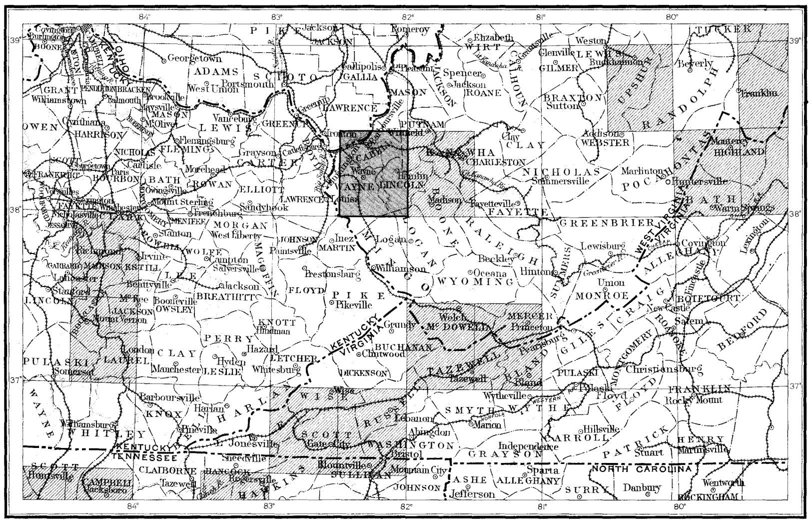
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

HUNTINGTON FOLIO
WEST VIRGINIA - OHIO

INDEX MAP



SCALE: 40 MILES-1 INCH

▨ AREA OF THE HUNTINGTON FOLIO

▨ AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION
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FOLIO 69 LIBRARY EDITION HUNTINGTON

WASHINGTON, D. C.
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GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS; S. J. KUBEL, CHIEF ENGRAVER
1902

EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

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

Relief.—All elevations are measured from mean sea-level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical space between each two contours is called the *contour interval.* Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

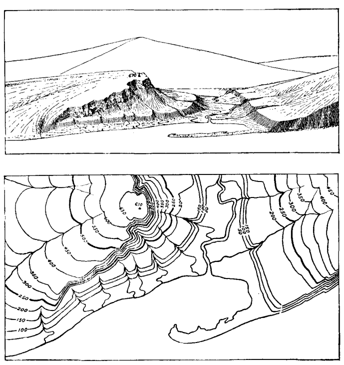

Fig. 1.—Ideal sketch and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand-bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while 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 sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

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

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If the stream flows the year round the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory are called *quadrangles.* Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree, i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known, and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks.* These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks.*

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it either consolidates in cracks or fissures crossing the bedding planes, thus forming dikes, or else spreads out between the strata in large bodies, called sills or laccoliths. Such rocks are called *intrusive.* Within their rock enclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive.* Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over it, the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

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

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be discovered by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbance of the beds has been so great that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then *fossils*, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color or colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations.

PERIOD.	SYMBOL.	COLOR.
Pleistocene	P	Any colors.
Neocene { Pliocene Miocene }	N	Buffs.
Eocene (including Oligocene)	E	Olive-browns.
Cretaceous	K	Olive-greens.
Juratrias { Jurassic Triassic }	J	Blue-greens.
Carboniferous (including Permian)	C	Blues.
Devonian	D	Blue-purples.
Silurian (including Ordovician)	S	Red-purples.
Cambrian	Ꞓ	Pinks.
Algonkian	A	Orange-browns.
Archean	AR	Any colors.

Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations of the Pleistocene render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the metamorphic rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any particular colored pattern and its letter-symbol on the map the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet by fainter color-patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

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

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

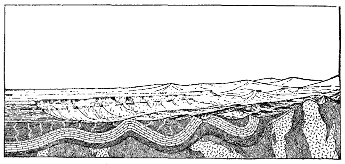

Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock·

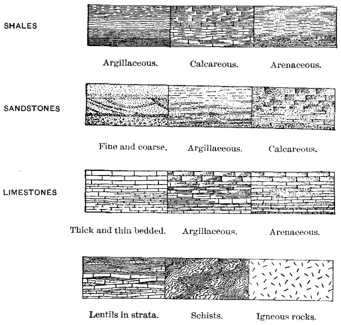

Fig. 3.—Symbols used to represent different kinds of rock.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section.

The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone 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 underground can be inferred.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. But these sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones.

On the right of the sketch the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has swelled upward from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

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

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger strata thus rest upon an eroded surface of older strata the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

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

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

Columnar-section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. The diagrams and verbal statements form a summary of the facts relating to the character of the rocks, to the thicknesses of the formations, and to the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be indicated graphically or by the word "unconformity," printed in the columnar section.

Each formation shown in the columnar section is accompanied by its name, a description of its character, and its letter-symbol as used in the maps and their legends.

CHARLES D. WALCOTT,
Director.

Revised June, 1897.

DESCRIPTION OF THE HUNTINGTON QUADRANGLE.

GEOGRAPHY.

Counties embraced.

General relations.—The Huntington quadrangle embraces an area of about 938 square miles, extending from latitude 38° on the south to 38° 30′ on the north, and from longitude 82° on the east to 82° 30′ on the west. The greater part of this quadrangle lies within the State of West Virginia, but its northwest corner extends into Ohio, and its southwest corner includes a very small portion of Kentucky. The quadrangle embraces parts of the counties of Wayne, Cabell, Lincoln, Putnam, and Logan of West Virginia, Lawrence of Ohio, and Lawrence of Kentucky. It is named from the city of Huntington, the largest town within its borders.

In its geographic and geologic relations this quadrangle forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain on the east to the Mississippi lowlands on the west, and from central Alabama to southern New York.

Subdivisions of the Appalachian province.—Respecting the attitude of the rocks, the Appalachian province may be divided into two nearly equal parts by a line which follows the northwestern side of the Appalachian Valley, along the Allegheny Front and the eastern escarpment of the Cumberland Plateau. East of this line the rocks are greatly disturbed by folds and faults, and in many places they are so metamorphosed that their original character can not be determined. West of the division line the rocks are almost wholly sedimentary and with few exceptions the strata lie nearly flat, in approximately the same attitude in which they were deposited.

Relation between the Appalachian province and the Mississippi Valley.

The western division of the province is therefore sharply differentiated from the eastern division, but it can not be so easily separated from the remaining portion of the Mississippi Valley. In a geologic sense it is a part of the Mississippi Valley. The character and stratigraphic succession of the rocks are the same, and the geologic structure which is characteristic of one is also found throughout the other. On account of these facts it would be arbitrary, on geologic grounds, to separate the two, or, in other words, to assign a definite western limit to the Appalachian province.

Limits of the western division of the Appalachian province.

From a physiographic standpoint this division is clearly a part of the Appalachian province, for its history can not be written apart from that of the whole province, but it has little or no relation to the region west of Mississippi River, either in its physiographic history or in its present surface features. This division is, therefore, physiographically limited on the east by the Allegheny Front and the eastern escarpment of the Cumberland Plateau and on the west by the flood plain of Mississippi River and the prairie plains of Illinois and Indiana. In contradistinction from the low lands on either side, it has been called by Powell the Allegheny Plateaus.

Allegheny Plateaus.

The Allegheny Plateaus are made up of a variety of topographic features, including the greatly dissected Cumberland–Allegheny Plateau on the east, the Highland Rim and the Lexington Plain in the middle of the territory, and the Central Basin of Tennessee and the low plains bordering the Mississippi River on the west.

The geologic structure of the Allegheny Plateaus is comparatively simple. The strata lie nearly flat, but in many places along the eastern margin their horizontality is disturbed by sharp folds which give rise to long, even-crested ridges, or to equally long, narrow valleys parallel with the margin of the field. In the interior there are a few broad folds, but their height is so small compared with their breadth that the resulting dip of the rocks is scarcely perceptible.

Cincinnati anticline.

The most prominent structural feature is a low, broad arch, known as the Cincinnati anticline, which enters this division of the province from the direction of Chicago; it curves southward through Cincinnati, Ohio, and Lexington, Kentucky, and then trends to the southwest, parallel with the Appalachian Valley, as far as Nashville, Tennessee. Its maximum development is in the vicinity of Lexington, where the Trenton limestone is exposed at the surface at an altitude of 1000 feet above sea level, but in Tennessee it again swells out into a dome-like structure which, being eroded, is represented topographically by the great Central Basin of Tennessee.

Divisions of the Allegheny Plateaus.

Geographically this anticline separates the Allegheny Plateaus into two parts, or structural basins, which differ from each other in the character of the rocks which they contain, in geologic structure, and in the topography developed upon them. The eastern basin, extending the entire length of the province from northeast to southwest, is well known as the Appalachian coal field. The western basin is more restricted, being the southeastern part of the coal field of Illinois, Indiana, and Kentucky. The rocks outcropping on the crest of the Cincinnati anticline are prevailingly calcareous, hence the two coal fields are not only structurally distinct, but are separated by a wide band of rocks which are lithologically very different from the sandy coal-bearing strata on either side.

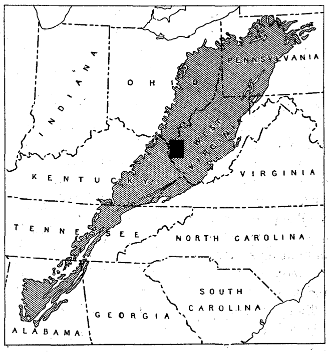

Fig. 1.—Outline map showing the relation of the Huntington quadrangle to the Appalachian coal field.

Coal field is represented by the shaded area.

Ridges produced by anticlines.

Anticlinal valleys.

Topography of the Allegheny Plateaus.—The altitude of this division is greatest along the southeastern margin, where the ridges and plateaus attain sufficient elevation to be considered mountains. They are not continuous, and in no sense can they be grouped into a mountain system. In the northern part of the province the general surface forms a plateau at an altitude of from 2000 to 3000 feet above the sea. Upon this platform stand numerous ridges which have been formed by partial erosion of small anticlinal folds that traverse the plateau in lines parallel with its eastern margin. In the central part of the basin the plateau is not so well marked nor so high, and it has been deeply dissected by the streams which drain its surface, leaving a hilly, broken region in the place of the plateau. This region is also free from minor folds, hence there are no ridges rising above the general level. Farther south extensive folds occur within the limits of this division, and parallel ridges are found which are similar to those in the northern part of the province. In southern Tennessee and northern Alabama, however, the lithologic and structural conditions have been such that the anticlines are entirely eroded, leaving the central parts of the broad synclines as elevated plateaus, which, in various places, have received local names, but which may be grouped under the general name of the Cumberland Plateau.

Altitude of the mountainous belt.

Escarpment at western margin of coal field.

The altitude of the mountainous belt varies from 500 feet in central Alabama to 2000 feet at Chattanooga, 3500 feet in the vicinity of Cumberland Gap, and from 2000 to 4000 feet throughout the northern part of the province. From this extreme altitude on the southeastern margin the surface descends to less than 500 feet on the western border, near Mississippi River. This descent is accomplished by a succession of steps or escarpments, which mark the present extent of particularly hard beds of rock and also the various stages in the reduction of the surface to its present position. The highest and most pronounced escarpment is along the western margin of the Appalachian coal field, separating, in Kentucky, the great interior plain from the higher and more hilly region of the coal field, and in Tennessee marking the line between the Eastern Highlands and the Cumberland Plateau. In the latter State the escarpment is steep and regular and the plateau is very perfectly preserved, but in the former the capping rocks were not hard enough to protect the plain after it was uplifted, and it has been completely dissected by the numerous streams which drain its surface, forming a hilly region in the place of the plateau and a broken margin of irregular hill slopes instead of an escarpment. North of Ohio River the distinction between the topographic features is less pronounced than farther south and there is more or less merging of the eastern plateaus into the low plains of the Mississippi Valley.

Plains at altitude of 1000 feet.

From the foot of the escarpment which marks the western limit of the coal-field plateau there extends a second plain or plateau, which is a prominent feature of the topography of Kentucky and Tennessee. This plain stands at an altitude of about 1000 feet throughout the "Blue grass" region of Kentucky, and can be traced northward into Ohio and Indiana. In Tennessee it is beautifully developed along the western front of the Cumberland Plateau, where it has approximately the same altitude as in central Kentucky. Doubtless this surface once extended across the Central Basin, for the latter is bounded on the south by high land along the Tennessee–Alabama line, and on the north by the great interior plain of Kentucky.

Central Basin a limited plain of about 700 feet elevation.

The evidence indicates that this surface was formed by subaerial erosion which operated so extensively that it reduced the soft rocks nearly to the level of the sea, forming a peneplain. Since that time the surface has been elevated to its present position, 1000 feet above sea level, and streams have dissected it extensively. Owing to the softness of the rocks in Tennessee and to the geologic structure which is there developed, a second limited plain was formed, which was subsequently elevated and now forms the floor of the Central Basin. This surface has a general altitude of from 500 to 700 feet, and it is separated from the higher surface by a steep slope or escarpment which is generally called the Highland Rim. Since the formation of the Central Basin the land has been elevated several hundred feet and the principal streams have carved deep and narrow valleys in its once even surface.

In northern Kentucky the conditions were not so favorable for extensive erosion as in Tennessee, consequently there is no feature exactly equivalent to the Central Basin, but there are old high-level stream valleys, such as have been described in the Richmond (Kentucky) folio, which indicate that similar, although not identical, conditions prevailed in the Ohio Valley during the same general period.

TOPOGRAPHY OF THE HUNTINGTON QUADRANGLE.

This quadrangle lies entirely within the Appalachian coal basin, and its topography is of the type which characterizes that field, where the rocks are comparatively soft and undisturbed.

Main streams and their drainage areas.

Changes in drainage.

Drainage.—The drainage of this territory is effected by Ohio River, which crosses the northwest corner of the quadrangle. Its principal tributaries are Guyandot River, Twelvepole Creek, and Big Sandy River. The first, with its principal tributary, Mud River, drains the major portion of the quadrangle; Twelvepole Creek is next in importance; and lastly comes Big Sandy River, which drains but a limited amount of territory in the southwest corner of the quadrangle. There is conclusive evidence that, in comparatively late geologic time, even while this territory had much the same appearance topographically as it has to-day, the arrangement of the streams was very different from the present. The details of this history will be given in a subsequent paragraph, so that at present it will be necessary only to remark that at one time Kanawha River, instead of turning northward at Saint Albans, as it does at present, continued westward through Teay Valley, along the line of the Chesapeake and Ohio Railway, by Hurricane, Milton, Barboursville, and Huntington, and left the territory at Central City, where the present Ohio River is located. It is probable that Ohio River then had no existence and that the stream formed by the junction of Kanawha and Big Sandy rivers flowed northward through the valley of the present Scioto River and discharged its waters into the system of the Great Lakes. The subsequent ponding of these northward-flowing streams, presumably by the advance of the glacial ice, caused them to overflow and form a new river along the line of lowest divides. This new stream is Ohio River, and its outlet is into the Mississippi instead of the Great Lakes. The details of these great changes have not been worked out, but sufficient data are now available to establish the principal facts of the change as here outlined.

At that time the tributaries of Kanawha River were Mud and Guyandot rivers, Twelvepole Creek, and possibly a small stream that occupied the valley of the present Ohio River above the mouth of Guyandot River. When Kanawha River was diverted to its present course, Teay Valley was left to the former tributaries of that stream. Mud River entered the valley near Milton and followed it to Barboursville, where it united with the Guyandot and a short distance beyond reached Ohio River. In attempting to adjust itself to the new conditions Mud River meandered broadly over the wide valley of the Kanawha. Its sluggish character continues to the present day, as indicated by its name, even though it has succeeded in removing the alluvium and is now cutting into the rock floor of the old Kanawha Valley.

The arrangement of the lines of drainage in the basins of this quadrangle is worthy of discussion. Unfortunately the quadrangle does not embrace any complete river basin, and it is necessary to describe features not shown upon this map but found upon maps contiguous to it.

Unsymmetrical arrangement of stream in its basin.

To one considering the hydrographic basin of Twelvepole Creek, it is apparent that this stream is flowing very near the western margin of its basin. The divide between it and Big Sandy River on the west is nowhere more than 3 miles from Twelvepole Creek, whereas the divide between Guyandot River and Twelvepole Creek is from 12 to 15 miles from the latter stream. This arrangement of the stream can not be explained by the occurrence of harder beds of rock in one locality than in another, for the strata are essentially the same in different parts of this basin; nor can it be explained by the dip of the rocks, for, as shown by the structure section, the dip is nearly due north, or parallel with the stream instead of at right angles to it. What, then, can be the cause of this unsymmetrical arrangement of the stream in its basin? If this case stood alone it might be considered simply as an eccentric arrangement due to certain ancient conditions which have been removed or so modified by erosion of the surface as to be no longer recognizable; but when other river systems in this region are examined it is found that many, though not all, of them have an unsymmetrical development similar to that of Twelvepole Creek. The facts are therefore to be explained by some general condition which forced the river basins to develop in this manner.

Unsymmetrical basins explained by tilting.

This effect is most reasonably attributed to tilting of the land at a time when the surface relief was slight and the streams were in a state of delicate balance one against another. The velocity of streams whose direction of flow corresponded with the new slope of the surface was accelerated by the tilting and these streams gained an advantage over those whose courses were in the opposite direction and whose flow was lessened by the movement. The more rapid streams cut more vigorously and worked headwards at the expense of their opponents, and they thus crowded the divide between them up the slope, or toward the axis of uplift.

In the present case the uplift appears to have been on the east, with its axis approximately north and south. Consequently the streams flowing west, or down the slope of the surface, have been accelerated, while those opposed to them have been retarded in their development, and so have not been able to hold their own against their more favored opponents. By this process the divides, which originally may have been located midway between the trunk streams, have migrated up the slope toward the axis, or, in this case eastward, until they approach closely the trunk stream of the next basin in that direction.

The basin of Mud River is as strikingly unsymmetrical as that of Twelvepole Creek, but the fact can not be appreciated without an examination of the Charleston atlas sheet, which adjoins this on the east. As in the previous case, the major stream is flowing within 2 or 3 miles of the western margin of its basin, but on the east there is four or five times that distance between the trunk stream and the divide. The amount of migration has been essentially the same, and the direction in which it has taken place also corresponds, hence there must have been a common cause that affected a territory larger than a quadrangle.

A symmetrical river basin.

Curiously enough, between these two striking examples of unsymmetrical drainage basins is one which is strictly symmetrical. This stream is Guyandot River, the largest tributary of the Ohio in this territory. It carries a much greater volume of water than either Twelvepole Creek or Mud River, and hence, after any crustal movement, it should more quickly have deepened its channel to the level of the outlet, and consequently its tributaries would have had sufficient advantage over their opponents to have maintained their ground. In this case we have an exception to account for, and it is a difficult problem to solve, for, under the conditions just postulated, this river should have crowded its eastern divide close to Mud River, if indeed it should not have captured that stream. The explation of this anomalous feature has apparently to do with changes in drainage that have taken place in other portions of the coal field, and hence can not properly be discussed here in full, but a brief outline will probably be sufficient to explain the exception.

Explanation of the exceptional symmetrical basin.

The alignment of the upper course of this stream with Tug Fork of Big Sandy and the very low divide between them suggest a former connection of the Guyandot Basin above Horse Creek with that of the Big Sandy. Before this capture was effected Guyandot River was presumably a creek, smaller than either Twelvepole Creek or Mud River. In that condition it was not a powerful antagonist, as the present Guyandot River would be under similar physiographic conditions. The original stream was so small that its tributaries gained no particular advantage through any tilting of the surface, and hence it remained nearly symmetrical. In later time it appears to have had a slight advantage over its neighbors and to have succeeded in cutting headwards and capturing a large branch of Tug Fork. This greatly augmented the volume of the stream and increased its power of corrasion, so that it has cut directly down in its former channel. Since it was thus enlarged, however, conditions have not been favorable for the acquisition of territory on either side, although the river is flowing at a level lower than that of the adjacent streams. Under certain conditions this difference would give to the tributaries of Guyandot River a decided advantage over those belonging to adjacent systems, and the divides would shift accordingly, but with the present mountainous character of the topography the migration of the divides is so slow as to be inappreciable.

Relief.—The surface features of any quadrangle are difficult of interpretation if the student is confined to the facts shown in that quadrangle, for many of the conditions which have modified the action of erosion so as to produce the present topography are general in their character and can be understood only through a knowledge of the surface features and the configuration of the drainage lines over a wide extent of territory. The topography of the Huntington quadrangle is especially difficult of interpretation, for the rocks which compose the surface are so nearly homogeneous that topographic features formed at different times and under different conditions of erosion grade almost imperceptibly one into another.

In attempting to read the physiographic history of this quadrangle, it will be necessary first to consider the history of a portion of the same general region in which the topographic forms are well marked and clearly distinguishable one from another. The nearest region to which we can go for reference is central Kentucky, where there is a clean-cut and sharp distinction between the features of the coal field and those of the "Blue grass" region. This has been described in the Richmond and London (Kentucky) folios, to which the reader is referred for a more detailed description.

Topography typically developed in Kentucky.

In Kentucky the surface of the coal field is a partially dissected plateau which stands at an elevation of about 1500 feet above the level of the sea. At its western edge there is a sharp descent to the surface of the Lexington Plain, which has an altitude of about 1000 feet. Along divides and near the headwaters of the streams the latter feature is an almost perfect plain, but near the lower courses of the principal streams its even surface has been destroyed to some extent by the backward cutting of small branches. Below the Lexington Plain, Kentucky and Licking rivers have cut deep gorges, but the presence of extensive terraces on both streams shows that their down-cutting was interrupted by a pause in the upward movement of the land, which permitted the streams to broaden their valleys at one particular stage of their development. Since the episode of terrace-cutting there is no evidence of variation in the work of the streams, and presumably the conditions under which it has been accomplished have remained fairly constant from that time to the present.

Complete and partial cycles of erosion.

Ages of the surface features.

These features of central Kentucky appear to be due to subaerial erosion; they are the results either of complete cycles of erosion, during which the surface of the entire region was reduced to a peneplain, or of partial cycles in which the reduction extended only to such areas as were characterized by the outcrops of soft rocks. In the Lexington region the rocks are so nearly horizontal that, at first sight, they appear to have controlled the operation of erosion by determining level surfaces corresponding with their bedding planes, but careful examination shows that the surface of this plain bevels the formations at a very low angle. The production of such a feature is evidence that the work of erosion was limited, in its downward progress, by some horizon below which it could not operate and which had no relation to the bedding planes of the underlying rocks. Such a limiting horizon is the base-level of erosion, and more or less extensive areas of the surface were reduced approximately to this condition in at least two periods of the post-Paleozoic history of Kentucky. The ages of these surface features have not been definitely determined, but there is sufficient evidence to class provisionally the uppermost peneplain as Cretaceous, the Lexington Plain as late Eocene or Neocene, and the terraces of the river valleys as the latest feature of the Neocene period.

The Huntington quadrangle doubtless passed through approximately the same cycle of events, but the conditions in West Virginia were not so favorable for the formation and the preservation of sharp distinctions between topographic features, and hence any interpretation of these features is less exact on account of the obscurity of the record.

General slope of the upland to the northwest.

By reference to the topographic map it will be seen that the features of the Huntington quadrangle show little variation throughout. It is a deeply dissected plateau region in which there is a fair degree of regularity in the altitude of the tops of the hills and a gradual descent from 1200 or 1500 feet at the south to about 900 feet in the northwest corner. The regularity in the uneven surface of the quadrangle contrasts with the strong topographic features of central Kentucky, and at first sight it seems impossible to interpret these features in the terms of erosion cycles by which we are accustomed to express the physiographic history of land areas. It is apparent that the criteria for the interpretation of the events of geologic history must be very different in the Huntington region from those which are used in central Kentucky.

Dip of rocks steeper than slope of surface.

The general upland surface of this quadrangle slopes regularly toward the northwest at a rate which averages about 25 feet to the mile; the rocks dip in the same general direction, but their average rate of descent is considerably greater than the slope of the surface, hence the older rocks which are exposed in the southeastern part of the quadrangle dip below the surface in passing to the northwest and are replaced by younger formations in successive order. The Charleston sandstone, which caps the hills in the southern half of the quadrangle, is harder and more resistant than the other formations, hence the surface, to a certain extent, is modified by this stratum; but its effect is not so pronounced as one would imagine, for in passing from its outcrop, either to younger strata toward the northwest or to older strata toward the southeast, one observes that the general regularity of the surface continues. The red shales overlying this sandstone are the most easily eroded rocks of the quadrangle, but, taken as a whole, the rock series is fairly homogeneous and resistant to the action of erosion. In rocks having the above-described characteristics and relation to the surface, escarpments are not produced, and features formed at different times and under different conditions of erosion are only moderately differentiated. If, then, the cycles and subcycles of erosion have been the same in West Virginia as in Kentucky, the effects of development should be dissimilar rather than alike in their topographic expression.

The first cycle of erosion recorded in the topography.

The cycle of erosion in which was produced the higher plateau of Kentucky was doubtless of great duration and affected the entire Appalachian province. The coal field appears to have been reduced to a gently undulating surface, which is now shown not only in the even hilltops of the Kentucky region, but also in West Virginia.

The evidence upon which a reconstruction of this supposed surface can be founded is slight, because the amount of land remaining at its altitude is small, but there is a correspondence in the highest points all along the Allegheny Plateaus which makes it seem highly probable that the surface represented by these high points was once a peneplain.

The plateau represented by the higher points throughout the quadrangle.

This surface may be represented in a general way by contour lines drawn through the higher points in the quadrangle. On this basis the 1000-foot contour follows closely Ohio River; the 1100-foot contour extends from Lavalette to Ona and on northeastward; the 1200-foot contour, from Wayne to Hurricane; the 1300-foot contour, from Fleming to Sweetland; the 1400-foot contour, from Ferguson to Jenks; the 1500-foot contour, from Queens Ridge to Spurlockville; and the 1600-foot contour, from the mouth of Green Shoal Branch northeastward.

Cycle of erosion terminated by uplift.

The cycle of erosion was terminated by a movement of elevation which was greatest along the axis of the Appalachian province, and from this axial line it diminished at about the same rate toward the northwest and southeast. In Kentucky the uplift was about 500 feet at the present margin of the coal field; in West Virginia it varied from less than 100 feet in the northwest corner of the Huntington quadrangle to many times that amount in the axial region, near the eastern edge of the coal field.

Under the conditions favoring erosion in Kentucky the great Lexington Plain and the scarp separating it from the higher plateau developed during the next cycle. In West Virginia the same uplift appears to have prevailed, but, on account of the hardness and homogeneity of the rocks, the surface resulting from the later cycle of degradation is not a plain and is not separated from the higher surface by any feature resembling a scarp.

A second cycle of erosion represented by the spurs and low gaps.

The surface features of this age probably consisted of broad valleys separated by gently undulating divides which rose gradually to the surface of the upper plain. The floors of these valleys are now represented by the tops of the spurs which project toward the principal streams and by low gaps in many of the divides. If the valleys could be filled to the height of spurs and low divides, the restored surface would nearly represent the plain as it existed at that time.

Before attempting to discriminate the leading physiographic features of this region, it is well to call attention to the fact that the base map was made many years ago and that the instrument used in determining relative elevations within the quadrangle was the aneroid barometer. The results, therefore, are only approximately correct; hence refinements can not be introduced in the study of the topography. The altitudes of only those summits which are crossed by roads or trails, or which have been occupied as triangulation stations, have been sufficiently well determined to be used as evidence. On examination of these summits of spurs and low divides it will be found that those north of a line drawn through Wayne and Hurricane are generally less than 1000 feet above sea level and that those south of this line are more than 1000 feet; consequently such a line may be considered as a contour 1000 feet above sea on the lower plain. Applying the same criteria for the 1100-foot contour, it will be found to extend from Dunlow to Sweetland; similarly the 1200-foot contour extends from near Fourteen to Spurlockville, and presumably the 1300-foot contour crosses the extreme southeast corner. These contours are approximately correct for the general elevation of spurs that project into stream valleys, hence the surface represented by them is that of rather wide valleys along the principal streams and the lowest divides between stream basins. The surface represents a partial erosion cycle of moderate duration, fairly comparable to that in which the Lexington peneplain was formed. In the northern part of the quadrangle the contoured surface corresponds with the general level of the hilltops, showing that the reduction was more nearly complete where the rocks were soft and in territory contiguous to the principal streams.

Relation of the two old surfaces to each other.

It will be noted that the two surfaces, as contoured, are not parallel, the difference of altitude ranging from less than 100 feet in the vicinity of Huntington to 300 or 400 feet at the southeast corner of the quadrangle. This determination involves so many uncertain factors that it should not be too definitely accepted, but, in a general way, there appears to be an interval between these surfaces which grows progressively greater toward the southeast.

The cycle of erosion which resulted in the formation of the broad valleys just described was interrupted by an upward movement of the land. The streams were rejuvenated and cut deep trenches in the floors of their former valleys These trenches are the ones at present occupied by the streams of this region.

The terrace stage of the development of central Kentucky appears to have no representation in the surface features of the Kanawha region, unless it corresponds to the stage in which Teay Valley was cut. In that case its age should be Pleistocene rather than Neocene.

Summary of events producing surface features.

The physiographic features discussed indicate a sequence of events which may be summarized as follows: First, a long epoch of sub-aerial erosion, in which the surface of this quadrangle, as well as that of most of the Appalachian province, was reduced nearly to the level of the sea. This was followed by an uplift along an axis located southeast of this quadrangle, which raised the surface and tilted it toward the northwest. On this uplifted surface erosion became active, and in the epoch of quiescence which followed the uplift it developed a peneplain over the outcrops of soft rocks and in regions adjacent to the principal drainage lines. Peneplanation was again interrupted by an upward movement, during and after which the streams again cut sharp channels into the level floors of their old broad valleys. From the beginning of this uplift to the present time the active work of the streams has been interrupted only once by cessation of the upward movements, and that epoch was of so short duration that the river valleys were broadened to only a slight extent. The activity of the present streams shows either that this upward movement of the land is in progress at present or that the cessation of movement has been so recent that the streams have not had time appreciably to widen their valleys.

Teay Valley.

The most interesting episode in the recent geologic history of this region is the change in the course of Kanawha River from west to north, resulting in the evacuation of its old channel along Teay Valley. Teay Valley has long been recognized as an abandoned river channel, and various suggestions have been made to explain the diversion of the stream which formerly occupied it and to account for the deposits of clay occurring in it. Prominent among the suggestions is one which assumes that Ohio River was dammed by a glacier at Cincinnati during the Glacial epoch, but this fails to account for the facts, as do other assumptions involving the direct effects of glacial ice masses or warping of the earth's crust.

Nevertheless these adjustments appear to be intimately though not directly related to the great ice epoch. Teay Valley is but one of several similar features which occur within about 100 miles of the outermost limit of glaciation; and in some of the most noted cases on Monongahela River, clay analogous to that of Teay Valley has yielded fossil plants which, according to Dr. F. H. Knowlton, belong to a Glacial flora. Although these abandoned channels seem to be due to conditions which were general throughout the Ohio Valley, their relation to the surrounding topography, the variation, from place to place, of the character of the sediments deposited in them, and the difference in height to which these deposits extend, indicate that local and special conditions determined each case of diversion separately.

Abandonment of channels due to local ice dams.

The only hypothesis which appears to satisfy existing conditions is that of local ice dams formed by the occasional breaking up of river ice. In order to accomplish the diversion of the river to a new course the dam must have been capable of raising the water from 100 to 150 feet above its former level and the climate must have been severe enough to hold such a dam in place from season to season until the ponded water corraded a new channel below the level of the silt which, in the meantime, had accumulated on the rocky floor of the old channel.

Ice dam at Ashland Kentucky.

In applying this hypothesis to Teay Valley it will be necessary to suppose that a dam of this kind occurred in the vicinity of Ashland, Kentucky, by which the stream was forced to abandon its valley back of Russell and to seek a new channel farther north, by Ironton, Ohio, where the present river is located. Below such a barrier there would be no deposition of sediments, for since the formation of the dam the valley has not been occupied either by standing water or by a stream of any consequence. Above the barrier the water, although ponded to such an extent as to cause it to drop most of its load of fine material, was still affected by currents, so that the material laid down was rudely stratified, being arranged in much the same manner as the flood-plain deposits of the present large streams.

Ice dam near Milton, West Virginia.

In the course of time another dam appears to have formed in the vicinity of Milton, and this barrier was so high and strong that it backed the water up to the level of the divide on the northern side of the valley, across which the stream found several outlets into the present valley of Kanawha River. The corrading action of a current flowing across a divide from 100 to 150 feet above the general stream level is very strong, and it would be only a short time, comparatively, until the channels would be cut to or below the level of the silt in the old valley. At least three channels appear to have carried off the overflow from the submerged valley. One of these lines of discharge was located along the present course of Kanawha River, and the other two were situated farther west, in the valley of Hurricane Creek. Owing to the favorable location of the easternmost channel and to the large deposit of silt in the upper end of Teay Valley, the stream was turned into its present course and the outlets by way of Hurricane Creek were abandoned. During the reduction of this divide the water in the upper end of Teay Valley was stationary and undisturbed by the current which passed northward through the new outlet. In this quiet water finely laminated clay was deposited, not only in Teay Valley, but wherever the ponded water was free from the current of the river.

Laminated clay deposit.

In studying the deposits of Teay Valley a large collection of bowlders was discovered on Trace Fork about 3 miles south of Hurricane. This bed occurs fully a mile south of the limit of Teay Valley and distinctly out of the reach of a current of water flowing down the valley. It is impossible to account for this deposit by the action of a normal stream, but on the supposition of an ice dam near Milton it can be explained by floating ice which in the immense pond back of the dam drifted into this side valley and discharged its burden of waterworn material.

A diversion of Guyandot River.

In the Huntington district there are other examples of this sort of stream diversion, and in all cases the abandoned channels have nearly the same altitude as the floor of Teay Valley. Their close agreement in character and altitude indicates that they are probably due to the same set of conditions which forced Kanawha River from Teay Valley — the formation of dams by river ice. Near the line between Lincoln and Wayne counties Guyandot River now occupies a different channel from that in which it originally flowed. The old channel is distinctly marked at the head of Madison Creek by a low divide, which connects it with a small branch entering the river farther to the south. On this divide is a thick deposit of sand and bowlders, which could have been transported only by a stream of considerable volume. The altitude of this divide is between 700 and 800 feet, approximately the same elevation as Teay Valley. In the frigid climate which permitted the blocking of Teay Valley it seems probable that a similar jam of ice occurred in the old course of Guyandot near the head of Madison Creek, forcing the stream to seek a new outlet, which it found to the east along its present course.

The area near Big Sandy River has not been examined so carefully as has this quadrangle, but in a reconnaissance of that region old valleys were observed at several places which were once connected and formed the meandering course of that stream. These are also at the same altitude as Teay Valley, and they were presumably deserted for the same reason that the Kanawha left its original course.

Most of the large stream valleys of this region are marked by terraces cut into their bluffs and projecting spurs at about the same altitude as the rocky floor of Teay Valley. Terraces are prominent on Twelvepole Creek below Wayne, on Guyandot River below Madison Creek, and throughout almost the entire extent of Mud River. They are remnants of old, broad valleys within and below which the streams have cut their present narrow channels. These broad valleys indicate a somewhat advanced cycle of erosion, which was interrupted by elevation of the land and the inauguration of the present, or post-Glacial, cycle.

GEOLOGY.

GENERAL SEDIMENTARY RECORD.

All the consolidated rocks appearing at the surface within the limits of the Huntington quadrangle are of sedimentary origin — that is, they were deposited by water. They consist of shales, sandstones, and coal beds, having a total average thickness of about 1500 feet. The materials of which they are composed were originally mud, sand, and gravel derived from the waste of the older rocks and from the remains of plants which lived while the strata were being laid down.

Wide distribution of the lower Carboniferous shale

The geography of the time when the rocks of this quadrangle were deposited is not well known, but some advance has been made in determining the physical conditions which then prevailed, especially the configuration of the land during the period of the deposition of the coal-bearing rocks. In the closing stages of the lower Carboniferous or Mississippian epoch a considerable, although probably variable, thickness of mottled red and green calcareous shale (Mauch Chunk) was deposited over most of the Appalachian province. In all except the northeastern part of the province this followed a great epoch of limestone deposition, and hence the shale is generally regarded as indicative of a shallowed sea and also relatively higher adjacent land. In the Appalachian Valley it is uncertain what was the next change, but along the western margin of the coal field, across eastern Ohio and Kentucky and central Tennessee, the red shales were lifted above the level of the sea, forming a land area which corresponded, in a general way, with the Cincinnati anticline. It also seems probable, although at present it can not be demonstrated, that the Appalachian Valley, or at least a large portion of it, also rose above sea level, leaving a narrow trough along the eastern margin of the Appalachian coal field, in which deposition of the coal-bearing rocks first occurred.

Land area at the close of the lower Carboniferous.

The general scarcity of fossil marine organisms in the coal-bearing rocks of this region leads to the supposition that this basin was generally separated from the sea and consisted, in large measure, of fresh-water lagoons and extensive swamps, in which accumulated the vegetable matter that has since been consolidated into coal, and over which the sand and mud constituting the larger part of the formations were distributed. It has lately been suggested that rivers may have had an important part to play in the distribution of the greatly diversified sediments of the coal-bearing rocks. This is certainly possible, for the existence of extensive peat swamps implies a land surface of faint relief, and the close succession of coal seams and beds of rock formed from the waste of the land shows that there were frequent incursions of water into the swamp, in the form either of rivers or of lakes, or, occasionally, of the sea. It can not be doubted that the great and presumably rapid accumulation of mechanical sediments was accomplished by large streams, and it seems possible that these streams may have been agents of wide distribution as well, depositing their load on the low plains at or only slightly above the level of the sea.

Unconformity toward the west of the basin.

Into the narrow basin on the eastern margin of the present coal field the streams from the continental area on the east swept their burden of waste from the surface of the land. The rock floor of the Appalachian trough gradually sank, allowing the accumulating material to extend farther and farther toward the west, each succeeding bed overlapping that which was laid down before it, and resting unconformably upon the eroded surface of what was previously land on the western side of the trough. The continued subsidence allowed the coal-bearing rocks to be deposited as far west as the present limit of the field, and it is possible that originally they extended entirely across the Cincinnati anticline, connecting the Appalachian field with that of western Kentucky, Indiana, and Illinois.

Area raised to permanent dry land.

After the deposition of beds of sandstone, shale, and coal to a thickness of several thousand feet, the entire Appalachian coal field was raised above the level of the sea and permanently added to the continental area.

Since the final emergence of this part of the province from the Carboniferous sea the coal field has been continuously dry land, and its history during this period is more or less perfectly preserved in the topographic features found upon its surface to-day. To a certain extent this history has been interpreted, and the leading features have been presented under the heading "Topography of the Huntington quadrangle."

STRATIGRAPHY.

The strata exposed in the Huntington quadrangle have a thickness of about 1500 feet. The thicknesses of the formations, their order of succession, and their general characteristics are given on the Columnar Section sheet, but more detailed descriptions of the individual beds and the indications of their probable equivalents in other fields are given in the following paragraphs.

WELL SECTIONS.

A number of deep wells have been drilled in this quadrangle, which reveal the presence of formations lower in the geologic series than those appearing at the surface. These sections, as reported by the drillers, are shown in graphic manner on the Columnar Section sheet. In all cases some allowance must be made for the difficulty which the driller encounters in determining the exact nature of the material and for possible inaccuracy in his observations. In order to preserve details which can not be shown in a small-scale drawing, the sections are here given in type.

Well A.—This well is outside of the quadrangle, but its section is given for comparison with those which are located in the area under consideration. It is situated on Catletts Creek 1 mile west of Catlettsburg, Kentucky. It was drilled in 1897 and the following log of the well was furnished by Mr. W. H. Kemler:

Log of well on Catletts Creek 1 mile west of Catlettsburg, Kentucky.

	Thickness in feet.	Depth in feet.
Clay	40	
Sand and slate	100	140
Slate and shells	100	240
Sand	30	270
Blue slate	150	420
Sand	60	480
Slate	40	520
Sand	80	600
Slate	35	635
Sand	60	695
Limestone	80	775
Slate	10	785
Blue sand	165	950
Black slate	379	1329
Sand	7	1336
Slate	4	1340
Sand	40	1380
Slate	45	1425
Sand	20	1445
Black slate	175	1620
Black and white slate	230	1850
Black sand	5	1855
Slate	10	1865
Black sand	15	1880
Slate	90	1970
Black sand	9	1979
Slate	46	2025

Well B.—This well was drilled in 1898 on Fourpole Creek near Central City. The rocks penetrated by the drill are shown in the following table, which was furnished by Mr. Thomas W. Harvey, the owner of the well:

Log of well on Fourpole Creek near Central City.

	Thickness in feet.	Depth in feet.
Conductor	26	
Shale and lime (sand ?)	94	120
Lime	7	127
Slate and fire clay	98	225
Sandstone	25	250
Shale	50	300
Sandstone	30	330
Black slate	10	340
Gray sand	60	400
Black slate	10	410
Sandstone	85	495
White and blue slate	25	520
Sand and lime	20	540
Slate	20	560
Black slate	175	735
Gray sandstone	25	760
Black and blue slate	75	835
Shale and lime	30	865
Sandstone	30	895
Black slate (sand ?)	10	905
Black slate	30	935
Limestone	5	940
Black slate	30	970
Limestone	150	1120
Slate	28	1148
Gray sand	177	1325
Black slate	370	1695
Hard limestone	10	1705
Brown slate	25	1730
Sandstone	25	1755
Black slate	10	1765
Sand and lime	23	1788
Slate	6	1794
Black shale	20	1814
Black sand	97	1911
Slate	24	1935
White slate	100	2035
Lime and shale	9	2044
Black slate	211	2255
Brown slate	55	2310
Sand and shale	45	2355
Black and blue slate	30	2385
Black sand	30	2415
Black slate	5	2420
White sand	5	2425
Slate, various colors	325	2750
Sandstone	5	2755
Limestone	215	2970

Well C. — This well was drilled several years ago, at the Chesapeake and Ohio Railway shops in Huntington. The reported log of the well is as follows:

Log of well at Chesapeake and Ohio Railway shops in Huntington.

	Thickness in feet.	Depth in feet.
Clay	20	
Red shale	330	350
Sandstone	125	475
Black shale	3	478
Coal	10	488
Shale	30	518
Coal	4	522
Shale	40	562
Coal	6	568
Shale	332	900
White sand	100	1000
Shale	172	1172
Limestone	110	1282
Slate and shale	461	1743
Limestone	23	1766
Sandstone	15	1781
Slate	192	1973
Hard limestone	4	1977

Well D.—In order to show the changes in the strata around the borders of the quadrangle the following section is given on the authority of Mr. G. H. Dimmick, from a well drilled in 1896 on Ohio River at Greenbottom, some distance north of the northern boundary of the quadrangle.

Log of well at Greenbottom, on Ohio River.

	Thickness in feet.	Depth in feet.
Conductor	50	
Blue slate	20	70
Sandstone	50	120
Slate	354	474
Hard sandstone	30	504
Coal	8	512
Sandstone	35	547
Slate and shale	457	1004
Sandstone	190	1194
Slate	20	1214
Sandstone	130	1344
Limestone	140	1484
Sandstone	90	1574
Slate and shells	200	1774
Dark sand	25	1799
Red rock	50	1849
Shale and slate	701	2550

Well E.—No wells have been drilled in the northern part of this quadrangle, but at Winfield, on Kanawha River, a short distance to the northeast of this territory, a well was drilled in 1890 which furnished the following log:

Log of well at Winfield, on Kanawha River.

	Thickness in feet.	Depth in feet.
Shale	20	
Sandstone	7	27
Limestone	5	32
Slate	87	115
Red shale	10	125
Shale	5	130
Sandstone	25	155
Shale	5	160
Red rock	25	185
Sandstone	15	200
Red rock	15	215
Sandstone	10	225
Slate	85	310
Sandstone	10	320
Slate	37	357
Sandstone	40	397
Slate	43	440
Sandstone	35	475
Slate	25	500
Sandstone	10	510
Slate	25	535
Sandstone	70	605
Coal and slate	20	625
Sandstone	108	733
Slate	52	785
Sandstone	20	805
Slate	37	842
Sandstone	21	863
Slate	15	878
Sandstone	19	897
Shells	13	910
Sandstone	45	955
Slate	10	965
Sandstone	20	985
Slate	15	1000
Coal and slate	25	1025
Sandstone	45	1070
Slate	45	1115
Sandstone	15	1130
Slate	20	1150
Sandstone	255	1405
Dark sandstone	20	1425
Limestone	15	1440
Sandstone	5	1445
Limestone	175	1620
Slate	25	1645
Sandstone	25	1670

Well F.—In passing in a general way across the field from northwest to southeast it will be necessary to consider the section reported by Mr. E. O. Taylor, contractor, from a well drilled in 1886 near the mouth of Blaine Creek, Kentucky.

Log of well near mouth of Blaine Creek, Kentucky.

	Thickness in feet.	Depth in feet.
Drift	15	
Fire clay	5	20
Sandstone	15	35
Slate	5	40
Sandstone	20	60
Black slate	5	65
Sandstone	30	95
Black slate	50	145
Coal (?)	3	148
Fire clay	7	155
Sandstone	65	220
Black shale	15	235
Sandstone	25	260
Black shale	10	270
Coal	3	273
White slate	27	300
Sandstone	6	306
Black slate	24	330
Sandstone	25	355
Coal	7	362
Fire clay	3	365
Sandstone	70	435
Slate	60	495
Sandstone	25	520
Black slate	60	580
Sandstone	25	605
Black slate	5	610
Sandstone	45	655
Slate	55	710
Sandstone	150	860
Black slate	10	870
Sandstone	90	960
Black slate	25	985
Sandstone	40	1025
Limestone	140	1165
Sandstone	5	1170
Sandstone and slate	20	1190
Green sandstone	70	1260
Green shale	65	1325
Blue shale	375	1700
Black shale	27	1727
Sandstone	60	1787
Black shale	53	1840

Well G.—On a small branch of Guyandot River about 1 mile below Trace Creek three wells have been drilled, within a short distance of the river. No record was kept of one of these wells, and of the other two only a meager account of the strata penetrated by the drill is available. The following, given on the authority of Mr. W. H. Kemler, is the log of the well shown in the section at the close of this description:

Logs of wells on small branch of Guyandot River about 1 mile below Trace Creek.

	Thickness in feet.	Depth in feet.
Slate, shells, and sand	560	
Sandstone	15	575
Coal	6	581
Sandstone	30	611
Slate	339	950
Sandstone	420	1370
Slate	15	1385
Limestone	200	1585
Slate	40	1625
Sandstone	90	1715
Slate	40	1755

The second well, drilled 1400 feet distant from the one of which the log is given above, according to the same authority, furnished the following section:

	Thickness in feet.	Depth in feet.
Slate, shale, and sand	400	
Sandstone	160	560
Coal	5	565
Sandstone	80	645
Slate	275	920
Sandstone	410	1330
Limestone	165	1495
Slate	60	1555
Sandstone	100	1655
Slate	20	1675

Well H.—This well was drilled on Twelvepole Creek at the mouth of Arkansas Branch, just beyond the southern margin of this quadrangle.

Log of well on Twelvepole Creek at mouth of Arkansas Branch.

	Thickness in feet.	Depth in feet.
Soil	34	
Slate	41	75
Coal	4	79
Slate and rock	327	406
Coal	6	412
Slate and sandstone	264	676
Sandstone	280	956
Slate	86	1042
Sandstone	87	1129
Slate	5	1134
Sandstone	42	1176
Slate	40	1216
Limestone	210	1426
Slate	180	1606
Red rock	60	1666
Slate	250	1916
Limestone	15	1931
Slate	30	1961
Sandstone	7	1968

Well I.—The following section was obtained from a deep well drilled several years ago on Guyandot River near the mouth of Big Hart Creek:

Log of well on Guyandot River near mouth of Big Hart Creek.

	Thickness in feet.	Depth in feet.
Conductor	26	
Slate	20	46
Sandstone	80	126
Coal	9	135
Sandstone	175	310
Blue slate	107	417
Sandstone	403	820
Blue slate	20	840
Sandstone	22	862
Blue slate	6	868
Yellow sand and flint	38	906
Slate	45	951
Sandstone	182	1133
Blue slate	18	1151
Red rock	20	1171
Sandstone	42	1213
Limestone	235	1448
Red rock	80	1528
Blue slate	180	1708
Sandstone	105	1813
Blue slate	20	1833
Sandstone	10	1843
Blue slate	168	2011
Black sandstone	15	2026
Blue slate	1150	3176
Gray sandstone	8	3184
Black slate	77	3261

Well J.—Another deep well in the vicinity of this quadrangle was drilled at Dingess, on the line of the Norfolk and Western Railway, near the head of Twelvepole Creek. This is farther southeast than any other well section given, and consequently it shows the greatest thickness of the various formations involved. The section, according to Messrs. Gibson and Giles, contractors, is as follows:

Log of well at Dingess, near head of Twelvepole Creek.

	Thickness in feet.	Depth in feet.
Soil	3	
Sandstone	13	16
Coal	4	20
White sandstone	15	35
Black slate	10	45
White sandstone	46	91
Coal	1	92
Sandy slate	158	250
White sandstone	10	260
White slate	65	325
White sandstone	130	455
Slate	89	544
White sandstone	473	1017
Black slate	11	1028
Coal	6	1034
Black slate	4	1038
White sandstone	308	1346
Black slate	22	1368
Limestone	6	1374
Red rock	4	1378
Limestone	2	1380
White slate	4	1384
Red rock	2	1386
White sand	8	1394
Slaty white sand	26	1420
Limestone	176	1596
Red sandstone	94	1690
White slate	114	1804
Slaty sandstone	66	1870
White slate	230	2100
Shale	26	2126

There is one stratum which is always recognizable in these sections, and that is the lower Carboniferous limestone. It varies in thickness from 100 to 275 feet and it undoubtedly underlies the entire territory. In several cases the drill has penetrated from 1500 to 1800 feet beneath this key rock, but it is difficult to classify the material which was encountered. It seems probable that the upper part belongs to the Carboniferous and the lower to the Devonian, but formations can not be distinguished. In the well at Central City a limestone is reported at a depth of 2750 feet which may correspond to the bed at the base of the Devonian, or the bed at the top of the Silurian. In three sections there occur above the Carboniferous limestone traces of the red shales which previously have been mentioned as the last of the marine deposits of the Carboniferous period. As shown in the sections, this formation is very thin and irregular, being absent in many places—a fact which argues strongly that its upper limit marks an unconformity representing the old land surface upon which the coal-bearing rocks were subsequently deposited. With only one or two exceptions, the well sections show coarse, sandy deposits overlying the limestone and calcareous shale. In a general way, these represent the "Conglomerate," or Pottsville series, as it is now generally called. Above this is usually an interval in which the sediments are composed largely of shale. This shale formation is the lowest that is exposed at the surface in the Huntington quadrangle, and hence it is possible to consider it in greater detail.

The lower Carboniferous limestone a reference datum.

Unconformity observed in the well records.

CARBONIFEROUS STRATA.

Kanawha formation.—In determining the various formations into which it is possible to divide the coal-bearing rocks of southern West Virginia, the Kanawha River section has been regarded as the type for the field. In that section there is exposed a fairly homogeneous series of rocks which are clearly delimited by the heavy beds of the Pottsville series below and the black flint horizon above. In a general way this is a lithologic unit, and it is called the Kanawha formation, from the river along which it is best shown. It is composed principally of beds of shale and sandstone, but in association with them are also many seams of coal and, near the bottom of the formation, thin beds of impure limestone and calcareous shale.

Type section in the Kanawha Valley.

Following the Pennsylvania nomenclature, Prof. I. C. White has called this formation the Allegheny River series, and he has defined its upper limit as the Lewisburg or Stockton seam of coal, which occurs from 30 to 40 feet below the horizon of the black flint. The flint is here regarded as the dividing plane between this formation and the one which overlies it for the reason that the flint is the great datum to which all determinations regarding the positions of coal seams are referred, and also because it occurs at about the horizon where the change begins from the generally shaly beds of the Kanawha formation to the sandy series which overlies them.

The black flint a horizon marker.

The Kanawha is the lowest formation exposed in the Huntington quadrangle. Owing to the northward dip of the rock, it shows only in the southern part of the quadrangle, and in that region it is best exposed in the valley of Guyandot River.

Throughout most of the region south and west of Kanawha River the black flint is not present to determine the upper limit of this formation. No exact boundary can be drawn between this and the overlying formations; the change is gradual, forming a zone of transition, which frequently is covered by débris from the coarse formation above. In the Huntington quadrangle it is found impossible to determine this boundary within limits of about 100 feet, and on the geologic map this uncertainty is indicated by the absence of a boundary line and by the blending of patterns throughout a narrow zone.

Below this zone of transition the formation is fairly homogeneous, consisting of shales, sandstones, and coal beds through an exposed thickness of not less than 400 feet. The section given under "Well I" gives some clue to the lower limit of the formation at the mouth of Big Hart Creek, Lincoln County, but it is suscpetible of various interpretations, and therefore offers no conclusive evidence. Prof. I. C. White regards the coal bed 134 feet below the surface as marking the base of the formation, but it would seem equally, if not more, appropriate to include in the Kanawha formation the bed of shale 107 feet in thickness. On the supposition that Professor White is correct in his identification, the Kanawha formation would have a thickness not exceeding 500 feet, whereas, on the other supposition, it would measure about 750 feet. The nearest point at which this thickness has been approximately determined is on Little Coal River near Madison, where it has a thickness of about 700 feet. The well sections at Huntington, Greenbottom, and Winfield seem to show this formation fairly well differentiated from those which occur above and below, and these sections give an average thickness of about 400 feet for the Kanawha formation. Therefore, when the section on Guyandot River is compared with these just cited, it would seem reasonable to suppose that there is a closer agreement between the Guyandot and Madison sections than between the Guyandot and Huntington sections, and it seems advisable provisionally, at least, to regard the top of the Pottsville as about 400 feet beneath the surface at the mouth of Big Hart Creek.

Lower limit of Kanawha formation.

The Kanawha formation shows in outcrop on Guyandot River and on its principal branches almost down to the mouth of Fourmile Creek. It outcrops to a slight extent in the valley of Mud River, on Twelvepole Creek, and on Tug Fork of Big Sandy River. On East Fork of Twelvepole Creek it sinks beneath water level a short distance below Cove Creek post-office, and on West Fork near Radnor.

Charleston sandstone.—Above the blue and grayish shales and sandstones which constitute the Kanawha formation, and below the red shales of the formation next above, is a sandy conglomeratic series which varies from 200 to 300 feet in thickness and is named from the city of Charleston, where it is especially well developed along the bluffs of Kanawha River.

The base of this formation occurs at the horizon of the black flint and is indefinite in this quadrangle. The top is more definite, but even this horizon is irregular. The coarse material which is the prevailing constituent of this formation is not made up of a continuous sheet of sandstone or conglomerate, but is composed of many lenses of coarse material which overlap one another, so that it is often difficult to determine whether one is following the same horizon or not. The representation of the top of this formation by a boundary line is doubtless in error to some extent, but it is believed that across this quadrangle the amount of error is not great enough to sensibly vitiate the work. There is no regularity in the number and thickness of the sandstones which compose this formation; they vary greatly from place to place.

Overlapping sandstones at top of the Charleston.

In outcrop the Charleston sandstone shows only in the southern half of the quadrangle. It comes well toward the tops of the hills along the southern margin of the territory, and northward sinks gradually until it passes beneath drainage level. On Mud River this is accomplished about 2 miles above Hamlin, on Guyandot River it dips beneath the stream near Falls Creek, on East Fork of Twelvepole Creek it disappears near Elmwood, and on West Fork near Sidney. In the well sections it can be identified with considerable certainty at Catlettsburg, Central City, Huntington, Greenbottom, and Winfield; and at no very great distance below this quadrangle on Ohio River it can be seen rising from the river level on the northwestern side of the basin.

Braxton formation.—This includes all of the Carboniferous strata in this district above the Charleston sandstone. In previous reports on the region this formation, together with the Charleston sandstone, which underlies it, has been called the Elk River series. In the present case there seems to be no reason for grouping formations of such diverse characteristics as the Charleston sandstone and the Braxton formation, hence they are considered as separate lithologic units. The Braxton formation consists largely of red and green shales and green sandstone, but there are numerous lenses of white, compact sandstone or conglomerate. These lenses are generally large, frequently extending 5 or 10 miles, but eventually thinning out and disappearing from the section. Owing to this irregularity and uncertainty in the hard and prominent beds, it is almost impossible to determine the exact structure and to ascertain with certainty the thickness of the strata involved. The well sections, however, afford a fairly reliable measure of this formation in the northwest corner of the quad-

Numerous lenses of sandstone in the Braxton.

rangle. It is thus found that the Braxton formation is not less than 800 feet in thickness, but the upper limit can not be determined in this region, for the reason that there is no stratum in its upper part that has sufficient individuality or continuity to be used as a horizon upon which to subdivide the formation. Moreover, there is no change in the character of the material from the top of the Charleston sandstone to the highest beds that can be found in this district, except local variations which are useless for purposes of geologic subdivision.

The softness of this formation gives rise to rather smooth and rounded topographic outlines, and although the country is hilly, it is not so rugged and forbidding as that formed from the lower measures.

PLEISTOCENE (?) DEPOSITS.

Stream gravels at the base of the Teay formation.

Teay formation.—In the Huntington quadrangle this formation is limited in its geographic distribution to the Teay Valley, from which it derives its name. It consists of the flood-plain deposit of the ancient Kanawha River and of the finely laminated clay laid down by it before it abandoned Teay Valley for its present course. The rising of the land since this episode and the consequent dissection of the old valley has afforded ample opportunity for the study of the deposits. Wherever the rock floor of the valley is exposed, it is found to be covered with a layer of bowlders and gravel, all well rounded and evidently shaped and deposited by a vigorous stream. These bowlders consist largely of vein quartz, which has been transported probably from the mountains of North Carolina, but there is also a notable element of quartzite and black flint bowlders in the collection. The latter are abundant and of considerable size, one being observed which measured from 12 to 16 inches in its longest diameter and from 10 to 12 inches transversely. The suggestion has been made that some other stream than the Kanawha excavated the Teay Valley, but the presence of flint bowlders in abundance shows clearly that Kanawha River occupied this valley, for only that river traverses the territory in which the black flint occurs.

Beds of sand generally occur above the pavement of bowlders and gravel, but the arrangement of the material is irregular, as would be expected from the work of a stream. Interbedded clay and sand usually take up considerable space, but above that, in the region east of Colloden, is a deposit of finely laminated clay which has a maximum thickness of about 50 feet. This clay is very fine and carries the same colors that are found in the shales of the Braxton formation.

Limited extent of laminated clay in the Teay formation.

The distribution of the different materials in this old valley is interesting and extremely important, since it presumably has a bearing on the history of the change in the drainage arrangement. Bowlders and gravel have been found at every point where the old valley floor is exposed; sand also is apparently a constant feature, but the clay appears to be limited to certain portions. In a remnant of this same valley back of Russell, Kentucky, there is no clay to be seen; the floor of the valley is composed entirely of bowlders and sand, and the same black flints occur here as in the Huntington region. In the vicinity of the city of Huntington sand is very abundant in the valley, and there is also a thick deposit of fine clay, but at no point was lamination observed in the clay. East of Colloden finely laminated and banded clay is the most noticeable feature of the deposit, and it occurs entirely across the valley. Occasional pockets of such material may be found on the flood plain of a large and sluggish river where the overflow from great freshets collects in a back lagoon, allowing the mud carried in suspension slowly to settle, but this mode of deposition will not suffice to explain a deposit 50 feet in thickness and apparently extending entirely across the old valley. At first sight it might seem as though the original suggestion of a glacial ice dam in Ohio River would best explain the phenomena, but if such a dam existed, it would cause deposition of fine sediments all along the old channel above the dam, consequently the valley back of Russell, Kentucky, should contain such sediments as well as the Teay Valley proper. Ponding undoubtedly occurred in the upper end of Teay Valley, and it seems probable that it was caused by the accumulation of floating river ice borne down by the waters of Kanawha River.

On the above supposition the clay deposited in Teay Valley belongs to the early part of the Pleistocene period, and the sand and gravel, which are practically inseparable in mapping, are considered of the same geologic age.

Alluvium.—Alluvium is the latest deposit of the flood plains of Ohio River and smaller streams; these plains are in process of formation and re-formation at every period of high water, and they vary in composition from the gravel plains of the mountain streams to the fine silt of the Ohio Valley. The latter is very extensive, not only along the river itself, but in many of the small ravines that are flooded when the great freshets of the river occur.

CORRELATION OF FORMATIONS.

Correlation with the Pennsylvania section.

The earliest geologic work in the Appalachian coal field was done in Pennsylvania, hence that has been generally regarded as the type locality, and the rock series there exposed has been taken as the standard for the entire basin. When the coal-bearing rocks of the Kanawha Valley were examined they were found to bear a strong resemblance, both in their lithologic character and in their succession, to the type section of Pennsylvania, and the formation names for the latter locality were carried south to the new field. This transfer of names was made entirely upon the lithologic similarity of the rock series in the Kanawha Valley to that of the northern field, without reference to their contained fossils. The difficulty in using fossils for correlation purposes was that those of marine origin are too sparingly distributed, both geographically and throughout the geologic column, and the fossil plants had not been adequately studied at the time of the earliest work in this region.

During the course of the present work extensive collections of fossil plants have been made by Mr. David White from the formations in the Kanawha Valley. Upon comparison with fossils from the type localities in Pennsylvania, it has been found by Mr. White that the correlations based on lithologic similarities do not correspond to those made on the evidence of the fossil plants. Hence the application of Pennsylvania names to formations, and even to individual coal seams in this region is incorrect and the names must give place to a local nomenclature based on the character of the beds, without reference to sections in other parts of the field. This space is too limited to express in full Mr. White's conclusions, but they may be found in his paper entitled Relative age of the Kanawha and Allegheny series as indicated by the fossil plants: Bulletin of the Geological Society of America, Vol. II, pp. 145–178.

STRUCTURE.

The structure of the Appalachian coal field is that of a broad, flat trough, in which, in a general way, the oldest strata line the bottom of the trough and extend to the margins on either side; the succeeding formations occupy similar positions, except that their outcrops are always within and concentric with those of the next older formations. This succession continues until the latest or youngest rocks are reached, in the center of the basin. This result may be produced in one of two ways: Either the rocks were deposited in horizontal and parallel formations and then folded into a trough or syncline subsequent to their deposition, or they were deposited in a trough or syncline of deposition the form of which was determined mainly by the floor on which the sediments were deposited. The basin would be gradually filled by the successive deposits, restricting its area more and more, until finally the last sediments poured into the basin filled it completely and removed it from the area of active deposition.

The coal basin a folded syncline of deposition.

Doubtless the geologic phenomena shown in the Appalachian coal field are the combined results of the processes here outlined, for it is evident that much of the material now constituting the coal-bearing rocks was originally laid down in synclines of deposition, and also that this same material, since its consolidation into indurated rock, has been thrown into great folds along the eastern margin of the field.

Thus in the Appalachian trough the sedimentation of the coal-bearing rocks undoubtedly began in a trough-shaped depression, but that depression was not located on the axis of the basin; the earliest deposition began along the eastern margin, and since the supply of material came from the east, that part of the basin received by far the larger part of the material and consequently the lower formations are very much thicker there than on the western side. Since the close of deposition, movements have occurred, which, in many places, produced large folds within the limits of the coal field; and in all cases, except in the southern end of the field, they have raised the eastern margin far above the western side.

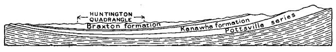

Fig. 2.—Sketch section across the Appalachian coal basin in the latitude of Huntington, West Virginia.

Thinning of formations toward the west.

A sketch section across the basin as it now stands is shown in fig. 2. The lowest formation — the Pottsville — is represented as thinning from 1500 feet on the eastern outcrop to about 250 feet on the western. A similar change is observed in the Kanawha from 1100 feet on the east to 270 feet on the west; and some change in the same direction is noticeable in the Charleston sandstone. As shown by the figure, the position of the Huntington quadrangle is in the center of the basin so far as the Braxton formation is concerned, but its geographic position is well over toward the western edge of the field.

Although the coal-bearing rocks of Virginia, Tennessee, and Alabama may be many times thicker than those of northern West Virginia, Pennsylvania, and Ohio, the northern part of the basin contains more formations and younger rocks than the southern. That is, the northern part represents a longer period of time, but a slower rate of accumulation of material. The Huntington quadrangle is at the southern extremity of this northern basin, and hence its rocks are more influenced by the pitch of the syncline toward the north than by the dips toward the center. Across this area the outcrop of the Braxton formation is approximately east and west, but when this line is followed to the east and the west it is found to bend to the north and within a score of miles to run parallel with the axis of the basin and on the opposite sides thereof.

Structure section.—The section on the Structure Section sheet represents the strata as they would appear in the side of a deep trench cut across the quadrangle along the line A–A. The vertical and horizontal scales are the same, hence the actual form and slope of the land and the dips of the strata are shown. The deep drilling which has been done in this region renders it possible to show many of the formations below the surface and therefore to present a far more accurate section than could possibly be constructed from surface observations alone. Thus the section shows the probable base of the Kanawha formation, the Pottsville series, and the Newman limestone. It also shows in a graphic manner the thinning of several of these formations toward the northwest.

MINERAL RESOURCES.

COAL.

Coal is by far the most important mineral occurring within the limits of the Huntington quadrangle. It is not equally distributed throughout the geologic formations, and consequently its geographic range is somewhat restricted. The red shales of the Braxton formation contain very few coal beds, and those which do occur are generally too thin to be of commercial importance. The coarser beds of the Charleston sandstone contain important coals which have a rather wide distribution in this territory. The Kanawha formation also carries some promising coal beds in this quadrangle, but its outcrop is so limited that the exposed coals are largely confined to the valley of Guyandot River.

Correlation with the Pittsburg coal.

Coal in the Braxton formation.—The highest known workable coal in this formation occurs near the summits of the hills back of Huntington. It is generally regarded as the equivalent of the Pittsburg coal of western Pennsylvania, but it can not be traced continuously to any known outcrop of that celebrated seam. The openings on this bed had fallen shut, but the section reported by Prof. I. C. White (section 1 of Coal Section sheet) shows a bench of clean coal 42 inches in thickness. The horizon of this coal doubtless outcrops entirely across the northern part of this quadrangle, but it is very doubtful whether the coal itself can be found in workable thickness. The supposed Pittsburg coal is fully represented on Kanawha River near Raymond, where it has been mined for many years, but in passing westward it is soon lost to view, and probably it is thin or absent in much of the territory between Kanawha River and Huntington. On the headwaters of Fudger Creek, 4½ miles southwest of Milton, a coal bed 27 inches in thickness was observed, which may be the representative of the Huntington bed, but the absence of any continuous and distinctive stratum in the red shales renders it almost impossible to determine the exact stratigraphic position of coal outcrops in the upper part of the Braxton formation.

Small mine at Hamlin.

In the lower part of the Braxton formation there seems to be a general coal horizon from 100 to 200 feet above the base. A coal bed varying from 34 to 36 inches in thickness has been prospected rather extensively on Big Sandy River opposite Louisa, Kentucky. A coal at about the same horizon has been opened in a number of places on Big Hurricane Creek in the vicinity of Roundbottom, where it ranges from 24 to 30 inches in thickness. Both of these localities are west of this quadrangle and nearly west of and within a radius of 7 miles of Sidney. On Tug Fork of Big Sandy River openings have been made on a coal belonging to this group (section 2) which shows increased thickness, but a number of small shale partings. A coal bed at about this horizon has been opened on Trace Fork of Greenbrier Creek, just beyond the western edge of this quadrangle, which shows a total thickness of 3 feet, with some shale partings. What is presumably the same bed is mined on a small scale on West Fork of Twelvepole Creek about 2 miles above Wayne, where it shows a thickness of only 2 feet. East of Twelvepole Creek this horizon seems to be unpromising, at least no openings were seen in which the coal was exposed, except on Mud River just below Hamlin, where a mine is being operated in a small way to supply the local demand, on a bed which shows 3 feet of clean coal (section 3).

On the eastern margin of this quadrangle a coal horizon appears to be within 50 feet of the base of the formation; it does not show well at any point in this territory, but was seen at a number of places within a mile of the eastern margin. It is most extensively developed on Middle Fork of Mud River in the vicinity of Griffithsville, where several small mines have been opened. The bed section at a mine just northeast of the village is shown in section 4, and at a mine east of the village in section 5. What is probably the same seam is opened 2 miles south of Griffithsville on Sugartree Fork, but if so, the character of the bed is greatly changed, as shown in section 6.

The coal beds of the red shales.

The conditions which prevailed during the deposition of the red shales were not favorable for great accumulations of vegetable matter, and hence the coal beds found in these strata are, as a rule, thin and of little commercial value. The maximum thickness that may be expected in these beds appears to be about 3 to 3½ feet, and the great majority fall considerably below this measure.

Coal in the Charleston sandstone. — On the whole, this is the most productive formation exposed in this territory. As before noted, its boundaries are too uncertain to allow of the exact location of all the observed coal outcrops in or about the horizon of this formation, hence the stratigraphic positions herein assigned to the various exposures of coal must be taken with some allowance.

Abandoned plant at Fleming.

The most important coal horizon in the Charleston sandstone occurs about 70 feet below the top of the formation. After the building of the Norfolk and Western Railway up Twelvepole Creek persistent efforts were made to mine this bed of coal, but, owing to the amount of impurities in it, the work has been abandoned. In the bend of the creek below Fleming an elaborate mining plant was established on this bed, but the great number of partings, as shown in section 8, rendered mining expensive and the plant was abandoned. In the bend of the stream above Radnor a coal was opened at what appears to be the same horizon and a mining plant was partly completed when the work was abandoned. Two beds, separated by an interval of 60 feet, were opened at this point; the upper bed was not visible at the time of this survey, but, from the character of the dump heap, it carries a large amount of bony coal; the lower coal is small, as shown in section 9, and certainly could not have been mined to advantage. Section 10 is from the same bed at an opening just below Ferguson, where it preserves its shale partings and generally poor character. East of Ferguson, on the road which leads across the ridge to Rich Creek, there has been opened by the roadside (section 11) a small coal which occurs at about this horizon, but which shows little resemblance to the sections already described.

Openings in the vicinity of East Lynn.

On East Fork of Twelvepole Creek in the vicinity of East Lynn two openings have been made at this horizon which show a much cleaner, though thinner, bed than that on the other fork of the creek. The character of the coal at the forks of the road is shown in section 12, and that one-fourth of a mile north is shown in section 13. On Big Lynn Creek, 2 miles from the openings just described, this coal shows a much greater thickness (section 14), but it partakes more of the shaly character of the coal on West Fork. On Left Fork of Camp Creek about 3 miles east of East Lynn an opening has been made at this horizon which shows a total thickness of 5 feet and the base of the bottom bench of coal is not visible, but, as shown in section 15, the bed carries a 10-inch parting of shale which greatly detracts from its value. On Beechy Branch there are two beds of coal, separated by an interval of 100 feet, which make a rather favorable showing. The uppermost bed appears to be at the horizon which we have been considering. Section 16 represents the seam at an opening 1¾ miles from the mouth of the branch. The lower bed will be described hereafter in connection with the next general coal horizon. On Little Laurel Creek 1½ miles southwest of Cove Gap there is a well-known bed of cannel coal which appears to be at this horizon. The cannel is, of course, a local development and there is no evidence to show the extent of the deposit. It is not very thick at this point, as is shown by section 17. Only one other exposure of this seam is known on the tributaries of Twelvepole Creek. This occurs on a small branch of East Fork below Maynard Branch, and the bed at this point is small (section 18) and does not show any trace of cannel.

Openings near Sheridan.

Large amount of coal on Fourmile Creek.

On Guyandot River this horizon seems to be characterized by a thicker bed of coal than farther west, and it has attracted considerable attention from prospectors and speculators. As early as 1853 a report was made on this region by Prof. John Locke, to which the writer is indebted for many sections of coal beds that have become inaccessible. It seems probable that in the measurements of these sections some small shale partings have been ignored, but on the whole the sections agree with those obtained at a later date from adjacent localities. The coal horizon rises above water level in this valley near Sheridan, and the first openings of which any record exists occur near the river bank about a mile above the post-office. At this point Professor Locke reports three openings on the coal, the thickness and character of which is shown in sections 19, 20, and 21. The variability of the bed is well shown by sections 19 and 20, which are from openings only a short distance apart on the eastern side of the river. Section 19 shows a bench of cannel 16 inches in thickness at the top of the bed; in section 20 the division into two benches still holds, but no mention is made of cannel in the uppermost bench. The shale parting, which on the eastern side of the river is insignificant, has a thickness of 24 inches at the opening on the western side (section 21), although the distance between these localities is not more than one-half mile. Section 22 represents this bed at the mouth of Fourmile Creek, where it has been opened at an elevation of 50 feet above water level. The total amount of coal shown at this point is considerable, but it is badly cut up by two shale partings, each 10 inches in thickness. This bed of coal has a remarkable development on Fourmile Creek, but along with the expanded section of the coal there is thickening of the shale partings and also great variability from place to place in the appearance of the seam. A large amount of coal is visible on this creek, but it will be expensive to mine owing to the great proportion of impurities in the bed and to its variability. On Trace Fork a short distance above the main stream this bed makes a large showing in the banks of the stream, but, unfortunately, it includes almost as much shale as coal, as is shown in section 23. On Harless Fork the thickness given by Professor Locke is shown in section 26. The coal is certainly remarkably thick, but it seems probable that it is more broken by shale partings than appears in this section. At the time of the present survey the full thickness of the coal could not be determined, for the lower bench was obscured by débris, but a careful measurement of the upper bench is represented in section 25. It will be observed that the total thickness of the coal shown in section 25, including all of the shale partings, differs only 1 inch from the thickness of the top bench in section 26, hence it seems probable that in the sections given by Professor Locke the minor shale partings have been generally ignored.

Thick coal on the Guyandot at Stout Creek.

The rocks rise rapidly southward, so that in passing up the river this bed of coal occupies a position high in the hills and eventually the plane of the bed passes above the highest summits. Professor Locke reports an opening on this coal just below the mouth of Salt Sulphur Branch and 200 feet above the level of Guyandot River. Its character at this point is shown in section 27. In the point just below the mouth of Stout Creek and 234 feet above the level of the river an opening has recently been made on this seam which shows the best bed section that has yet been exposed. It consists of two benches of coal (section 28), aggregating a thickness of 99 inches, all of which, except 4 inches, is clean coal. Section 29 represents only a part of the same seam about a mile up Stout Creek, and although some allowance must be made for minor features, it shows that approximately the same body of coal exists for a considerable distance on this side of the river. Near the head of Ninemile Creek a coal bed at about the same horizon has been opened, but, while it has a thickness of 4 feet (section 30), the coal is dirty and contains considerable sulphur. It is possible that this is only one bench of the large bed, but there is no evidence at present available to show that the great development of this bed extends indefinitely southward from Stout Creek. The absence of any large bed or beds at this horizon on the headwaters of the East Fork of Twelvepole Creek makes it seem probable that the great thickness which prevails on Stout Creek does not extend far toward the south. A coal bed at this horizon, reported to have a thickness of from 4 to 5 feet, has been opened on the long spur on the western side of the river nearly opposite the mouth of Sand Creek. This is the last opening known on this coal along Guyandot River.

On Mud River this horizon is inconspicuous as far as workable coal beds are concerned. On Bear Branch a coal at this horizon has been opened, which is perhaps typical of the conditions of the bed in this region. Its character is shown in section 31, from which it will be seen that not only is the bed thin, but it has many partings, which detract very much from its value.

The thick coal bed restricted in area.

In briefly reviewing the facts concerning this coal horizon it will be seen that it is of little value in the basins of Twelvepole Creek and Mud River. Its principal development is in the Guyandot Basin between Sheridan and Big Ugly Creek, but even in this territory its greatest development is confined to a small area.

Four foot coal near Radnor.

A few coal openings were observed which appear to be near the middle of the Charleston sandstone. Section 32 represents this bed at an opening on West Fork of Twelvepole Creek in the vicinity of Radnor. The exact section could not be measured at this point, but it had the appearance of being about 4 feet in thickness. On Beechy Branch of East Fork of the same stream two openings were visited which appear to be at this horizon. Section 33 represents the coal near the mouth of the branch and section 34 an opening near its head and 100 feet below the coal shown in section 16. In each of these sections the full thickness of the bottom bench of coal could not be determined, hence they are incomplete, representing only that which was visible. Near the head of Trough Creek, on the road leading from Kiah Fork to Little Hart Creek, there is an opening on a coal bed at or near this horizon which is represented in section 35. The top of the bed contains a bench of bony coal 16 inches in thickness, which detracts very much from its market value.

Coal in the Kanawha formation.—A number of openings were observed upon a coal bed which appears to belong at about the division line between the Charleston sandstone and the Kanawha formation. The uncertainties of this boundary line make it doubtful whether these various exposures are all on the same bed, but if they are not, they at least appear to be at the same general horizon.

One of the early attempts at development of the coal resources of Twelvepole Valley was made at this horizon at Dunlow, but, like similar operations farther downstream, it was abandoned on account of the poor character of the coal bed. Section 36 represents the coal at the old mines. On East Fork near Maynard Branch a worthless coal bed, represented in section 37, has been opened.

A smaller important coal bed of the Guyandot Valley.

In the Guyandot Valley this bed has been noted at a number of places, but it is generally small, at least by comparison with the big bed in the Charleston sandstone which is so prominent in that locality. The smaller bed rises from water level just above the mouth of Fourmile Creek. Section 38 is from an opening about a mile below Sixmile Creek, as reported by Professor Locke. The coal rises southward at the same rate as the seam above, and opposite Vanetta Creek it shows in an opening 115 feet above water level. It thickens also as it rises, for at the latter opening, as reported by Professor Locke, it has the character shown in section 39. A short distance farther up, and opposite Laurel Creek, it shows a total of 56 inches of coal, as indicated in section 40. Just below the mouth of Fourteenmile Creek an opening is reported by Professor Locke (section 41) which appears to be on a coal bed slightly lower in the series than the beds previously considered. All of the exposures so far described occur presumably within an interval of 50 feet. On Mud River at the mouth of Stonecoal Branch, which is just beyond the eastern margin of this quadrangle, there is another opening at this same general horizon.

The observed coal outcrops which come within about 250 feet of the top of the Kanawha formation are rather scattering in their stratigraphic arrangement, and it is difficult, if not impossible, to make definite correlations. One of these outcrops was observed on Guyandot River on the point of the ridge between Big and Little Ugly creeks. Section 43 shows that there is some cannel in the bed at this point, but the amount is too small to render it of commercial importance. The next opening on this general horizon is reported by Professor Locke from a small ravine below the mouth of Big Hart Creek and at an elevation of about 200 feet above the level of the river. This coal is promising, as shown by section 44. A lower coal bed was found on Marsh Fork of Big Hart Creek just beyond the limit of this quadrangle. The coal is inaccessible, but current report places its thickness at about 42 inches (section 45). On Big Creek, in the extreme southeast corner of the quadrangle, there are a number of openings on a coal bed considerably lower in the series, but at one point a bed is exposed high on the hillside which apparently belongs to the horizon under consideration. Section 46 represents the coal at this point.

One hundred and thirty feet below the above-described coal opening there is another coal which has the character shown in section 47. This is not a very thick bed, but it carries at the bottom a foot of cannel and cannel shale, which may, upon further exploitation, prove valuable enough to be worked.

Coal in Big Creek region.

The principal coal bed in the Big Creek region ranges from 300 to 400 feet beneath the top of the formation. Its lowest observed outcrop is on Guyandot River a mile above Green Shoal Branch, where it shows a thickness of 40 inches of clear coal (section 48); it outcrops again just below Limestone Branch, with the same thickness (section 49) as shown in the previous section. On Big Creek there are six openings which appear to be on this coal bed, but some of them may be on beds either a short distance above or below the type coal on Guyandot River. These openings show that the bed or beds increase in size in this direction as seen in sections 50, 51, 52, 53, 54, and 55.

Summary of data on the coal of the quadrangle.

Summarizing the evidence just presented regarding the coal beds of the Huntington quadrangle, it would appear that the distribution of the commercially valuable coal, as far as can be judged from the evidence in hand, is about as follows: In the red shales, or the Braxton formation, there is small probability of finding coal beds of sufficient thickness to be of commercial importance. There may be pockets in which the supposed Pittsburg coal is thick enough to be mined, but the existence of such pockets is doubtful. The coal horizon near the base may furnish supplies for local consumption, but the outlook for anything better than this is not encouraging. The various horizons of the Charleston sandstone are more promising, especially in the valley of Guyandot River. Outside of this valley the experience has been that mining at these horizons is unprofitable, and there seems no reason now to change this verdict, unless local deposits of cannel of sufficient thickness to be economically mined shall be found. Along Guyandot River the coal near the top of the Charleston formation is an attractive looking bed at some points, and doubtless will be of value when transportation can be secured for the product of the mines.

Geographically the coals in the Kanawha formation also are limited to the Guyandot Valley, and they give promise of a supply nearly equal to that of the formation next above.

SOILS.

The soils of the Huntington quadrangle are largely derived from the decay and disintegration of the rocks immediately underlying them. Consequently the geologic map which shows the areal distribution of the various formations may with certain modifications be regarded as a soil map also. In such an interpretation of a geologic map, however, it must be distinctly understood that in the process of soil production many of the important elements of the rocks are removed by solution, and consequently the soil, as a rule, contains only the more insoluble elements of the rock from which it was derived.

The soils derived from the Kanawha formation are unimportant in this quadrangle, for they occupy only a small territory and the surface upon which these rocks outcrop is so steep that it has only limited agricultural possibilities. The soils derived from the Charleston sandstone are generally too arenaceous for good farming lands, and the outcrop is generally too steep to be profitably farmed. The Braxton formation is much better adapted to the formation of tillable soils. Its rocks are more clayey and also more calcareous, so that the resulting soil is frequently a very rich and fertile loam. The rocks composing this formation vary considerably from place to place, and the soil shows a similar change; hence the agricultural possibilities are different in the various sections of the quadrangle covered by the Braxton formation. The alluvial bottoms, or the flood plains of the creeks and rivers, constitute the most productive land of the region. This land is formed of material derived from various sources and brought down by the streams during periods of high water and deposited where the current is sluggish, out of the immediate channel. By the repetition of this process at each freshet the soils are renewed and the elements which had been exhausted by the growing crop are again added to the soil.

The Ohio portion of this quadrangle is almost entirely cleared of forest and is either under cultivation or devoted to the grazing of stock. In the West Virginia portion the surface is more broken, the forests are much more extensive, and a smaller proportion of the land is used for farming purposes.

MARIUS R. CAMPBELL,
Geologist.

December, 1900.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT DIRECTOR

TOPOGRAPHIC SHEET

WEST VIRGINIA—OHIO—KY.
HUNTINGTON QUADRANGLE

Henry Gannett, Chief Topographer.
Gilbert Thompson, Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
Topography by L.C. Fletcher.
Surveyed in 1890.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.

Datum is mean sea level.

Edition of June 1900.

LEGEND

RELIEF
(printed in brown)

1431

Figures
(showing heights above mean sea level instrumentally determined)

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

DRAINAGE
(printed in blue)

Streams

CULTURE
(printed in black)

Roads and buildings

Trails

Railroads

Bridges

Ferries

State boundary lines

County boundary lines

△

Triangulation stations

U.S. GEOLOGICAL SURVEY
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HISTORICAL GEOLOGY SHEET

WEST VIRGINIA—OHIO—KY.
HUNTINGTON QUADRANGLE

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Edition of July 1900

Geology by M.R. Campbell.
Assisted by W.C. Mendenhall
and L.C. Glenn.
Surveyed in 1897.

LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles.)

PLEISTOCENE

- Pal — Alluvium *(flood plain of the Ohio River)*
- Pt — Teay formation *(gravel, sand, and laminated clay deposited by the ancient Kanawha River)*

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

CARBONIFEROUS

- XV XIV
  - Cbx — Braxton formation *(red and green shales, with local developments of sandstone, conglomerate, and seams of coal)*
  - Cch — Charleston sandstone *(coarse sandstone or conglomerate, frequently interbedded with shale and coal seams)*
- XIII
  - Ck — Kanawha formation *(shales and sandstones with many seams of coal)*

Section

U.S. GEOLOGICAL SURVEY
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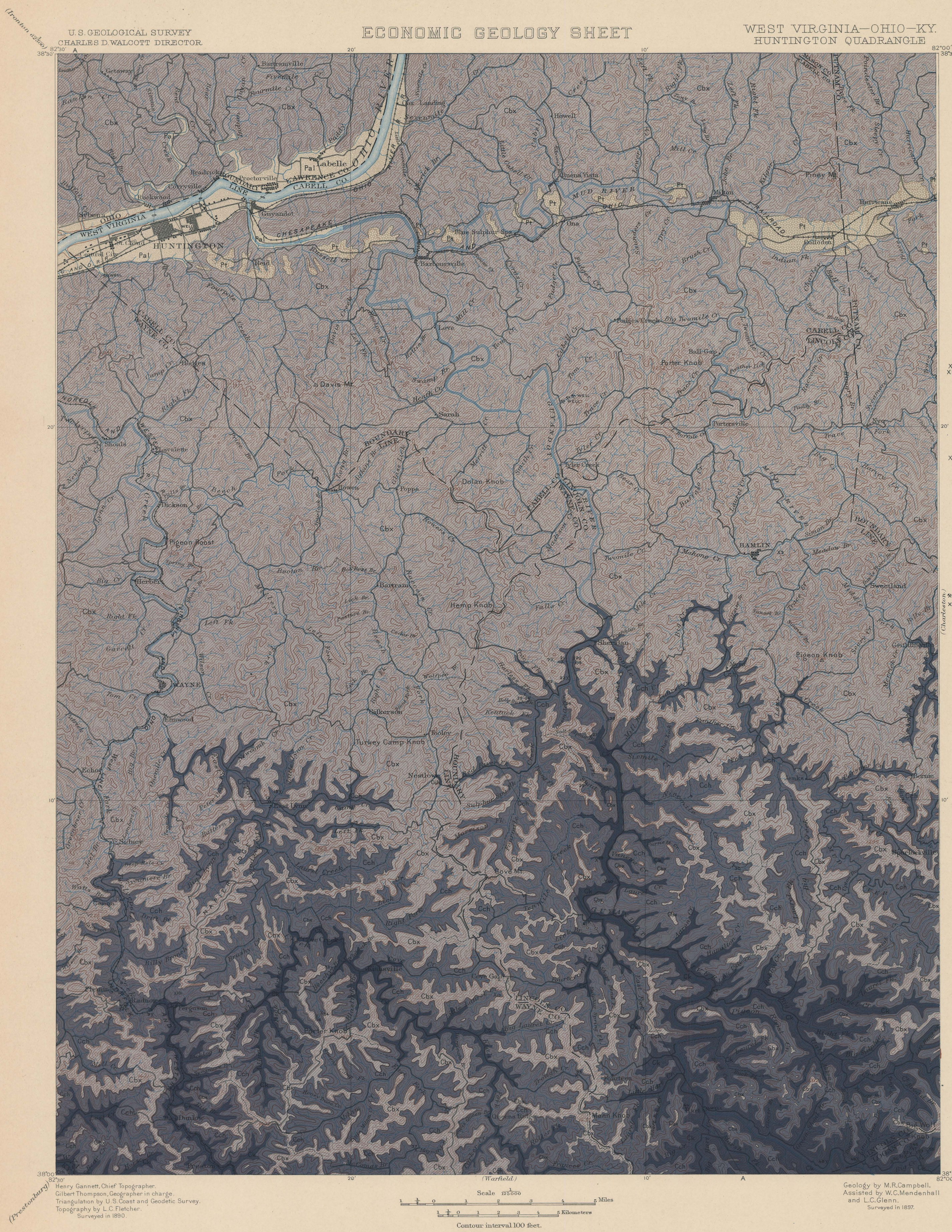
ECONOMIC GEOLOGY SHEET

WEST VIRGINIA—OHIO—KY.
HUNTINGTON QUADRANGLE



LEGEND

SURFICIAL ROCKS

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(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

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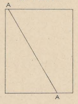
XIII

Ck — Kanawha formation *(shales and sandstones with many seams of coal)*

Section



⚒ *Wells drilled for oil*

× *Coal prospects; numbers refer to detailed sections on coal-section sheet.*

Known productive formations

Cbx — *Coal* *(Braxton formation contains coal seams)*

Cch — *Coal* *(Charleston sandstone contains coal seams)*

Ck — *Coal* *(Kanawha formation contains many seams of coal)*

Henry Gannett, Chief Topographer.
Gilbert Thompson, Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
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Scale 1/125000

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U.S. GEOLOGICAL SURVEY
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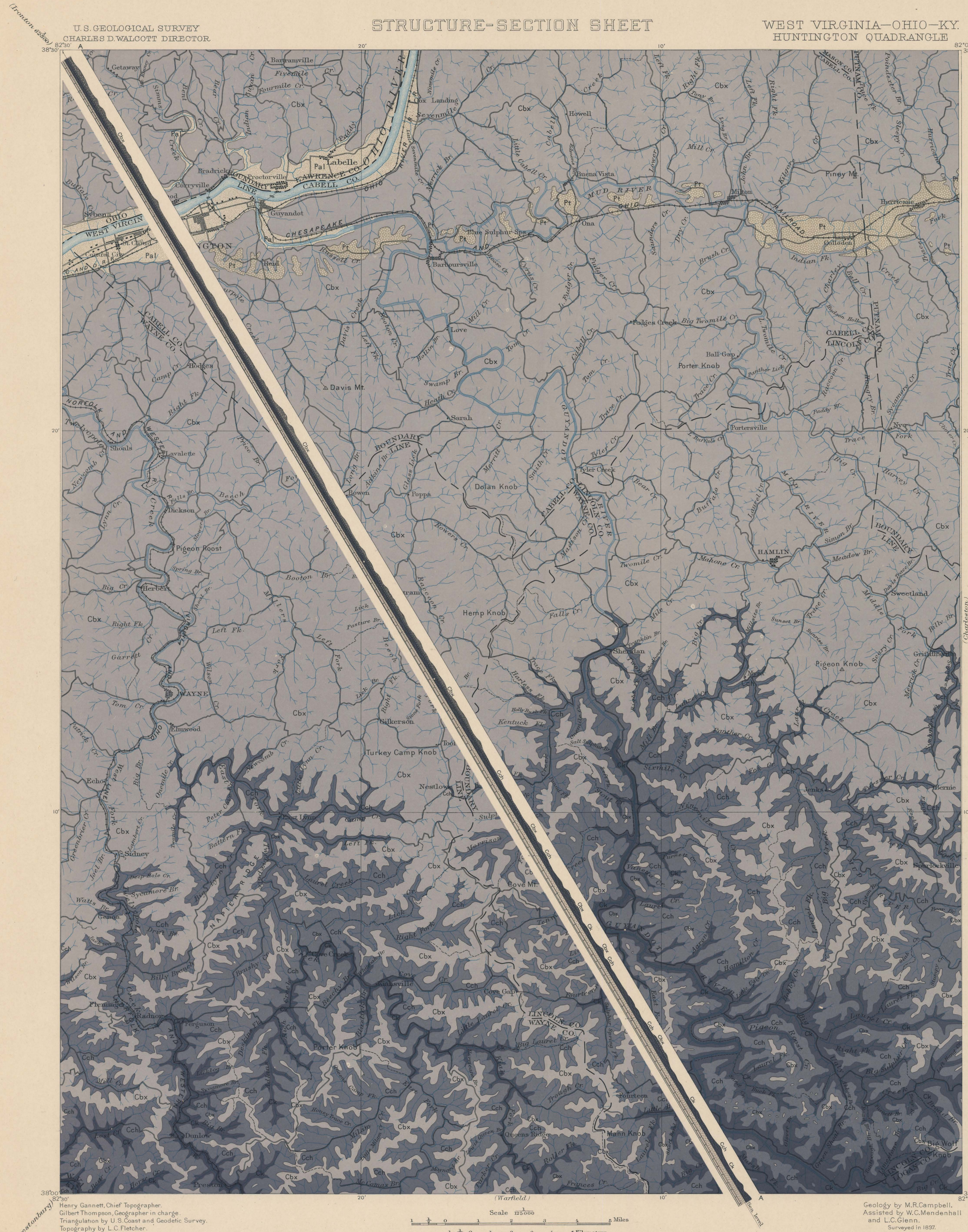
STRUCTURE-SECTION SHEET

WEST VIRGINIA–OHIO–KY.
HUNTINGTON QUADRANGLE



LEGEND

SURFICIAL ROCKS

SHEET SYMBOL		
Pal	**Alluvium** *(flood plain of the Ohio River)*	PLEISTOCENE
Pt	**Teay formation** *(gravel, sand, and laminated clay deposited by the ancient Kanawha River)*	

SEDIMENTARY ROCKS

	SHEET SYMBOL	SECTION SYMBOL		
XV XIV	Cbx	Cbx	**Braxton formation** *(red and green shales, with local developments of sandstone, conglomerate, and seams of coal)*	CARBONIFEROUS
	Cch	Cch	**Charleston sandstone** *(coarse sandstone or conglomerate, frequently interbedded with shale and coal seams)*	
XIII	Ck	Ck	**Kanawha formation** *(shales and sandstones with many seams of coal)*	
		▨	*(sandstone, conglomerate, and limestone; observed beneath the Kanawha formation in well borings)*	

Known productive formations

Cbx	Coal *(Braxton formation contains coal seams)*
Cch	Coal *(Charleston sandstone contains coal seams)*
Ck	Coal *(Kanawha formation contains many seams of coal)*

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1 ½ 0 1 2 3 4 5 Kilometers

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