GEOLOGIC ATLAS
OF THE
UNITED STATES
KENOVA FOLIO
KENTUCKY—WEST VIRGINIA—OHIO
BY
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This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the illustrations to show the regional country contours intervals of 10,00, 35, 50, and 100 feet are used.

The chief agents in the transportation of rock debris in water motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particle sand and the water, and to some extent as organic. Such are gravel, sand, and clay, which are later consolidated into conglomerates, sandstones, and clays. Some of the materials so consolidated are unconsolidated deposits of organic or fossil inorganic matter. Oil, gas, and bitumens are the most important rocks of chemical origin. The materials are derived from the sea, urce, post, lignites, 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 ice-deposited earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of boulders and pebbles and sand.

Colluvial 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 above or below sea level 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 on the bottom of the sea, sometimes 100 or 200 feet below sea level.

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. These processes and the more soluble parts are washed out, and the more insoluble 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. Alluvium is a deposit of collected known as clay, and clays develop into the muddy clay, and the residual layer is commonly included with them. Those of a number of species, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks are formed directly from igneous and by various processes, rocks may become greatly changed in composition and in texture, and the new characteristics are more pronounced than the original rocks, and may be only partly a result of the process of metamorphism the constituents of a chemical rock may enter into new combinations and certain minerals 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 mixed and later exposed by erosion. In such rocks the original structures may be entirely destroyed 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 it is 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 marked by a uniformly varied character, as, for example, an alternation of sandstone and limestone. Where the passage from one kind of rocks to another in the same mass is marked by two continuous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the continued fossils. The names by which rocks are known are names of one kind, of similar occurrences, or of like origin. A metamorphic formation may consist of rock of uniform character or of several rocks of a kind, or more generally, of a kind, and of rocks, and of rocks.

When for scientific or commercial reasons it is desirable to recognize one or more such specially developed parts of a variety of rocks, the names of those parts are called members, or by some other appropriate term, as lavas.

AGES OF ROCKS.

Geologic Time.—The time during which rocks were made is divided into periods. Smaller scale divisions are called epochs,

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 gently sloping hill; that on the left is broken by a steep escarpment 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 distinct 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 20 feet; therefore the contour lines are drawn at 20, 40, 60, 80, and 100 feet, and so on, above mean sea level. Along the center at 250 feet lie all points of the surface that are 250 feet above the sea—that is, this center would be the same if the sea were flat at 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 center 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 is drawn at 670 feet above sea level. In this illustration all the contour lines are numbered, and those for 250 and 900 feet are accentuated by being made heavier. Usually it is not desirable to number all the contour lines. The spacing or number of contour lines—my every fifth one—heights and the heights of the others may be ascertained by adding together the differences in elevation between two consecutive contour lines. The spacing of contour lines on any given sheet is approximately uniform, as may be seen from the accompanying table.

2. Contour lines show or express the forms of slopes. As contours are continuous horizontal lines, they wind smoothly about every hill or ridge, and give an idea of the general character of the surface. The slopes or the character of surfaces are expressed by the contour lines. A steep slope is indicated by a few parallel lines close together; a gentle slope by a long line.

3. Contour lines are the approximate grade of any slope. The vertical interval between two contours is the same, whatever their distance apart a contour or on a steep slope; but to obtain a given height on the gentle slope one must go farther than on a steep slope, and therefore the contours are far apart on gentle slopes and very close on steep slopes.

A small contour interval is necessary to express the relief of a flat or gently undulating country; a steep or mountainous country, on the contrary, requires a larger interval. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet.
DESCRIPTION OF THE KENOVA QUADRANGLE.

By W. E. Hafen.

INTRODUCTION.

GENERAL RELATIONS OF THE QUADRANGLE.

The Kenva quadrangle lies in Kentucky, Ohio, and West Virginia, between parallels 38° 30' and 39° 0' and meridians 80° 30' and 81° 30' and is a part of bourbon county. 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.

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

In its geographic and geologic relations the Kenva quadrangle is a part of the Appalachian province, which extends from the Atlantic Coastal Plain to the lowlands of the Mississippi Valley. The Kenva quadrangle lies on the western side and just north of the center of the great limestone 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, 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 place much metamorphosed; those west of this line lie nearly flat and are almost entirely unaltered. The few faults that break the regularity of the structure are so broad and open that they produce scarcely 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 small and small ranges bearing ridges and valleys. To the north and west of the Allegheny Plateau, which is now known as the Appalachian Plateau, the different parts of this plateau have received distinct names. The plateau is not easily seen in any area as well as the Kenva quadrangle, but when viewed broadly in comparison with the lowlands of the Mississippi and the Ohio and the alternating ridges and valleys of the Appalachian Valley on the east it is readily perceived.

THE APPALACHIAN PLATEAU.

Relief.—The Allegheny Plateau as a whole is a broad flat mesa, the surface of which slopes more or less uniformly northward from its southern escarpment to the lowlands of the Mississippi Valley. This surface is lowest at its northern margin, where it merges into a broad plateau of the Ohio and the Appalachian Valley.

The plateau differs widely in character in different parts of the province, its nature depending on the character of the underlying rocks, the movements that have affected them, and the drainage consequent on both of these factors. That part of it which lies in the southern part of the quadrangle is well preserved, and its surface has 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 higher 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 Scolopie peneplain, from its typical development near Schooley Mountain, New Jersey. The top of many ridges in Pennsylvania, especially those in the valley of Allegheny and Monongahela rivers, represent another level that stands at a lower level. This lower peneplain has been named the Harrisburg, on account of its excellent development near Harrisburg, Pa. A similar low level has also been noted in the Allegheny province, which 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 Wheeling upland from its excellent development near Wheeling, W. Va.

Drainage.—The Appalachian Plateau, except its northeastem part, is drained by western tributaries in the northern 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 present streams north of the Allegheny Front have their sources in the St. Lawrence or its tributaries, and that the advancing ice sheet acted as a barrier, closing this northern outlet and establishing the drainage lines shown in figure 2. A few of the westward-flowing streams in the southern half of the province have their sources at the summit of the Ridge and flow westward across the Allegheny Valley and through the plateau into the Mississippi system.

Stratigraphy.—Most of the consolidated rocks of the plateau are of Carboniferous age and are exposed about the margins of the plateau and also erode has cut most deeply, and they extend under the Carboniferous rocks throughout the plateau. The Carboniferous strata are subdivided into the Following: the Mississippian below, the Pennsylvanian in the middle, and the Permian above. The Pennsylvanian and Permian series are coal bearing; the Mississippian series are coal bearing. The Mississippian rocks 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 Mississippi rocks include some thin 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 lines of which trend northeastward from Pittsburgh across West Virginia to the Ohio at Huntington. The rocks of the upper part of this line generally dip northward; those of the lower part of this line also dip northward. 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 Kenva quadrangle is situated at the extreme southwestern end of this trough.

TOPOGRAPHY.

Drainage.—The topography of the Kenva quadrangle is due to the long-continued erosion of rocks of different degrees of hardness. This erosion has been accomplished by streams that drain the plateau.

The present drainage of the general region, including that of the Kenva quadrangle, is chiefly inherited from an ancient drainage and exhibits many features that indicate maintenant in the structure of the land by its pronounced dendritic character, which, with deep trenching, has produced a rugged topography but comparatively slight relief. Erosion has not yet revealed the divides, which are generally rather sharp. Where the present streams do not follow the ancient channels these modern channels form beds of flat country, of which the "Flats" near Ashland are a conspicuous example.

The Kenva quadrangle is drained either directly or indirectly by the Ohio River, which crosses its northeastern corner. The chief tributaries of the Ohio are Big and Little Sandy rivers and Tugwater Creek and Tugwater Creek, the last-named flowing across the extreme northwest corner of the area. Tugwater Creek, entering from the Huntington quadrangle on the east, flows about 10 miles in a southeasterly course in West Virginia and empties into the Ohio at Huntington. Practically all the smaller streams flow into Big and Little Sandy rivers. One 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, which 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 the Big Sandy and Kentucky forks. After flowing northwestward 27 miles it joins Ohio River at Catlettsburg. Lewis Fork is often referred to as Big Sandy River.

Drainage.—For an intelligent understanding of the present arrangement of the drainage of the Kenva quadrangle it is necessary to go back 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, Tugwater Creek flows nearly parallel to the Ohio River from its source, and the divide between it and Big Sandy River on the west is not more than 2 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 the western sides of the valley is not nearly so striking as it is the difference across Tugwater Creek.

The basin of the Big Sandy and East Fork of Little Sandy are asymmetrical, for reasons that will be given later (p. 8). In the basin of Tugwater Creek, which flows across the extreme western part of the quadrangle, the lack of symmetry is not apparent, but the asymmetry is opposite in kind to that in the basins of Big Sandy River and Tugwater Creek. (See fig. 6.)

BELIEF.

The Kenva quadrangle lies near the eastern side of the Appalachian Plateau, in the lowland section, which constitutes a section of the Allegheny Plateau, in West Virginia, southwestern Virginia, and eastern North Carolina. The
that reach well up to their heads. The relief though not great is pronounced, ranging from about 150 to 300 feet.

The lowest point in the Big Sandy River lies on a stream that is the main tributary on the Ohio and Little Sandy rivers and on the Typos Creek. The flood plain of the Big Sandy River lies at a lower level than the Ohio and Little Sandy rivers, which are the main tributaries on the Ohio and Little Sandy rivers and on the Typos Creek. The flood plain of the Big Sandy River has an elevation of 600 feet at the south edge of the Ohio and Little Sandy rivers and 500 feet where it enters the Ohio near Latrobe. It thus has a gradient of 1.1 feet per mile within the quadrangle. This is slightly less than the gradient of the Ohio and Little Sandy Rivers.

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, uniformly 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 and Little Sandy rivers lies with one half to three-fourths of a mile. The flood plain of the Little Sandy from Grayson to Argillie 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 Putritesville formation. The flood plains of both Big and Little Sandy rivers are termed, the vertical distance between the terraces on the Big Sandy River ranging from 8 to 10 feet.

Right 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 locations in the Kenova quadrangle. Back of Ashland, for example, is a district known as the "Flatswoods." This cut can readily be 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 aerial valley map so 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 valleys to their mouths, as in the valleys of the present streams. In Tight's account of the "Flatswoods" area and of soy Valley, in the Huntington quadrangle, on the east, the gravel and silt deposits are indistinctly described.

SUBWATER. -- The largest town is Ashland; Celintuck, the county seat of Boyd County; Louisa, the county seat of Lawrence County; Grayson, the county seat of Carter County; and Kenova, on this side of the river. It is doubtful whether the combined population of the larger towns equals the strictly rural population.

Forestry. -- The area is almost wholly forested. The flood plains of the streams are subject to periodic overflows and hence are very fertile. In the valley 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 cultivated and the usual garden crops consist of 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 last century. The construction of which is facilitated by the softness of the rocks.

Roads. -- Although the country is comparatively rugged, it is traversed by a few country roads, especially those of which the construction is facilitated by the softness of the rocks. In Boyd County the roads are notably well kept, and there are many miles of "pikes," or macadamized roads.

Rivers. -- The main line of the Chesapeake & Ohio Railroad enters the area from Huntington, W. Va., crossing the Ohio River at Ashtabula and crosses the northwestern part of the quadrangle. The Ashland Coal & Iron Railway runs from Ashland to Canton; 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 Tribetown division and crosses the Ohio at Kenova. The Baltimore & Ohio Railroad has a terminal at Kenova. The Eastern Kentucky Railway, a short line constructed several years ago, runs from Webbville, Lawrence County, to Ervin, Greenup County, where it joins the Chesapeake & Ohio Railway.

River crossings. -- Big Sandy River has been under improvement by the United States Government since 1878. It is the Kenova quadrangle: three locks have been built on this river below Louisa, one on Tug Fork at Sulphur, and one on Levisa Fork at Clayman. The river will thus be made navigable the whole year without danger of much rain, and the present canoes will be largely augmented. The development of the thinner canals 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 fish, are navigable during only a short season.

Relation of culture to topography. -- The larger towns are on the railroads, which naturally have been built along the easiest routes. The river valleys are the centers of population and the railroad population live in the stream valleys, because most of the roads have been built along these valleys and because the only level land in the area are the flood plains themselves. The flood plains in the valleys have generally been built slightly above the valley sides, so that evenshaws caused by the spring frosts. Though in a broad way they follow the gradations of the streams rather closely, yet they run up and down across many in their courses. So as the area is much dissected by streams many of the other roads cross such divisions, and in order to pass over the highest points of each are difficult. Ridge roads are above or near the ridge--low and wooded, and poorly kept, but for five people live on the ridge.

The valleys are generally cultivated, but the hillsides have not been indicated nor mapped. The soil of the quadrangle in Carter County, for example--even steep hillsides are planted in tobacco.

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. The rocks are sandstone, sand, shales, limestones, coal beds, iron ore, clay, and glass sand. Their total thickness is between 1900 and 1900 feet. The sedimentary rocks belong to the Appalachian system, except the imperfectly consolidated gravels of the river terraces, which are of Pliocene age, and the alluvium of the flood plain, which is of Recent age. The Mississippian series of the Carboniferous system are represented in the rocks of this quadrangle. Each series contains about twenty formations, which in turn are subdivided into members, the various subformations being distinguished by their lithologic character and their fossil content. The workable coals of the area are found in the Pennsylvania 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. None 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 geological 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 made by persons inexpert to make such determinations; and third, unless measurements are made with steel tape errors in determination of thickness of beds are likely to occur. 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 generally unfaulted 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.

THE RECORDS OF DEEPWELL SHOWS, beneath the shales and sandstones at the base of the Mississippian series, a body of more or lesscolloidal sand, 500 to 600 feet thick, at the base of which occurs a green oil-bearing sand called the England 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 England "sand" are Ohio shales. In some wells the England is underlain by a few feet of black shale, but in others the underlying rocks are more or less colloidal. It is probable that the wells drilled in the southern part of the area (see well sections on the color-plate section sheet) reached Silurian limestones. 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 21-foot section at the base of the section (see p. 5) 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 rocks are not over 75 feet thick.

CARBONIFEROUS SERIES. MISSISSIPPIAN SERIES.

The Mississippian series includes the Maxville limestones 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 further south. The Berea sandstone and the Summerville ("Beaver") sandstone near the base of the series consist of oil and gas bearing sandstone and shale from 60 to 300 feet in thickness. Although these formations do not outcrop in the quadrangle, they have been identified by cores at various points in the northwestern part of the quadrangle. In several of the well sections the Berea sandstone has been designated limestones in the driller's records, but it should probably have been called shales near the surface, as a true limestone at the base of the Berea sandstone is not known.

Upon the Summerville sand lies a rather thick body of shales containing a few thin beds of sandstone, presumably the Cuyahoga shales of Kentucky. In the western part of the quadrangle this sand ranges in thickness from 370 to 470 feet. In the wells in the central part of the quadrangle, where the Big Sandy River is about 10 miles above the City (Big Sandy 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 out over about 400 feet.

* Pauker, F. A. Jour. Geol., vol. 17, 1909, pp. 185, 190, 191.
In the wells in the northern part of the quadrangle there is a porous sandstone beneath the Maxville limestone. It places it a foot above the same bed, commonly thin but 40 feet thick in the Joshua Kelly well (well section No. 1, on column-section sheet). At Straight Creek and on Ossiny Fork, the sandstone was recorded at this horizon, but the Horsemound creek well (No. 18) shows 85 feet of it. In the Blythe Creek section (well No. 19) 370 feet of white sandstone and conglomerate are present at this horizon, and undoubtlessly part of this thickness is the upper sandstone of the Logan formation. The remainder may be sandstone of Pennsylvania age, the interbedding of Maxville limestone being locally absent, or it may be limestone erroneously called sandstone. The sandstone is generally absent from the southern part of the quadrangle, but the map (see No. 3, 18) 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 Genevieve well, near Gracysville, no typical sandstone is recorded from the section. The complete record, which seems to be 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.

In the record of the deep well near Central City, W. Va., the sandstone, overlying by 28 feet of shale, is recorded in 177 feet thick, showing that its extent was greater beyond this quadrangle. The well was drilled in 1880. The record given above was furnished by Thomas W. Harvey, owner.

The broken and ragged character of this sandstone points out a sand. It represents the Big Bear sandstone (the Big Finn group of the Kentucky Geological Survey) and the Blackhawk and Logan formations of the Ohio Geological Survey. Its thickness ranges from 70 to 370 feet.

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In the wells in the northern part of the quadrangle there is a porous sandstone beneath the Maxville limestone. It places it a foot above the same bed, commonly thin but 40 feet thick in the Joshua Kelly well (well section No. 1, on column-section sheet). At Straight Creek and on Ossiny Fork, the sandstone was recorded at this horizon, but the Horsemound creek well (No. 18) shows 85 feet of it. In the Blythe Creek section (well No. 19) 370 feet of white sandstone and conglomerate are present at this horizon, and undoubtlessly part of this thickness is the upper sandstone of the Logan formation. The remainder may be sandstone of Pennsylvania age, the interbedding of Maxville limestone being locally absent, or it may be limestone erroneously called sandstone. The sandstone is generally absent from the southern part of the quadrangle, but the map (see No. 3, 18) 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 Genevieve well, near Gracysville, no typical sandstone is recorded from the section. The complete record, which seems to be 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.

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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 the classification of the coal members, is equivalent to the Conemaugh in the Allegheny. It is a coaly bed, differing from the Pottsville by a difference in lithologic character, and its fossil plants also are different from those of the Pottsville.

The Allegheny formation includes the most important part of the area, including the portion of the Allegheny basin. It is a coaly bed, differing from the Pottsville by a difference in lithologic character, and its fossil plants also are different from those of the Pottsville.

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No. 9 of the Kentucky Survey, but instead of coming within the Mahoning sandstone, where coal No. 9 was placed by Cronnell, it occurs just below it, as in Pennsylvania.

The sandstone which is most abundant in the area is that seen along the tracks of the Norfolk & Western Railway in Wayne County, V. A., from the mouth of the Big Sandy to the river, that is, along the private right near the mouth of Grapton Creek. A hand-level section exposed in the bluffs just back of this town of Kenova is as follows:

<table>
<thead>
<tr>
<th>Section of Mahoning Formation between Kenova and Oakgrove.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandstone (Subsidiary or Overcoat?)</td>
</tr>
<tr>
<td>Interbedded</td>
</tr>
<tr>
<td>Lignite, Coal, and Underclay (Subsidiary)</td>
</tr>
<tr>
<td>Sedimentary Limestone (Mahoning sandstone)</td>
</tr>
<tr>
<td>Limestone, sandstone, and shale (Upper Mahoning sandstone)</td>
</tr>
<tr>
<td>Limestone, sandstone, and shale (Mahoning sandstone)</td>
</tr>
</tbody>
</table>

The Mahoning sandstone is a well-stratified, sandstone 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 erosion unconformity at or near its base and the Upper Freeport does not show. This coal, however, is present along the hillside further to the south, near Columbia, and is also outcropping in more than a few instances. The outcrop is seen on the east side of the Big Sandy River in this area approximately 300 feet thick. This is not the maximum thickness of the formation, as the Mahoning sandstone is thicker than the above figure (46 feet) east of Kenova and along Twelpoole Creek.

The thickness given for the lower part of the Conemaugh below the upper part of the Conemaugh formation 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 coal measured in the Conemaugh quadrangle is about 46 feet, as is shown in the figure that the Bureau of the Chief Geologist in Washington has found to be the thickness of the sandstone in the area. This is the most abundant part of the Conemaugh sandstone, and it is present here in such an area.

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

In accordance with L.C. White’s correlation, the coal bed at the top of the hills east of Lett, W.Va., near the mouth of Grogan Creek, is accepted as the Pittsburgh coal, marking the base of the Monongahela formation. 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 is very massive. The residual surface is composed of redshale and sand beds with beds of massive sandstone.

Location.—The Kenova quadrangle lies outside the glaciated area, but it contains deposits that are held to be of Pleistocene age. In the "Thurmond" area, near the mouth of the New River, the hill-tops are flat and do not rise more than 700 feet above sea level. These flat land areas are covered with deposits of sand and gravel and with quartz and chert beds, the largest bed being 12 inches in diameter. Deposits of sand and gravel similar to those of Ashland occur along Big Sandy River and some of its tributaries, as indicated on the map. Similar material occurs along Little Sandy River, and though the correlation of the deposits has not been attempted it is probable that the geology along the Little Sandy, when traced up the Ohio, will merge with that along the Big Sandy. Sti lithiastics with quartz pebbles has been discovered at lower altitudes along the Little Sandy, indicating the depth of glacial advance before the present period of deglaciation. The sequence of these changes is stated under the heading “Geologic history.”

Deposition.—These 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. The material derived chiefly by the peculiar tectonics characteristics of some of the transported river debris, namely, the rounded pebbles of Kamekuda thick flint in the valley of Keener near the mouth of the New River. This material, about whose source and identity there is no question, has been found in Toney Valley and back of Ashland, thus proving that the Big Sandy rivers 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 gravel is apparently being cut out and redeposited at each period of high water.

Beds.—The alluvium of the stream is the youngest bedded deposit in this area. It is composed 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 as well defined as those of the flood plains average three-fourths of a mile; on Big Sandy and Little Sandy rivers it is narrower. Most of the deposits are terraced and in this area, 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 gravel is apparently being cut out and redeposited at each period of high water.
this way, for the intervals assumed are not uniform throughout the region, especially in areas underlain by the formations above the Home Wood. Furthermore, the attitudes were deter-
minal with assay determinants which are subject to sudden variations and have to be checked repeatedly by spiritual determinations. In spite of these sources of error, it has been thought advisable to use certain structure lines. These show the generalized surface formed by the top of the Home-
wood sandstone and, less precisely, the level of the underlying and overlying formations. They may be generally taken as equal to contour intervals, but where, in this area, the beds are not of uniform thickness it may be more. This mode of procedure is necessary in the structure of the area, enables one to estimate the depth to the top of the Home-
wood sandstone where it is below drainage level. For example, near Zebulon, the 300-foot contour line was drawn. The elevation of Zebulon is 380 feet; therefore the top of the Home-
wood sandstone should be at a depth of 180 feet. The distance 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 Keokuk quadrangle lies at the southeast end of the great trough formed by the coal-bearing rocks of the northern Appalachian field. The axis of this trough extends southeast-
ward from a point near Pittsburgh, Pa., crossing Ohio River a little east of the town of Zanesville, Big Sandy River 8 to 10 miles above its confluence with the Ohio. The axial line follows Big Sandy River southwest for 2 miles and gradually curves to the east until it reaches central West Virginia and thence southwestward becomes gradually shall-
ower, picking upward within this quadrangle along a line practically coincident with the line 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 are southeasterly. The dip of most of the area is 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 Clarksburg the upper part of the Pottsville formation is exposed at railroad level, but across Big Sandy River the lowest rocks exposed in this area dip with the member of the Conemaugh sandstone of the Conemaugh formation; thus there is a dip of more than 50 feet to the mile between these points. Near Willow and southwestward in 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 Logan, but it narrows westward until at Blaine it is not more than a mile in width. West of this town the beds curve gently northward around the head of the basin. The dips in the ridge south of Logan are fully 100 feet to the mile. Near Adams and on Right Fork of Blaine Creek the rocks in place dip 300 feet to the mile. The steeper dips are confined to the mouth 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°, but in some places the rocks are covered, but their throws are probably not great enough to affect the structure contours materially. A few minor folds are present in the main syncline. In the region near Iredell and Ossie, Lawrence County, the Home-
wood sandstone thickness rapidly toward the west causing a slight arch in most of which the sandstone is somewhat thinner and allows a slight depression. West of Cheers Creek, near Elliott County, the structure seems to be rather irregular. This may be more apparent than real, and the irregularity in the contacts may be due to the fact that they are based on flat 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 Cincinnatian arch. West of this quadrangle the beds grad-
ually dip to the axis 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 Keokuk quadrangle were laid down an interior sea occupied a large part of North America which extended from the Gulf of Mexico to Canada and from the Blue Ridge westward beyond the Mississippi Valley. The land east of this great sea was comparatively low. Most of the exposed rocks of pre-Cambrian time are schist and igneous rocks, the wearing away of which furnished the sediment deposited in the sea. The most prominent of these sediments are the present land masses in the region then covered by the sea. The surface separating the older schist and igneous rocks from the younger derived from them has been by some writers termed a basincormal.
seem to the land mass or a thrust of the land mass due to construction may also influence 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 the original character of the sediments has been partly obliterated. Further west, in the great Appalachian region, 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 Kanensa quadrangle is situated.

INTRODUCTION OF SEDIMENT.

The time of the initiation of the sedimentary basin is unknown. The early 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 sediments were 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 exposure 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 series of sediments in other parts of the Appalachian province, which are believed to have been intruded since the post-Carboniferous deformation, it seems reasonable to conclude that the evidence of the period 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 has therefore been the rarest event in the geologic history of the district. Nothing has been discovered to indicate whether the intrusion was connected with surface uplands, but probably it was not.

MINERAL AND CENOSOA EXPLORATION.

Since the emergence of the land and while deformation was proceeding, development of the surface has been in progress. The land has been worn down, and it is believed that the river systems were in a general view from any high point in the area indicate the position of an old paleosurface. This paleosurface was probably formed during late Jurassic or early Cretaceous times, when the region was in a state of comparative quiescence. That the region has been slowly elevated seems evident from the youthful character of the streams. Many of the small valleys are gorges, and the larger streams, like the Big Sandy, are interesting themselves in their present flood plains.

FLUVIAL DEPOSITION.

River deposits. — It has been stated that no part of the Kanensa quadrangle is under a glacial boundary, but that it contains unapparent deposits of Pleistocene age. These are low and high level gravelly deposits along the Ohio and the Big Sandy and back into the adjacent parts of the Kanensa quadrangle, which 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, Tipton, and others.

According to Campbell, in preglacial times the Ohio and the Kanensa flowed in the high-level valleys in which the alluvial gravelly deposits now rise. During the glacial epoch ice dams were formed at Ashland and near Milton, in the Milton quadrangle further east. These dams poured the water, which ran 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 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 course of some of the major drainage channels was different from that of the present courses. Those streams which flowed through the Kanensa quadrangle were quite different from the present courses. It is conclusively proved that Kanensa River, which now runs northward about 2 miles from Kanensa State and flows into the Ohio at Point Pleasant, once flowed westward across the Huntington quadrangle through Tioga Valley, along or near the present Ohio and Kanensa Rails. Ining the Kanensa 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 "Platforks" district, southward of Ashland. The smaller streams in the quadrangle, the ancient streams probably continued westward in approximately the present course of the Ohio, turning northwest at Wheeling. The Kanensa River, the Little Kanensa River, the Big Sandy River, and the Ohio River all flowed in the same direction from the present course of the Ohio, turning northwest at Wheeling. The Kanensa River, the Little Kanensa River, the Big Sandy River, and the Ohio River all flowed in the same direction.

The basin of the East Fork of Little Sandy River and, either wholly or in part, that of Little Sandy River itself occupy the area now included in the Kanensa quadrangle, and the banks of Little Sandy River may be traced upstream to the head of Big Sandy, and is also found along certain side streams, as indicated on the usral geology sheet. The Kanensa quadrangle contains the floors of many ancient valleys through which streams or streams long ago ceased to flow. Thus the Big Sandy has not always flowed in its present course, but has frequently meandered much more than it does at present. For example, the presence of river gravel along the courses of Deck Creek and Miller Creek, Wayne County, and the Big Sandy 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 Kanensa quadrangle it is necessary to go beyond its limits. The asymmetrical character of the drainage basin of Twelvemile Creek, in the Huntington quadrangle, on the east, has been discussed by M. R. Campbell. This stream flows near the southern boundary of the basin, and the divide between it and the Big Sandy River, on the west, is only approximately one-fourth as far away as is the divide between it and Gaynor Creek. The stream courses are similar in the basin of the Big Sandy, in part of its course in this area. Briefly, Campbell describes this lack of symmetry to an uplift of the land on the north, according to 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 out streams and laterally more rapidly than those flowing from the opposite side of the basin, and thus to erode the divides on the east and push toward the area in between. The basins of the Little Sandy and its East Fork are asymmetrical. The reasons for this will be given subsequently. In the basin of Tygara Creek, which crosses the extreme western tributary of the quadrangle, the lack of symmetry is notable but is opposed to it in the basins of the Big Sandy River and Twelvemile Creek.

It has already been stated that structurally the northern part of the Appalachian Plateau, of which the Kanensa quadrangle forms a part, is a broad, shallow trough, the beds on either side of which dip toward the axis, partly as a result of uplifts about its margins. Campbell has described a later uplift, on the east, of the lack of symmetry in the drainage basin of Twelvemile Creek and Mill River, in the Huntington quadrangle, and with these may be included the basin of the Big Sandy River, in the Kanensa quadrangle. The tributaries of Tygara Creek from the east are insignificant compared with those from the west. An eastern tributary is so small that it remains unseen. Lack of symmetry in a divide is well shown in the basin of Big Sandy River and Little Sandy River. In view of the explanation given above for the asymmetrical basins of Big Sandy River and Twelvemile Creek, it is evident that an uplift on the west may sufficiently account for the lack of symmetry in the basins of Big Sandy River and Twelvemile Creek.

The basin of the East Fork of Little Sandy River and, either wholly or in part, that of Little Sandy River itself occupy the area now included in the Kanensa quadrangle, and the banks of Little Sandy River may be traced upstream to the head of Big Sandy, and is also found along certain side streams, as indicated on the usral geology sheet. The Kanensa quadrangle contains the floors of many ancient valleys through which streams or streams long ago ceased to flow. Thus the Big Sandy has not always flowed in its present course, but has frequently meandered much more than it does at present. For example, the presence of river gravel along the courses of Deck Creek and Miller Creek, Wayne County, and the Big Sandy at one time in a great meander east of its present channel.

The movement of the currents and streams thus being mainly with the dip, erosion, surficial and possibly underlying, 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 elongate their tributaries flowing with the dip more rapidly than those flowing against it, and consequently to push the divides between the streams 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, the surface is essentially toward asymmetry. This explanation does not postulate an uplift later than which produced the main Appalachian folding.

ECONOMIC GEOLOGY.

The mineral resources of the Kanensa quadrangle are coal, iron ore, plastic clay, talc, hematite, iron ore, building stone, glauconite, salt, oil, and gas. The relations of the important economic beds and other stratigraphic value are given in the columnar-section sheet on the

ORIGINAL TEXT
General characteristics. - Workable coal beds are scattered throughout nearly the whole thickness of mucks exposed in this quadrangle and include the Pottsville coal at the base of the Muskingum formation. The names, positions, and relations of these coals are given in the generalized section on the columnar-section sheet.

The coal beds 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 shales along coal-crack layers and hence may be classed as semiblack coals. In general they are unsuitable for coking, but some of them after washing give fair satisfaction. The Lower Kittanning coal (No. 8 of Kentucky Survey), which has been mined for several years at Window, 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 even coked with a small amount of some standard cooking coal. All the coals give excellent results when used for ordinary stoves and domestic purposes. Nearly all beam transportation and stocking. The Middle Kittanning coal (No. 7 of Kentucky Survey), which ranks with and is stratigraphically equivalent to the Yellville coal of Ohio, is used by the Ashland Iron & Mining Co. in its blast furnaces.

Ordinary bituminous coal is associated with the splinty variety in most of the coal beds. It is finely interstratified with a shaly 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 in the soft bituminous variety, and the upper two benches of the harder splinty type.

Certain beds in small areas contain benches of cokemaking coal; for example, the coal now being worked by the Kentucky Coal & Coke Co. at Hough and Hannuwell. It is reported that the cokemaking layers are erratic in their occurrence. In Elliott County, near the western edge of the quadrangle, in the hills west of Stephenson and north of field, there is an important outcrop of a thin coal bed which will work. On the hilly areas not on the bank of the Ohio River, the lower bench of the coal has been worked in a small way. The coal on Brush Creek in Lawrence County also contains a cokemaking bed. Besides these beds there are others occurring in the region, notably the bench described above, which would seem preferable to them with the cokemaking coals. Certain layers in the Lower Mercer coal (No. 7 of Kentucky Survey) of Lewis Fork, in Lawrence County, have thin beds of bituminous coal which has been worked in a small way. The "Little Cannon" bed, lying 1.0 feet below the Lower Mercer coal, contains a bench whose analysis shows 92 per cent of coal in place of cokemaking.

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 519 of the U. S. Geological Survey, on the economic geology of the Kentucky quadrangle. For convenience in describing the coals and giving their relations the quadrangle is divided into five districts, as shown in figure 4, and all the coal beds are described according to their occurrence in these districts.


district

This coal is known as Tortice coal as the "Little Cannon" 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 cokemaking coals. Sections measured near Tortice light (figs. 5, sec. 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-third of an inch near the bottom. The cokemaking 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. It appears to resemble splint coal rather than true cokemaking. Perhaps the chief value of this bed in the future will be derived from this cokemaking band. It separates fairly readily from the bituminous coal and is trimmed and broken in large blocks. The coal is moderately fusible and gives a yellow-brown streak. Its cleavage is lamellar and its fracture is angular to subangular. Analyses are given below.

Analyses of "Little Cannon" coals from Lewis Fork.

<table>
<thead>
<tr>
<th>Analyses</th>
<th>Water</th>
<th>Volatile matter</th>
<th>Fixed carbon</th>
<th>Ash</th>
<th>Sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.8</td>
<td>92.17</td>
<td>6.12</td>
<td>0.66</td>
<td>0.61</td>
</tr>
</tbody>
</table>

1. Sample from Mercer's coal, Lawrence County, Ky. (As reported on the eastern side of the Kittanning coal, from its occurrence near the Ashland furnace.)

2. Sample from coal bed near Lewis Fork, Kentucky Survey, from its occurrence near the Ashland furnace. Sulphur is probably somewhat higher.

3. Sample from coal bed near Lewis Fork, Kentucky Survey, from its occurrence near the Ashland furnace. Sulphur is probably somewhat higher.

4. Sample from coal bed near Lewis Fork, Kentucky Survey, from its occurrence near the Ashland furnace. Sulphur is probably somewhat higher.

5. Sample from coal bed near Lewis Fork, Kentucky Survey, from its occurrence near the Ashland furnace. Sulphur is probably somewhat higher.
Below the lowest 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 dry.

UPPER MERRER COAL (NO. 4 OF KENTUCKY DEPOT).

Extract coal development.—The Upper Merrer coal is 15 to 75 feet above the Lower Merrer coal in the valley of Big Sandy River. It is locally known as the “Firefoot vein” but is sometimes called the “Big vein.” The area of its maximum development is in the basin of Lick Creek and between Lick Creek and Levin Fork. It has been prospected between Thomselle Creek and Levin Fork, where it is 50 to 60 feet thick, and in this area it is about 90 feet above the Lower Merrer coal. Prospects have been opened on it on Dunham Branch, east of Thomselle Creek, where it is also workable.

FIGURE 7.—Sections of Upper Merrer coal.

Character.—Sections of this bed are shown in figure 7. The section measured at the head of Lower Givin Creek differs strikingly from the remaining three, obtained in test drifts between Lick Creek and Levin Fork, just west of Terchilt. The upper 20 inches of the coal measured on Lower Givin Creek appears to be much broken. The lower bench, which averages about 15 inches where seen, is separated from the upper by a sharp 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 Dunham Branch, where the upper bench is slightly thicker than either of the two lower.

In the hills along Thomselle Creek this coal probably averages between 3 and 4 feet. West of Levin 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 2 inches to 5 feet. West of Lick Creek, about one-half mile north of the mouth of Blauhans 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 semi-cannel coal. The upper of the lower two benches appears to be the same in all drifts, but in places the lower may probably be worked with it. Locally, however, the lower bench is badly split by partings. In many places between Levin and Tagforka these benches are workable. As a rule the coal of the shale is splint, but in some places the massive Homewood sandstone member extends down practically to its top. The following analysis shows the chemical character of this coal:

Analyses of Upper Merrer coal.

A thickness of 4 feet 10 inches to 5 feet is reported from other country banks near Courthouse Creek. In some places, at least, this coal is sufficiently thick and free from impurities to make it valuable, but in others it is thrown up by clay and bone partings that it will have little value except for country trade.

LOWER KITTINGHAM COAL (NO. 6 OF KENTUCKY DEPOT).

Though the Lower Kittingham is not so widely worked, it is reported to be workable in many places near Blauhans Branch. It has been opened and worked on a small scale and is used chiefly in the vicinity of the town of Courthouse Creek. The coal in this vicinity is of good quality, ranging in thickness from 2 to 3 feet.

UPPER FREIGHT COAL.

Extract coal development.—In the valley of Big Sandy River the Upper Freight coal occurs in many places. The rise of the beds up the river brings this coal above drainage level at Zenda, where it has been opened on both sides of the river. Just south of Zenda the coal measured 27 inches (fig. 8, section 1). The Upper Freight coal has been opened and worked on both sides of the river near the mouth of Mill Branch and at Garnette, where it ranges from 2 to 3 feet in thickness. Southwest of Camps 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 Homewood Fork, where it is reported to be 30 feet thick near the mouth of Fuller, owing to the rise of the bed, 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.

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:

General section of Upper Kittingham coal near Coolsprings, Ohio.

<table>
<thead>
<tr>
<th>Sandstone</th>
<th>Coal</th>
<th>Stone</th>
<th>Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

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:

General section of Upper Freight coal near Coolsprings, Ohio.

<table>
<thead>
<tr>
<th>Sandstone</th>
<th>Coal</th>
<th>Stone</th>
<th>Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

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:

General section of Upper Kittingham coal near Coolsprings, Ohio.
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 2 to 25 feet. The massive sandstone that overlies the very bottom of the coal, and that gives the coal ample coal 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 making.

**Middle Kittanning coal** (No. 4 of Ohio Survey).

**Extant and development.**—The Middle Kittanning coal, which is the chief member of the Kittanning group, is present in the Hanging Rock Basin, in the western part of the state, and in the Allegheny basin, in the eastern part of the state. The Lower Kittanning coal is present in the Allegheny basin, in the eastern part of the state.

**Upper Kittanning coal** (No. 5 of Kentucky Survey).

**Extant and development.**—The Upper Kittanning coal occurs in the Allegheny formation and the coals in the Allegheny formation and the coals in the Kittanning group, and in the east of the state, in the Allegheny basin, in the eastern part of the state.

**East Fork of the Little Sandy River District, including Ohioville and Sycamore.**

**Extant and development.**—The stratigraphic position of the Quakertown (?) coal bed is clearly indicated in the section of the upper Kittanning and the upper Kittanning coal in the Allegheny basin. It is parallel with the valley of the Allegheny and the Ohio Rivers, and it is parallel with the valleys of the Ohio and the Allegheny Rivers.

**Lower Kittanning coal** (No. 6 of Kentucky Survey).

**Extant and development.**—The Lower Kittanning coal occurs in a broad area along the Allegheny and the Ohio Rivers, and it has been proved to be of workable thickness in several places. It is parallel with the Allegheny and the Ohio Rivers, and it is parallel with the valleys of the Ohio and the Allegheny Rivers.

**Upper Kittanning coal** (No. 4 of Kentucky Survey).

**Extant and development.**—Although the Upper Kittanning coal outcrops in a broad area along the Allegheny and the Ohio Rivers, it has not been proved to be of workable thickness in several places. It is parallel with the Allegheny and the Ohio Rivers, and it is parallel with the valleys of the Ohio and the Allegheny Rivers.

**Middle Kittanning coal** (No. 1 of Kentucky Survey).

**Extant.**—The Middle Kittanning coal outcrops in the northern part of the state, in the Allegheny basin, and it is parallel with the Allegheny basin. Outside of this part of the Kittanning coal, it is parallel with the Allegheny basin.

**Extant and development.**—The Middle Kittanning coal outcrops in the northern part of the state, in the Allegheny basin, and it is parallel with the Allegheny basin. Outside of this part of the Kittanning coal, it is parallel with the Allegheny basin.
drainage-level also on Chaddock Creek. On Garnor 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 the townships of Nole and Greenup and south of Green County, follows the divide between Little Sandy River and East Fork.

Development.—Nearby, not bed of coal that has been found in the district has been worked or prospected. South-west of Ashland, in the hills bordering Hood Creek, it is prospected above and below a number of times. None of them are worked, and it is reported to be too "pockets" to be worked profitably. This coal has been opened at many points on Shope Creek near Clinton furnace. It disappears below drainage level at the point where the Cutlets Creek joins the Shope Creek, a mark of the middle or lower coal. The prospecting is mostly unimportant. The result of this search seems to be that large and important veins of coal exist near the edge of the belt, and are less than a mile thick, but the actual numbers of these veins is very large and much ore is in important mines. In some of the hills the coal is reported as completely worked out.

CHARACTER.—The sections in figure 11 give a fair idea of the thickness of this bed. It is 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 part generally ranges from 0 to 1 feet and rarely exceeds 1 foot. In most places the lower part is from half an inch to 2 inches thick. About 50 feet north of the city quarry this part is clayey and thin. Near Mile Bar coal thin stratum observed above these benches is of interest to point to conditions of deposition similar to those prevailing elsewhere, which changed after this clay was deposited, so that seam was broken and deposited again. As a general rule the upper part of this coal is not mined, for two or more reasons: first, it is irregular in thickness, second, it is likely to contain much sulphur and bone, and as it opens along the Straight Creek bed near Dustin, it can readily be seen from the river that the basaltic andesite is of secondary importance. As a result, the coal is of good quality, but the lower part is not of much value. The thickness in the hills on the east side of the town is about 3 feet thick, but the thickness in the hills on the west side is about 6 inches thick, not counting the bone partings. As a rule, the coal is 3 to 4 feet thick, but it varies from 2 inches to 2 feet thick. The coal is fair and poor bedding for the bed, as a whole being about 3 feet thick, the bone is not thick, and the coal is not as uniform as the coal in the hills on the east side.

The two lower benches are almost everywhere workable. They are mixed together, the lower being separated by a thin band of clay. The lower bench, which is less than 2 inches thick, is more or less broken, but the upper bench is about 2 inches thick and is more or less broken. The upper bench is about 2 to 3 inches thick, but it is not much broken, and the lower bench is about 1 to 2 inches thick, but it is broken. The upper bench is about 2 to 3 inches thick, but it is not much broken, and the lower bench is about 1 to 2 inches thick, but it is broken. The upper bench is about 2 to 3 inches thick, but it is not much broken, and the lower bench is about 1 to 2 inches thick, but it is broken. The upper bench is about 2 to 3 inches thick, but it is not much broken, and the lower bench is about 1 to 2 inches thick, but it is broken. The upper bench is about 2 to 3 inches thick, but it is not much broken, and the lower bench is about 1 to 2 inches thick, but it is broken.
of Kunia Creek. At the head of John Branche, this coal is thick enough to be workable, and it is spread over an area of nearly one square mile. The coal lies in a thin seam, about one foot thick, and is worked in a number of small collieries.

**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 is found in a number of small collieries along the Coal Fork of the Big Sandy River, in the hills north of the town of Brookville, in the hills south of the town of Beech Creek, and in the hills west of the town of Florence. The coal is found in a number of small collieries along the Coal Fork of the Big Sandy River, in the hills north of the town of Brookville, in the hills south of the town of Beech Creek, and in the hills west of the town of Florence.

The coal is found in a number of small collieries along the Coal Fork of the Big Sandy River, in the hills north of the town of Brookville, in the hills south of the town of Beech Creek, and in the hills west of the town of Florence.

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, but it is unlikely that it is 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 John Branche, in the hills north of the town of Willard, this coal is found in a number of small collieries along the Coal Fork of the Big Sandy River. It is found in a number of small collieries along the Coal Fork of the Big Sandy River, in the hills north of the town of Brookville, in the hills south of the town of Beech Creek, and in the hills west of the town of Florence.

**Houghsville Coal (No. of Kentucky Survey)**

**Extent and development.**—About Willard and north of Westville, the Middle Kittanning Coal has been opened and worked at many places. It outcrops in a number of small collieries along the Coal Fork of the Big Sandy River, in the hills north of the town of Brookville, in the hills south of the town of Beech Creek, and in the hills west of the town of Florence. It is found in a number of small collieries along the Coal Fork of the Big Sandy River, in the hills north of the town of Brookville, in the hills south of the town of Beech Creek, and in the hills west of the town of Florence.
of these two worked benches rarely reaches 45 inches and averages most commonly about 35 feet. From 40 to 45 inches of workable coal in the 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 benches.

The roof is a rule a fair coarse shale of irregular thickness, usually capped by a massive sandstone. The top of the coal is generally honeycombed and the upper bench is soft and full of charcoals; the lower bench is hard and splintery. This composition of the coal is indicated by the analyses given on page 19. These figures for the most part those of analyses reported by U.S. Geol. Sur., analyses 11 and 12 represent samples collected from Lost Creek and west of Dry Fork near Willard, Ohio, and may be taken as typical of the coal in this vicinity. The output of the Eastern Kentucky Railway mine at Paris is used exclusively along the railway for steaming and domestic purposes.

**COALS IN THE CONOMavr AND MONONGAHELLA FORMATIONS.**

**COAL BUS CREEK RASH MINES COAL OF WEST VIRGINIA.**

In the hills lack of Cassville a small coal, called by E. B. White the Mason coal, but regarded as the same as the Brush Creek coal of Pennsylvania, is found above the Monongah sandstone, the base member of the Conomavr formation. It is 2 feet thick. The same bed has been opened at points along Trumbep Creek in few miles above Circleville. It is a rule a thin coal, excellently qualified, and only stays small extent here presents its commercial exploitation. In the hills east of Lett, some of the food, has been opened, and is found to range in thickness from 1 to 4 feet. It averages about 2 feet and has a thin but strong arched overlying massive sandstone 20 to 20 feet thick. The section measured at one of the openings indicates the character of this bed (fig. 8, section 2, p. 10).

**CLAY AND SHALE. DIVISION OF THE ELMS.**

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 called flint clay.

On pages 4 to 6 there will be found a somewhat extended description of the beds from which these clays are found and the way in which they are classified according to their ages. The columnar sections show the position of the more important clay horizons.

**CLAYS IN THE POTOMAC FORMATION.**

**COAL BUS CREEK RASH MINES COAL OF WEST VIRGINIA.**

In the Potomac formation one clay bed stands preeminently above the rest as regards quality, extent, and thickness. This is the Scio coal, so named in the reports of the Ohio Geological Survey, less commonly known as the Logan clay. It has been extensively mined at Scio, Ohio. It occurs a few feet above the Maxville limonite, but this limonite and the clay bed immediately above it are very sparsely distributed in this quadrangle. On the economic-geology map the green line on Everson Creek, Carter County, at the western edge of the quadrangle and the one on Tygert Creek indicate the theoretical extent of this horizon above drainage in this area, also where it should be looked for. On Everson Creek a few feet of massive clay shows and has been worked, but it was reported as being 5 feet thick and as resting directly against the limonite on North Fork of Oldtown Creek and as being present without the limonite in the hills east of Everson Creek. West of Tygert Creek the limonite is reported as being generally present, but little seems to be known of the clay. This clay may be regarded as being 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 limonite, in the absence of benches, occupying a similar position above the underlying sandstones. Though

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Unnatural 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 limonite and earthy matter. These ores occur stratigraphically throughout the Carboniferous rocks in the coal measures, but the most important are found in the Allegheny and Potawatomi formations. The ores are all hedged deposits in the sense that they occur at fairly well-defined geologic horizons, which are persistent over broad areas.

LIMESTONE ORES.

Ores of the Vanport limestone member of the Allegheny series.

Position and extent. — The higher of the important limestone ores is that of the Vanport ("Hanging Rock") limestone member and is known locally as the "Estonite" ore. It is often called also the red limestone ore and in the Kentuckiana Geological Survey reports the ferriferous limestone ore. It occurs from 10 to 60 feet above the top of the Potawatomi, 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 further north and west. As it lies so near the base of the Allegheny formation, the structure contours drawn on the top of the Potawatomi formation serve equally well for this ore and for its associated limestone and pleistocene shale. Moreover, the green line on the economic geology map represents the outcrop of this formation. The main western contact appears in the hills between Little Sandy River and East Fork and continues south-westward to the point where Elliott, Lawrence, and Grant counties meet. The southern limit of the outcrop is south-eastward to and beyond Big Sandy River. In Boyd, Greenup, and Carter counties much of the ore at this horizon has been removed by erosion; in the eastern county, good ore was seen in Lawrence County near the town of Illini and in the hills between Adams and Prosperity.

Character. — Generally speaking, 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 mean that the ore of the Tuscarawas 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 is found within a few feet of the earthy surface 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 pocketed and the pockets may be several feet thick.

The limestone occurring at the outcrop is commonly brown or red, more commonly red, and as a rule is dense and coarse-grained. The red ore is the most valuable. The carbonate or malachite ore is dense, coarse-grained, and of a bluish green color, and is therefore known as the blue or green limestone ore. Most of the furnaces used the limestone ore, as the furnace iron was made from the limestone and not from iron from the carbonates. The following analyses illustrate the character of both the limestone and the sideritic phases of the limestone.

Analysis of one of the Vanport limestone member in Kentuckiana quadrangle.

<table>
<thead>
<tr>
<th>Element</th>
<th>Pounds per Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>23.4</td>
</tr>
<tr>
<td>MgO</td>
<td>0.45</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.006</td>
</tr>
<tr>
<td>SiO₂</td>
<td>0.15</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.06</td>
</tr>
<tr>
<td>FeO</td>
<td>0.03</td>
</tr>
<tr>
<td>SO₃</td>
<td>0.003</td>
</tr>
<tr>
<td>S</td>
<td>0.005</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.05</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistical characteristics</th>
<th>Analysis</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Ash</td>
<td>4.5</td>
<td>-</td>
</tr>
<tr>
<td>Carbonate</td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td>Limestone</td>
<td>95</td>
<td>95</td>
</tr>
</tbody>
</table>

The ores of the Vanport member are generally of high grade, but in some areas they are very coarse-grained and difficult to reduce. The ore contains from 70 to 80 per cent of iron, and the total iron content is from 75 to 80 per cent.

Characteristics. — The Vanport limestone is one of the most important iron deposits in the United States, and its ore is very high in quality. It is a very important ore deposit, and its value is due to its high grade and its proximity to the larger centers of population. It is a typical example of an economic geology map, where the ore is shown as a thin sheet, but in reality it is a series of narrow bands, which are continuous for long distances.

An extended description of the origin of the limestone ores will not be given here. Those who are interested in the subject will find Meade's description most interesting and suggestive. As a result of studies made in mapping this region during the summer of 1906, the writer reached certain conclusions which are summarized elsewhere.

BLOCK ORES.

Position and extent. — Most of the block ores are found in the Potawatomi 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 ore is 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 Potawatomi. The area in which the block ore occurs stretches along the western and southern edges of the coal measures, chiefly west and south of the line of outcrop of the Vanport limestone. The block ores are mostly confined to the territory west of Little Sandy River, and are not extensive in the eastern part of the quadrangle being but a small fraction of their extent in this part of Kentucky. The upper block ores are largely represented in this particular area, and the lower are more numerous in the eastern part. The lower block ores are more numerous in Kentucky, and the upper block ores are more extensive in the western part.

Character. — Like the limestone ore, the block ore is a very important ore deposit, and its value is due to its high grade and its proximity to the larger centers of population. It is a typical example of an economic geology map, where the ore is shown as a thin sheet, but in reality it is a series of narrow bands, which are continuous for long distances.
Most of the sandstone in this area is micaceous, much of it being phylitic, and as a rule it contains iron oxides. Its texture varies from very fine to very coarse, and a few of the quartz pebbles in the conglomerates exceed an inch in largest dimension. Much of this sandstone is friable, disintegrating readily in the hand and forming loose fragments that may not be observed in the buildings in Ashland and so far as known proved satisfactory. It would appear, therefore, that freshly cut blocks, even of this phylitic sandstone, are subject to disintegration.

In the Conemaugh formation the most important sandstone lies at its base and is known as the Mahoning sandstone member. This sandstone is very well exposed along Big Sandy River near its mouth, in both Kentucky and West Virginia. Near Keeneville it appears to be sufficiently thick bedded for dimension stone, and it is stored several miles south of Keeneville. A similar occurrence over exposes the Abingdon sandstone member. In the Conemaugh formation the most important sandstone lies at its base and is known as the Mahoning sandstone member. This sandstone is very well exposed along Big Sandy River near its mouth, in both Kentucky and West Virginia. Near Keeneville it appears to be sufficiently thick bedded for dimension stone, and it is stored several miles south of Keeneville. A similar occurrence over exposes the Abingdon sandstone member.

The Potomac formation contains many sandstones of eolian origin that are suitable for building stone. A prominent feature in the construction of the Norfolk & Western Railway along the Potomac River and as the Chesapeake & Ohio Railway on the Ohio River. These sandstones are exposed near Ashland and as a masonry class is found between the eastern boundary of the city and Clarksburg Road. These are used extensively for the construction of dwellings. Lower sandstones of the Potomac have proved locally valuable.

CLAY SAND.

Some of the sandstones in this quadrangle may be of sufficient purity to be used as building stone, but most of them appear to be too ferruginous for this purpose. Sand found locally in the soil plains may also prove suitable when washed. Such a deposit was reported at North Keene, Ohio. The Mahoning sandstone member of the Conemaugh formation and the Homewood and other sandstones in the Potomac formation are probably 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 Homestead sandstone near Mount Savage may repay careful prospecting for glass sand. In order to determine the fitness of sandstone or stone sand for glass making the material must be carefully examined. Black and chemical tests should be made to ascertain its content of iron, which, if present in too large quantities, renders the glass black or gray in appearance; the glasses also have a deleterious effect. Better than any examination is a practical test of the material. It should be remembered also that sandstone is too much iron for glass making, yields a suitable sand after crushing and washing.

SALT.

Many years ago salt was obtained from wells sunk on Big Sandy River near Zeldas. The old salt works have long since disappeared. South of Zeldas, near Cadiz, 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 are known to have produced some gas. Most of 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. It is not known whether the gas found in these wells is 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 in the right-hand section-abstract, where the producing sands are indicated.

COAL SMOKE.

Rogaland sand.—Some oil is disseminated through the Devonian system in the Rogaland sandstone a few hundred feet from its top. In some of the wells records this sandstone appears to be embedded in shale, as in the Clinton sand (No. 2 of the well sections), the Calcutt Creek well (No. 4), and the Pickering or Longmore sand (No. 5); in others it appears to rest upon or be associated with it. It is barely possible that the Rogaland sand of the southwestern part of the quadrangle, found resting upon or embedded in the shaly sandstone at the base of the Calcutt Creek and Clinton sands, but the presumption is strongly in favor of this correlation. The reason for the better display in the Clinton in the Calcutt Creek and Clinton springs wells the gas-bearing sand is underlain by considerable bodies of shale, which are not developed in the Clinton sands, whereas in the southeastern part of the area the underlying rock is limestone. Some wells (Nos. 6 and 19) the rock at the bottom of the Rogaland horizon is probably a limestone. In the wells where the Rogaland sand is underlain by shale (Nos. 2, 4, 5, and 5), rocks older than Devonian may be represented. This gas-bearing sand, regarded as the Rogaland, is in no well a thinrock; but at the John Bugs well (No. 12) and the J. A. Young well (No. 4) it is reported to be more than 100 feet thick. In both County, in the Big Bend field, none of the records shows a single well the oil-bearing stratum greater than 25 feet. This sand furnishes the high-pressure gas on Calcutt Creek, but there the sandstone occurs in two benches. At the Jason Bugs well, on Coins Creek, Lawrence County, gas containing much hydrogen sulphide was encountered at this horizon.

EXPLANATION OF MAP.

Salt- and Fresh-water.-A sheet of water is represented in the southwestern part of the quadrangle, a sheet of water in the eastern part of the quadrangle, and a sheet of water in the western part of the quadrangle. No. 9) 250 feet of sand and conglomerate in this part of the section, but, as has already been pointed out, some of this is probably the Miamiwelle limestone reported as a sandstone. Both salt water and gas have been reported from this sandstone. Berae sand.—In the rocks below the Berae sand spomie channels of oil are reported, but no persistent oil and gas bearing rocks are encountered in the Berae sand shale or the Berae sandstone. Most of the records studied show, that the shale which is regarded as probably the Cuyahoga shaly member (in the hard black shale) below, is the Berae sandstone group of sandstones with shale layers which is correlated with the frumary shale and the Berae sandstone. In many of the sections of the well this shale under the hard black shale is too much sandstone to be of any use in the Berae sand stone, but in certain of the sections showing several sandstone bands the basal boundary has been drawn on the map as there seems to be no positive evidence to the contrary. In some of the well sections the Berae 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 Berae, 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 were notable exceptions. The town of Cadiz is located on Cadcutt Creek where a special layer of sandstone, thought to correspond to the Buckingham sand, at a depth of 170 feet. The pressure from below was reported to be 800 feet. The gas was then sold to the town. The volume was reported to be 750,000 cubic feet each 24 hours when the gas was tapped, and the rock pressure was 350 pounds per square inch with hydrogen sulphide. From the recent wells drilled in Lawrence County, Ky., south of Loupsider, there is reported a small production of oil from the Berae sand.
<table>
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<tr>
<th>Formation</th>
<th>Horizon</th>
<th>Section</th>
<th>Production Type</th>
<th>Water, Gas, Oil</th>
<th>General Characteristics</th>
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<td>Co</td>
<td>200</td>
<td>Sandstone</td>
<td>Water</td>
<td>Usually found in the middle of the section, in sandy deposits.</td>
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<td>Greenbush Formation</td>
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<td>400-600</td>
<td>Sandstone</td>
<td>Gas</td>
<td>Sandy, fine to medium sandstone, occasionally with pebbles.</td>
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<td>Blonghey Formation</td>
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<td>100-200</td>
<td>Sandstone</td>
<td>Oil</td>
<td>Sandy, medium to coarse sandstone, occasionally with pebbles.</td>
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<td>Holmfield Formation</td>
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<td>40</td>
<td>Sandstone</td>
<td>Water</td>
<td>Sandy, fine to medium sandstone.</td>
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<td>Co</td>
<td>50</td>
<td>Sandstone</td>
<td>Water</td>
<td>Sandy, fine to medium sandstone.</td>
</tr>
</tbody>
</table>

**SECTIONS OF DEEP WELLS IN THE KENOVA QUADRANGLE.**

Based on drillers' records, with correlations by author. The scale is 1 inch = 400 feet.

**Names and Locations of Wells**


**Geology of the Kenoa Quadrangle**

- Sandstone: Predominantly found in the middle section, in sandy deposits.
- Shale: Predominantly found in the lower section, in clayey deposits.
- Limestone: Predominantly found in the upper section, in carbonate deposits.
- Coal: Predominantly found in the lower section, in coal beds.
and still smaller ones, steps. 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 systems. The principal divisions of a system are called series. Any aggregate of formations less than a series is called a group.

For example, as sedimentary deposits accumulate successively the youngest rest on those that are older, and their relative ages may be determined by observing their positions. In many regions of interior formations, 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 sediments deposited on the land. Such rocks are said to be 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 a few similar 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 form, 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 come to be the age of any bed at which the first of them is found. For example, certain fossiliferous formations are remote from each other, and it is impossible to observe their relative positions, the characteristically fossil types found in them may determine which formation was deposited first. Fossil remains in the strata of different areas, provinces, and continents afford the most important means for combining different kinds into a general earth history.

It is in many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in some cases be determined by observing how the 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 igneous 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 metamorphosis.

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 the sedimentary strata deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and colluvial formations. Patterns of triangles, star, and dots, 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 a series parallel to the structure plane. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin. The patterns of parallel lines, circles, or triangles are used only in zones of similar color. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system.

The symbols consist 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 symbol is composed of small letters.

The names of the systems and of series, which have been given distinctive names, in order from youngest to oldest, with the colors and symbols assigned to each system, are given in the subjacent table.

<table>
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<tr>
<th>Symbol</th>
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<tr>
<td>T</td>
<td>Yellow</td>
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</tr>
<tr>
<td>R</td>
<td>Red</td>
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</table>

The rock figure is used to represent all the various kinds of rocks as shown by the underground relations on the map. The line of rock is indicated by appropriate patterns of lines, dots, and dashes. These patterns differ in much detail, but those shown in figure 2 are used to represent the coarse-grained kinds of rocks.

The red cliff is an illustration; it may be conveyed from any rock. To the cliff is added a bed with various kinds of flowers and pines. In the making of a section the alluvinial plain is first built and afterward partly eroded away. The stripping of this part of the plain leaves a double process, hills being worn away (depicted) and valleys being filled up (depicted). All parts of the land 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 lowering of the land, it can move on below sea level, and the sea is therefore called the base-level of erosion. Long or large rivers may determine local base-levels for certain regions. The stripping of a cliff or basin leaves the plain, a double process, hills being worn away (depicted) and valleys being filled up (depicted). The various erosional sheets.

Avrail 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 look for that color, pattern, and symbol in the legend, where you will find the name and description of the formation. If it is desired to find any particular formation, its name will probably be found in the margin or pattern notes; then the areas on the map corresponding in color and pattern may be traced out. The legend is also a partial statement of the character of the deposits of formations of wide geographic occurrence are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin. These symbols are arranged in order of age, so far as the present writer can determine, from the youngest to the oldest.

Amenous geology maps.—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 amenous geology map. The formations that appear on the areal geology map may be shown on this map by finer color patterns and the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of a mine or mining district. In the areas stippled the zones of the principal mineral mined or stone quarried. There are important mining industries or artisan basins in the areas stippled. The mining districts on this map are divided into topographic regions.

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

The geologic map is not limited, however, to natural and artificial cavities for its information concerning the earth's structure. Knowing the manner of formation of rocks and having traced out their history we study the surface. We 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.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations on the map. The line of rock is indicated by appropriate patterns of lines, dots, and dashes. These patterns differ in much detail, but those shown in figure 2 are used to represent the coarse-grained kinds of rocks.

sandstones, forming the cliffs, and shales, constituting the soles. The broad belt of loose rock is traversed by several ridges, which are seen in the section to correspond to the cuts of a bed of sandstone that rises to the surface. The upraised side of the bed to the right of the ridges, and the intermediate valleys follow the contours of lavender and calcareous shales.

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 under the earth's surface are determined. Sandstone, shales, and limestone were deposited beneath the sea in nearly flat sheets, the fact that they are now bent and folded is proof that leave 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 in figure 4.

At the right of figure 2 the section shows sheets that are traversed by igneous rocks. The strata are much contorted and their arrangement underground can not be inferred. Hematite, a mineral portion of the section, is a hematite but is not known by observation or by well-founded inference.

The section shows also 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 removed. The character of this set of parallel relations which is called conformable.

The second set of formations consists of strata that have been folded into arches and ranges. The strata in this group are continuous, but the crests of the arches have been removed. The beds, those of the first set, are conformable. The third set of strata sheet not upon the upturned or eroded edges of the bed of the second set shown at the left of the section. The overlying deposits are, from their formation, evidently younger than the underlying deposits, and the land- ing 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. The strata of this group are shown on the surface in the so-called cross sections. This marks a time interval between two periods of rock formation. The section and landscape in figure 3 are ideal, but they illustrate actual relations. The sections on the stratum section sheet are related to the map as the sections in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual surface of the ground along the section line, and the depth from the surface of any measured producing water-bearing stratum that appears in the section may be measured by using the scale of the map.

Column section.—The geologic maps are usually accompa- nied by a column section, which contains a vertical 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 both described, and their characters are indicated in the columnar description. The thickness of forma- tions are given in figures that state the least and greatest measurements, and the average thickness of each formation is shown by a column, which is scaled to size. 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 denudation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."
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* Prices are based on customer order.  
* Prices may be subject to change without notice. 
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Costs shown are the lowest cost for the purchase of the folio at any time. 
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**All folios are available in digital form.**