weaver Pottery Co., located near Catlettsburg. This firm is engaged in the manufacture of jugs. Of the 6 feet of clay measured in the company's bank only the upper portion of $3\frac{1}{2}$ feet is worked, the lower part of the bed being too sandy. Limestone pebbles have also caused some annoyance.

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

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

	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 (SO_3)	.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 horizon of Vanport limestone member, 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 Co.

OTHER CLAYS IN THE ALLEGHENY FORMATION.

Near North Kenova, Ohio, a clay was worked 30 years ago and hauled to Burlington and South Point, where it was used in making pottery. The clay is 25 feet above the Lower Freeport coal and directly beneath a massive sandstone, thus occupying a position near the Upper Freeport coal. This correlation is strengthened by its distance of about 85 feet above the Middle Kittanning coal. This is the only known occurrence of a workable clay at this horizon in the area.

At Cassville, W. Va., a flint clay has been prospected at a horizon lower than the above, in the hills north of the depot. It is found at an elevation of about 80 feet above the tracks of the Norfolk & Western Railway and about 100 feet below the base of the Mahoning sandstone member.

Section at clay pit, Cassville, W. Va.

	Feet.
Cliff of brown, fine-grained, argillaceous sandstone.	
Shale, olive-drab	5
Clay, drab, with many nodules of iron or lime, 2 to 4 inches in diameter, and distributed in layers	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 observed also at a few places in the hills along Mill Creek and is reported 4 feet thick at one of them.

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

CLAYS IN THE CONEMAUGH FORMATION.

As a rule the plastic clays in the Conemaugh formation are the underclays of coal beds. The coal beds of the Conemaugh are irregular in distribution and in thickness, as are the associated beds of clay. Clay has been noted at a few horizons, but so far as could be learned it is not worked at any place.

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 occur in the hills about Ohio and Big Sandy rivers and are conveniently situated for transportation.

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 that 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 more than 4 feet. Often in working a clay bed a sandy clay is encountered. These streaks of sand are also utilized by the brick manufacturers, but this sand has been found unsuitable for certain uses owing to the admixture with it of particles of coal. The deposits now worked are confined to the valley of Ohio River, near 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 making tile, shingles, fireproofing, and other articles. 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 for local country use. Flood-plain deposits along Big Sandy and Little Sandy rivers have not even been prospected. Undoubtedly valuable deposits of clay exist along both these streams, which may be utilized later.

IRON ORE AND ASSOCIATED LIMESTONE.

PRESENT CONDITION OF IRON MINING.

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 district and to the gradual disappearance of the forests on which the charcoal furnaces depended, the iron industry of this region has declined, and no furnaces depending on the local ore supply are now in operation. The mine openings are now fallen in, and many have entirely disappeared. The following descriptions are therefore necessarily brief, especially those relating to the block and kidney ores, which at present are not worked at all.

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

CLASSIFICATION OF IRON ORES.

The iron ores of this region are chiefly earthy carbonate, spathic ore, or siderite, which on the outcrop and to different distances in, depending largely on the porous or nonporous character of the roof, 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, and (4) black-band ores.

Limestone ores are those that 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 near the stratigraphic position of the limestone. In eastern Kentucky ores of this class occur at two horizons—the lower associated with the Maxville limestone, and the higher occurring in the Vanport limestone member of the Allegheny formation. Owing to their purity, uniformity, richness in iron, and ease of working they have been among the most highly valued iron ores in this region.

Block ore and kidney ore are so called from their physical appearance. The former cleaves into roughly rectangular prisms when raised from its bed; the latter derives its name from the rounded kidney-like shape of its little masses. Unaltered carbonate and siderite occur in both forms, and so also does the limonite on or near the outcrop. The term "black band" is applied to beds of iron carbonate associated with more or less bituminous and earthy matter.

These ores occur stratigraphically throughout the Carboniferous rocks in the Kenova quadrangle, but the most important are found in the Allegheny and Pottsville formations. The ores are all bedded deposits in the sense that they occur at fairly well defined geologic horizons, which are persistent over broad areas.

LIMESTONE ORES.

ORE OF THE VANPORT LIMESTONE MEMBER OF THE ALLEGHENY FORMATION.

Position and extent.—The higher of the important limestone ores is that of the Vanport ("Hanging Rock") limestone member and is hence known locally as the "limestone" ore. It is often called also the red limestone ore and in the Kentucky Geological Survey reports the ferriferous limestone ore. It occurs from 10 to 40 feet above the top of the Pottsville, and forms the topmost bed of the Vanport limestone member.

The ore of the Vanport member is found in both Ohio and Kentucky. In Ohio its outcrop is small in this quadrangle, but it is extensive farther north and west. As it lies so near the base of the Allegheny formation, the structure contours drawn on the top of the Pottsville formation serve equally well for this ore and for its associated limestone and plastic clay. Moreover, the green line on the economic geology map representing the outcrop of the clay at the base of the Allegheny represents equally well the iron ore and limestone. Immediately south of the Ohio its western limit is beyond the boundary of this quadrangle. The main western outcrop appears in the hills between Little Sandy River and East Fork and continues southwestward to the point where Elliott, Lawrence, and Carter counties meet. From this point the general trend of the outcrop is southeastward to and 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.—Although the green line indicating the position of the clay bed at the base of the Allegheny has been drawn continuously throughout the economic geology map, this by no means indicates that the associated ore and limestone will be found continuously. On the contrary, it is known that the limestone and ore are of irregular thickness and are wanting at many places. The ore rests on the limestone, and the bounding surface between ore and limestone is very irregular. The limestone ranges from a thin sheet up to 8 feet in thickness but may be absent where the ore is present. The ore ranges from a few inches to some feet in thickness but may be pockety and the pockets may be several feet thick.

The limonite ore occurring at the outcrop is commonly brown or red, more commonly red, and as a rule is dense and close-grained. The red ore is the more valuable. The carbonate or unaltered ore is dense, close grained, and of a bluish or grayish color, and is therefore known as the blue 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[a] illustrate the character of both the limonitic and the sideritic phases of the limestone ore:

Analyses of ore of the Vanport limestone member in 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	24.450	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 Hood Creek near Bellefont furnace. Op. cit., p. 20.
3. Limestone ore from the Graham bank, near Willard, Carter County. Average sample from the stock pile. Op. cit., p. 55.
4. Limestone ore from Brush Creek, Pennsylvanian furnace. Op. cit., p. 114.
5. Gray limestone ore, from J. P. Jones's drift near Ashland. Selected from the interior of the bank. Op. cit., p. 37.
6. Same as No. 5, but from exterior part of the bank. Analyses 5 and 6 show well the changes that occur when the original ore is exposed to the atmosphere and surface waters.
7. Gray limestone ore from Mount Savage furnace, Carter County. Op. cit., p. 51.

Analyses 1 to 4 and 6 represent limonite; 5 and 7 carbonate ore.

The percentages of ferric oxide and iron carbonate in the analyses show the fundamental difference between the oxidized and unoxidized ores. The amount of metallic iron in the limonites ranges in general from 40 to 50 per cent, rarely going outside these limits. In the unaltered ores the metallic content is much lower, ranging from 25 to 40 per cent. The remaining constituents differ considerably, but silica and insoluble silicates are high. Sulphur is low, except in analysis No. 4; phosphorus is in general high.

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

ORE ASSOCIATED WITH MAXVILLE LIMESTONE.

Position and extent.—The lower of the important limestone ores rests directly upon the Maxville limestone.

The limestone itself appears in places above drainage level in the valleys of Everman Creek and North Fork of Oldtown Creek, and throughout Tygarts Creek valley, in the northwest corner of the quadrangle. Its outcrop is not very large in this area, but farther west and northwest is larger, lying generally above drainage level. The green line on the economic geology map representing the clay lying above the limestone may be taken also to represent the top of the Maxville limestone and the ore overlying it, where the ore is present.

Character.—Where exposed on Everman Creek the Maxville limestone is 20 to 25 feet thick. West of this quadrangle it is much thicker, in some places reaching 100 feet and more but being absent from others. Many of the deeper wells drilled for oil and gas have penetrated this limestone and proved it to be very thick and generally persistent throughout the area. Sections of these deep wells are given on the columnar section sheet. The limestone is the usual bright gray variety; it has been burned and used for fertilizer, for which purpose there seems to be an ample supply. It is not impossible that this limestone may also prove suitable for the manufacture of cement.

The iron ore overlying the limestone is erratic in occurrence and thickness and in these respects is like the ore of the Vanport ("Hanging Rock") limestone member. In quality it is comparable with that ore, and its content of metallic iron in both its altered and unaltered phases is similar to that of the higher ore. It is likely to be more siliceous, however, and in many places contains 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 will not be given here. Those who are interested in the theoretical side of the subject will find Moore's description most interesting and suggestive.[a] As a result of studies made in mapping this region during the summer of 1905, the writer reached certain conclusions which are summarized elsewhere.[b]

BLOCK ORES.

Position and extent.—Most of the block ores are found in the Pottsville formation and in the lower part of the Allegheny formation. They have been separated into two groups with reference to their stratigraphic position—the upper block ores and the lower block ores. The upper ores are found from 90 feet below the Vanport limestone member to about 50 feet above it, and the lower block ores are confined to the lower 125 feet of the Pottsville.

The area in which the block ores occur stretches 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, the area occupied by them in this section of the quadrangle being but a small fraction of their extent in this part of Kentucky. The upper block ores are more largely represented in this particular area, their boundary lying farther east than that of the lower block ores and the Vanport limestone.

Character.—Like the limestone ores the block ores may consist either of unaltered carbonate or of limonite. They are more persistent than the limestone ores and each bed is more uniform in thickness, but different beds show much difference in thickness and quality. They are leaner, 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. Their most common impurity is sand. The following table shows their average content in metallic iron, sulphur, and phosphorus:

Average iron, sulphur, and phosphorus content of 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] Moore, P. N., Rept. Kentucky Geol. Survey, vol. C, 1884, pp. 83–88, 94.
[b] Phalen, W. C., Origin and occurrence of certain iron ores of northeastern Kentucky: Econ. Geology, vol. 1, 1906, pp. 660–669.

KIDNEY ORES.

Geologic position.—Most of the valuable kidney ores have been found in the lower part of the Allegheny formation. From three to six beds of kidney ore of local importance lie between 40 and 100 feet above the Vanport limestone. The lower of the two most important ores has been called the yellow kidney ore. It lies about midway between the Lower and Middle Kittanning coals. Since most of the oxidized kidney ore is colored yellow by limonite, this name is not distinctive, but it has been generally applied to the ore at this particular horizon. About 50 feet above the yellow kidney ore and 25 to 30 feet above the Middle Kittanning coal is another stratum 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 of less consequence than the two just mentioned.

Extent.—The western and southern boundaries of the kidney ores coincide roughly with the line representing the outcrop of the clay bed at the base of the Allegheny formation. Beyond this quadrangle on the south and west these ores are of minor importance. Within the arc formed across the quadrangle by the outcropping Vanport limestone and the accompanying clay (p. 14) these ores are found throughout a zone 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 stripped. They are also found near Willard in Carter County 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 suggests their physical appearance. Though occurring at clearly distinct geologic horizons, they do not form continuous beds or layers, but are scattered through zones from 3 to 6 feet thick. Like the limestone and block ores, they consist of iron in all stages of transition from the pure carbonate, unaltered by atmospheric influence, to practically pure limonite on the outcrop. Analyses of five samples of oxidized kidney ore collected in this region give the following averages: Metallic iron, 43.372 per cent; sulphur, 0.049 per cent; phosphorus, 0.166 per cent. 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 iron carbonate associated with more or less bituminous and earthy matter. There is a notable occurrence of this ore on the property of the Torchlight Coal Co., on Levisa Fork, in Lawrence County. The deposit lies about 15 feet below the Upper Mercer coal and is from 8 to 12 feet thick. It consists of layers of black or carbonaceous siderite from 1 inch to 3 inches thick, alternating with thin layers of bituminous shale. The ore carries 55.12 per cent of iron carbonate and compares favorably in content of iron with the Scotch black-band ores.

SUMMARY.

The ores of this part of Kentucky are not now being used, as they have little value at present, though they may become more important in the future. When the beds were being worked, the oxidized material at or near the outcrop was sought for, as the furnace managers were professedly unable to use the blue or gray carbonate in producing the desired coarse-grained foundry iron. The oxidized ore was obtained by benching or stripping, a procedure which, though economical for ore occurring at the outcrop, could not be carried underground for any distance; in consequence only an insignificant fraction of the ore has been removed. 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. The mining methods to be employed must be adopted after most careful study, but the fact that similar thin beds of iron ore have been successfully worked in Europe is encouraging.

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

BUILDING STONE.

The only rock suitable for use as building stone in this area is sandstone, and of this there is great abundance. As a rule this rock will not bear the cost of transportation, but locally it has proved valuable for constructing culverts for railroads that pass through the areas and for building chimneys, fireplaces, and the walls of some dwellings. Very little of it, if any, can be cut into large blocks, but being cheap and very accessible it serves as a satisfactory material for rough structures.

Most of the sandstone in this area is micaceous, much of it is feldspathic, and as a rule it contains iron oxide. Its texture ranges from very fine-grained to conglomeratic, but few of the quartz pebbles in the conglomerate exceed an inch in largest dimension. Much of this sandstone is friable, disintegrating readily to fine sand. Such rock was used in constructing buildings 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 member. This sandstone is well exposed along Big Sandy River near its mouth, in both Kentucky and West Virginia. Near Kenova it appears to be sufficiently thick bedded for dimension stone. At this point, besides being very massive, it is very coarse grained and here and there is conglomeratic. It has been used by the Norfolk & Western Railway in this locality. Farther south, along 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 & Western Railway and in recent changes in the grading of the Chesapeake & 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 sandstones, which, though suitable for local use, are not sufficiently valuable for shipment.

Sandstone from the Allegheny formation has been used along the Ohio opposite Ashland. At this point the sandstone above the Middle Kittanning coal is abnormally thick and has been quarried by the Norfolk & Western Railway for use along its line. It has yielded much rock of fair dimensions.

The Pottsville formation contains many sandstones of considerable thickness, several of which were drawn upon in the construction of the Norfolk & Western Railway along Tug Fork and of the Chesapeake & Ohio Railway on Levisa Fork. The Homewood or upper sandstone member of this formation outcrops near Ashland and occurs as a massive cliff between the eastern boundary of the city and Cliffside Park. The rock has been used with 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 yield sand for making glass, but most of them appear to be too ferruginous for this purpose. Sand found locally in the flood plains may also prove suitable when washed. Such a deposit was reported at North Kenova, Ohio. The Mahoning sandstone member of the Conemaugh formation and the Homewood and other sandstones in the Pottsville formation are probably 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 sandstone near Willard and the Homewood sandstone near Mount Savage may repay careful prospecting for glass sand. In order to determine the fitness of sandstone or loose sand for glass making the material should be examined microscopically and chemical tests should be made to ascertain its content of iron, which, if present in too large quantities, renders the glass opaque. Large amounts of alumina and magnesia also have a deleterious effect. Better than any examination is a practical test of the material. It should be remembered also that some sandstones, though naturally containing too much iron for glass making, yield a suitable sand after crushing and washing.

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.

OIL AND GAS.

OIL AND GAS WELLS.

On the economic-geology map two classes of wells are represented—those that are known to have produced gas in quantity and those that have produced oil. Nearly all the wells in this area were drilled in search of oil. In some of them oil was found, but in small amount, 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 below. Some of the characteristic well sections are given on the columnar-section sheet, where the producing sands are indicated.

OIL AND GAS SANDS.

DEVONIAN SANDS.

Ragland sand.—Some oil is disseminated through the Devonian shales, but the most persistent gas and oil bearing stratum in the Devonian is a sandstone band a few hundred feet from its top. In some of the well records this sandstone appears to be embedded in shale, as in the Clinton well (No. 2 of the well sections), the Catletts Creek well (No. 4), and the Richardson or Longabaugh well (No. 5); in others it appears to rest upon or to be 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 the doubt 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, whereas in the southeastern part of the area the underlying rock is limestone. In some wells (Nos. 6 and 19) the rock at the Ragland sand horizon is probably a limestone. In the wells in which the Ragland sand is underlain by shale (Nos. 2, 4, and 5), rocks older than Devonian may be represented. This gas-bearing sand, 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 Cains Creek, Lawrence County, gas containing much hydrogen sulphide was encountered at this horizon.

CARBONIFEROUS SANDS.

Salt sand.—Fresh water is reported in the Summit well (No. 3) 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 lies within 250 feet above the Maxville, in the lower part of the Pottsville formation. The oil and salt-water "sands" resting directly upon the Maxville limestone may be regarded as the equivalent of the Salt sand on the north in Ohio, but in Washington and Monroe counties, Ohio, the name Maxton sand has been applied to it. From this bed came the salt water in the old salt wells on Big Sandy River near Zelda.

Big Injun sand.—The sandstone containing salt water or gas lying directly below the Maxville limestone, or separated from it by a few feet of shale, belongs to the Big Injun sand of Pennsylvania drillers (Burgoon sandstone), the Big Injun group of the Kentucky Geological Survey, or the Logan and Blackhand formations of Ohio and Kentucky. In the Kenova quadrangle most records show at this horizon a single sandstone bed from 30 to 175 feet thick, which may be completely absent in places. In the Blaine Creek well (No. 9) 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 reported as a sandstone. Both salt water and gas have been reported from this sandstone.

Berea sand.—In the rocks below the Big Injun sand sporadic shows of oil are reported, but no persistent oil and gas bearing rocks are encountered until the Sunbury shale or the Berea sandstone is reached. Most of the records studied show, between the shale which is regarded as probably the Cuyahoga shale and the Devonian black shale (Ohio shale) below, a group of sandstones with shale layers which is correlated with the Sunbury shale and the Berea sandstone. In many of the sections the well-defined sandstone is without doubt the Berea sandstone proper, but in certain of the sections showing several sandstone bands the basal boundary has been drawn on the lowermost where there seemed to be no positive evidence to the contrary. In some of the well sections the Berea sandstone is shown as limestone; it is so given in the original records. The rock is probably sandstone, as indicated on page 3. 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 no well has produced on a profitable scale.

PRODUCTION.

Most of the wells drilled in this area report a 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 1979 feet. The pressure recorded was 975 pounds. This gas is now piped to Catlettsburg. At the Jason Boggs well on Cains Creek, Lawrence County, gas was encountered in the interval from 1672 to 1697½ feet below the surface, also in the Ragland sand. The volume was reported to be 750,000 cubic feet each 24 hours when the gas was tapped, and the rock pressure to be 350 pounds. The gas was heavily impregnated with hydrogen sulphide. From the recent wells drilled in Lawrence County, Ky., south of Louisa, there is reported a small production of oil from the Berea sand.

January, 1912.

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

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

TOPOGRAPHY

KENTUCKY - WEST VIRGINIA - OHIO
KENOVA QUADRANGLE

LEGEND

RELIEF
printed in brown

Figures
showing height above mean sea level instrumentally determined

Contours
showing height above sea, horizontal form, and steepness of slope of the surface

DRAINAGE
printed in blue

Streams

Ponds

CULTURE
printed in black

Roads and buildings

Private and secondary roads

Railroads

Tunnels

Bridges

Trails

Ferries

Fords

Lock
on navigable stream

State lines

County lines

Township lines

City, village and borough lines

Triangulation stations

Bench marks
giving elevation above sea

H. M. Wilson, Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
Topography by W. N. Morrill.
Surveyed in 1900-1901.

SURVEYED IN COOPERATION WITH THE STATES OF WEST VIRGINIA AND OHIO.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1902.

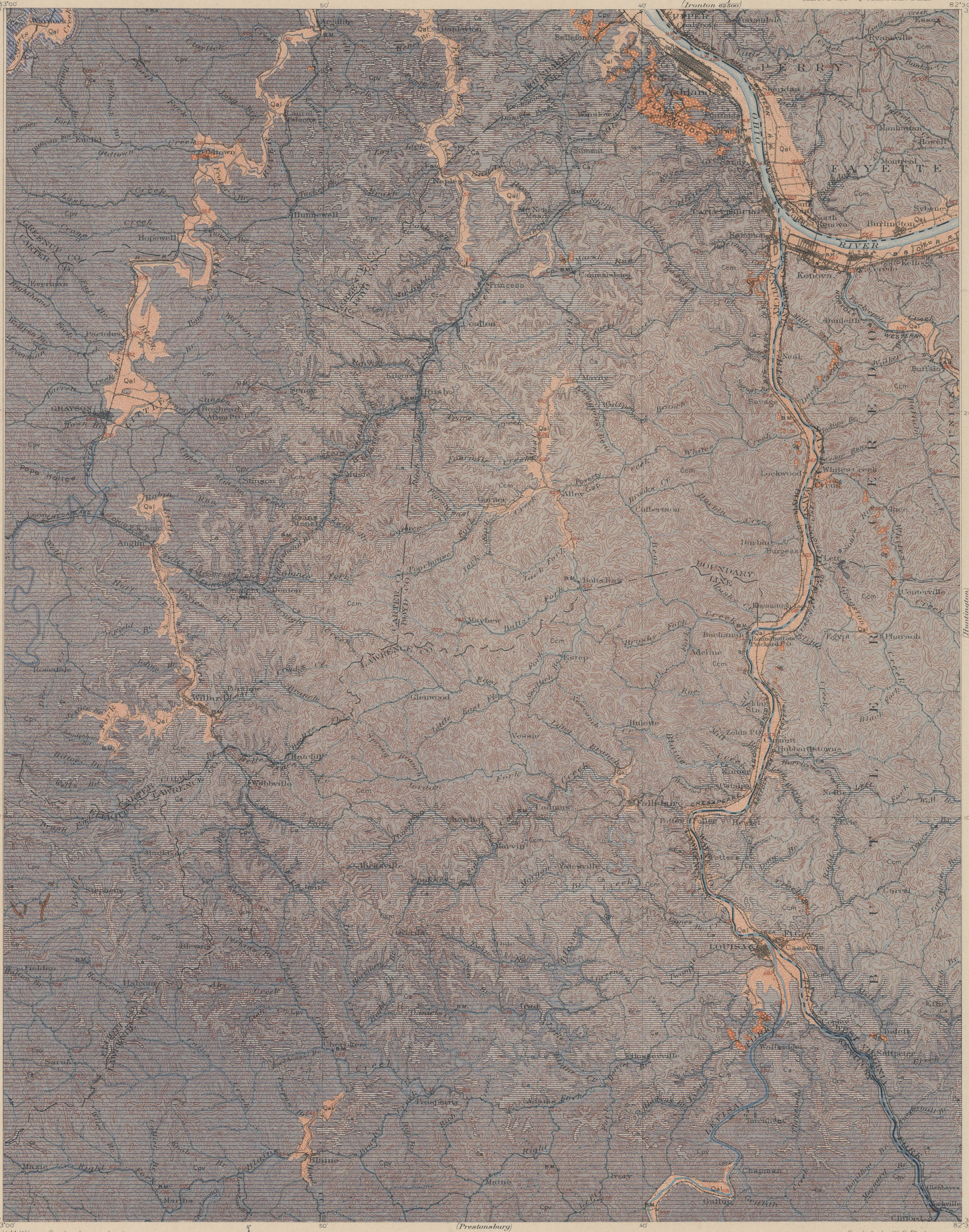
Scale 1/125000
1 ½ 0 1 2 3 4 5 Miles
1 ½ 0 1 2 3 4 5 Kilometers
Contour interval 100 feet.
Datum is mean sea level.

Edition of June 1903, reprinted Jan. 1912.

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

AREAL GEOLOGY

KENTUCKY - WEST VIRGINIA - OHIO
KENOVA QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines; subaerial deposits by patterns of dots and circles)

QUATERNARY

Recent

Qal — Alluvium *(only the larger areas shown)*

Pleistocene

Qg — High gravel deposits *(clay, sand, gravel, and bowlders, remnants of deposits in abandoned channels above the present drainage)*

CARBONIFEROUS

Pennsylvanian

Cm, pb — Monongahela formation *(sandstone and shale with Pittsburgh coal at base)*

Ccm — Conemaugh formation *(massive sandstone, shale, and limestone, with beds of unimportant coal, clay, and iron ore)*

Ca — Allegheny formation *(sandstone, shale, and shaly sandstone, with valuable coals and beds of clay and iron ore)*

Cpv — Pottsville formation *(sandstone, shale, and shaly sandstone, with valuable coal beds and beds of clay and iron ore)*

Mississippian

Cmv — Maxville limestone *(compact, bluish-gray, argillaceous limestone)*

Cl — Logan formation *(sandstone and shale)*

IGNEOUS ROCKS

pd — Peridotite dikes *(contain garnet and ilmenite)*

H. M. Wilson, Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
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Edition of Mar. 1912.

Geology by W. C. Phalen,
under the supervision of and
assisted by George H. Ashley.
Surveyed in 1905 and 1910.

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

STRUCTURE AND ECONOMIC GEOLOGY

KENTUCKY - WEST VIRGINIA - OHIO
KENOVA QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

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- Cmv — Maxville limestone *(compact, bluish-gray, argillaceous limestone)*
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IGNEOUS ROCKS

- pd — Peridotite dikes *(contain garnet and ilmenite)*

ECONOMIC AND STRUCTURE DATA

Coal outcrops *(dashed lines indicate uncertainty as to position or thickness of beds)*
pb, *Pittsburgh coal*
uf, *Upper Freeport coal*
mk, *Middle Kittanning coal*
lm, *Lower Mercer coal*
qt, *Quakertown coal*
bc, *Barrett Creek coal*

Refractory and pottery clays *(in the Allegheny and Pottsville formations)*

Structure contours on the sandstone at the top of the Pottsville formation *(contour interval is 50 feet, datum is mean sea level)*

Mines and quarries
Coal unless otherwise specified
A, indicates abandoned coal mines
Oil wells, abandoned
Gas wells

LIST OF MINES

Location indicated on the map by numbers

1. Coalgrove Coal & Stone Co.
2. Clinton or Ashland Iron & Mining Co. No. 8
3. Princess Land & Mining Co.
4. Kentucky Cannel Co., Hunnewell mine
5. Bailey mine
6. Norton Branch Coal Co.
7. Adkins Coal Co.
8. Ashland Iron & Mining Co., Rush No. 10
9. Ashland Iron & Mining Co., Rush No. 12
10. Morning Glory Coal Co.
11. Kentucky Cannel Co., Boghead mines
12. Straight Creek Coal Co.
13. Eastern Kentucky Railroad, Lost Creek mine
14. Torchlight Coal Co.

Note: Besides the mapped coal and clay beds there are workable clays and shales in the Pottsville, Allegheny, and Conemaugh formations and in the alluvium; the Maxville limestone is of commercial value for lime and possibly for flux; iron ore occurs in the Pottsville and Allegheny; building stone in all the consolidated formations; glass sand in the Pottsville, Allegheny, and Conemaugh; oil and gas in the deeply buried formations in various parts of the quadrangle.

H. M. Wilson, Geographer in charge.
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GENERALIZED SECTION OF THE ROCKS EXPOSED IN THE KENOVA QUADRANGLE.

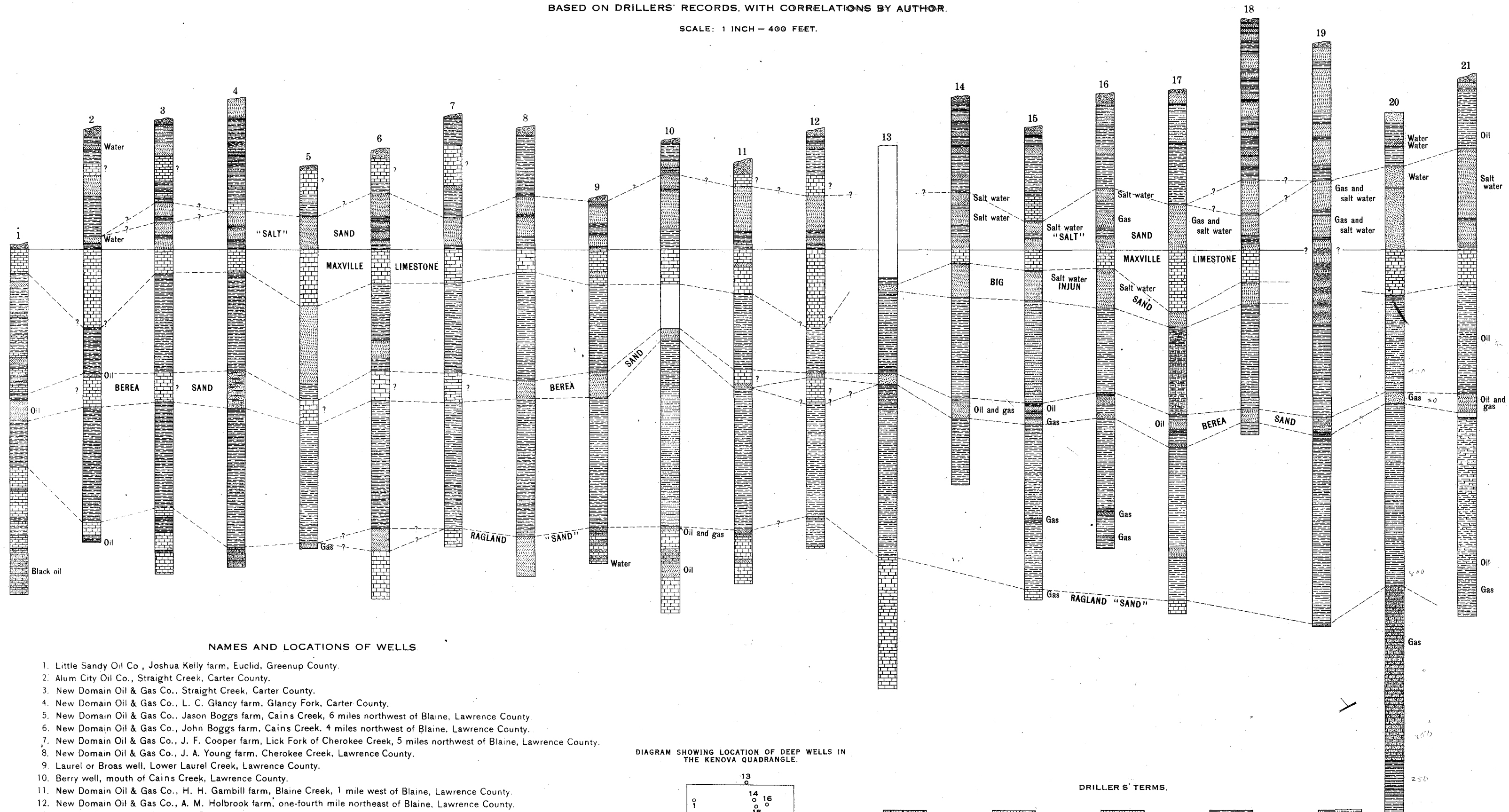
SCALE: 1 INCH = 200 FEET.

System.	Series.	Formation.	Symbol.	Section.	Thickness in Feet.	Minor Divisions.	Character of Minor Divisions.	General Character of Formation.
CARBONIFEROUS	PENNSYLVANIAN	Monongahela formation.	Cm		100+	Pittsburgh sandstone member. Pittsburgh coal.	Massive sandstone, 20 to 30 feet thick. Workable coal bed, averaging 3 feet in thickness.	The portion of the formation present in the quadrangle is prevailingly shale with scattered lenses of sandstone and a massive sandstone underlain by the Pittsburgh coal at its base.
		Conemaugh formation.	Ccm		400–600	Morgantown (?) sandstone member. Ames (?) limestone member. Buffalo sandstone member. Lower Cambridge limestone member. Brush Creek coal. Mahoning sandstone member.	Very massive in places, averaging about 50 feet in thickness. A siliceous, highly fossiliferous, limestone, important along Big Sandy River. Very massive in places, averaging 40 to 50 feet in thickness. Siliceous to argillaceous limestone, fossiliferous in places. Unimportant, mined locally. Massive sandstone, locally conglomeratic, having a maximum thickness of 100 feet.	Chiefly variegated shale with massive sandstones mainly in its lower part and thin limestones and thin coals.
		Allegheny formation.	Ca		180–200	Upper Freeport coal. Lower Freeport coal. Red kidney ore. Middle Kittanning coal. Yellow kidney ore. Lower Kittanning coal. Vanport limestone member. Brookville coal.	Locally important in the southeastern part. Average thickness 3 feet. Unimportant except locally in the northeastern part of the quadrangle. At present of no importance. The most important coal in the quadrangle. At present of no importance. Workable in northeastern part of quadrangle; 2 to 3 feet thick. Blue argillaceous limestone, associated with clay and iron ore. Locally very important, in places 5 feet in thickness.	Chiefly alternating shales and sandstones with beds of coal and refractory clay of present economic importance and iron ores formerly worked.
		Pottsville formation.	Cpv		400	Homewood sandstone member. Upper Mercer coal. Lower Mercer coal. Quakertown (?) coal. Barrett Creek or "Little Cannel" coal. Sharon (?) coal. Sharon (?) conglomerate member. Sciotoville fire clay.	Very massive coarse-grained sandstone, ranging from a few feet to nearly 100 feet in thickness. Important coal, worked along Levisa Fork and Stinson Creek. Important coal, worked along Levisa Fork and Stinson Creek. Workable in the northern part of the quadrangle. Important coal, worked near Torchlight and on Barret Creek in western part of quadrangle. Locally of importance. Massive conglomeratic sandstone, 40 to 50 feet thick, in places attaining 100 feet. Refractory fire clay along the western edge of the quadrangle.	Massive sandstones separated by shale beds with beds of coal and refractory clay of present economic importance, and iron ore not now worked. In the southern part of the quadrangle, where its entire thickness is not exposed, well records indicate that it thickens to over 600 feet.
	MISSISSIPPIAN	Maxville limestone.	Cmv		25			Blue argillaceous limestone. Well records indicate that it is much thicker under the southeastern part of the quadrangle.
		Logan formation.	Cl		100+			Alternating shales and sandstones.

SECTIONS OF DEEP WELLS IN THE KENOVA QUADRANGLE.

BASED ON DRILLERS' RECORDS, WITH CORRELATIONS BY AUTHOR.

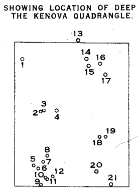
SCALE: 1 INCH = 400 FEET.



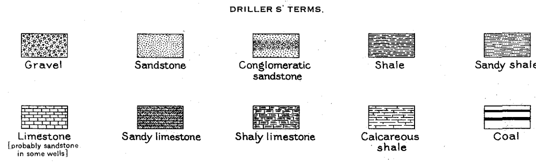
NAMES AND LOCATIONS OF WELLS.

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

DIAGRAM SHOWING LOCATION OF DEEP WELLS IN THE KENOVA QUADRANGLE.



DRILLER'S TERMS.



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140	Milwaukee Special	Wisconsin	25
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