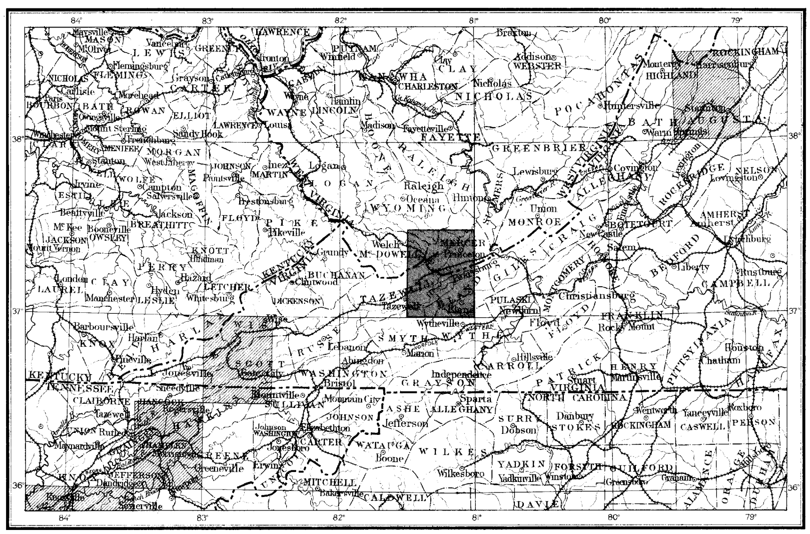
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS OF THE UNITED STATES

POCAHONTAS FOLIO

VIRGINIA - WEST VIRGINIA

INDEX MAP



SCALE: 40 MILES = 1 INCH

AREA OF THE POCAHONTAS FOLIO

AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION   TOPOGRAPHY   AREAL GEOLOGY   ECONOMIC GEOLOGY   STRUCTURE SECTIONS

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FOLIO 26   FIELD EDITION   POCAHONTAS

WASHINGTON, D. C.
ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

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 stated on the map by numbers. It is desirable to show also the elevation of any part of a hill, ridge, or valley; 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 constant 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:

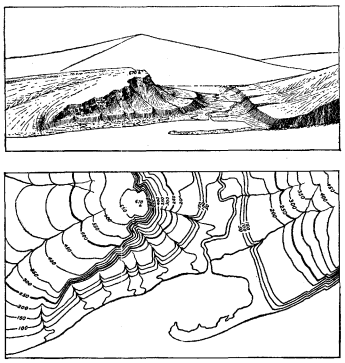


Fig. 1.—Ideal sketch and corresponding contour map.

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 to a precipice. Contrasted with this precipice is the gentle descent of the western 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 occur 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 so with any other contour. In the space between any two contours occur 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 240 feet long and 180 feet high this would cover, on a scale of 1 mile to the inch, 3,025,000 square inches. 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 special 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 fractional 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 of natural length to an inch of map length. 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 three scales are stated, 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.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree; 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. These areas correspond nearly to 4,000, 1,000, 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. For convenience of reference and to suggest the district represented, each sheet 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 region 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 areal geologic map represents 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 maps show 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 very 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 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 made are carried as solid particles by the 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 rocks 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 a guide 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 and formed 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 one was deposited first.

Fossil remains found in the rocks of different areas, of different provinces, and of different 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 below. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period names.

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, with the exception of the Pleistocene, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the

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	Є	Pinks.
Algonkian	A	Orange-browns.
Archean	Æ	Any colors

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. 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 of surficial formations of the Pleistocene is so great that, to distinguish its formations from those of other periods and from the igneous rocks, the entire series of colors is used in patterns of dots and circles.

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.

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.

Areal 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. The formations are arranged according to origin into surficial, sedimentary, and igneous, and within each class are placed in the order of age, so far as known, the youngest at the top.

Economic 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 areal 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 these 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:

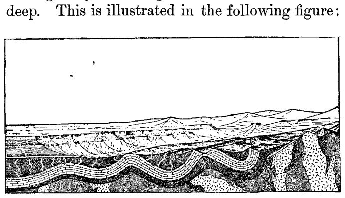


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape above.

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:

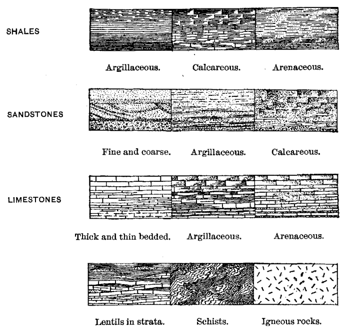


Fig. 3.—Symbols used to represent different kinds of rock.

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 position, 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 consist 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 constitute the local record of geologic history. 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 1,000 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.

DESCRIPTION OF THE POCAHONTAS SHEET.

GEOGRAPHY.

General relations.—The territory represented by the Pocahontas atlas sheet is one-quarter of a square degree of the earth's surface, extending from latitude 37° on the south to 37° 30′ on the north, and from longitude 81° on the east to 81° 30′ on the west. Its average width is 27.5 miles, its length 34.5 miles, and its area 951 square miles.

The sheet is named from the town of Pocahontas, Virginia, the point at which the first development of the Flat Top coal field was begun, and from which the celebrated seam of coal takes its name. The territory is nearly equally divided between the States of Virginia and West Virginia, including in the former portions of the counties of Bland, Wythe, Tazewell, and Smyth, and in the latter portions of the counties of McDowell, Mercer, and Wyoming. The adjacent atlas sheets (north to east, to south, to west) are as follows: Raleigh, Hinton, Dublin, Hillsville, Wytheville, Abingdon, Tazewell, and Oceana.

In its geographic and geologic relations this area 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. All parts of the region thus defined have a common history, recorded in its rocks, its geologic structure, and its topographic features. Only a part of this history can be read from an area so small as that covered by a single atlas sheet; hence it is necessary to consider the individual sheet in its relations to the entire province.

Subdivisions of the Appalachian province.—The Appalachian province may be subdivided into three well-marked physiographic divisions, throughout each of which certain forces have produced similar results in sedimentation, in geologic structure, and in topography. These divisions extend the entire length of the province, from northeast to southwest.

The central division is the Appalachian Valley. It is the best defined and most uniform of the three. It coincides with the belt of folded rocks which in the southern portion of the province forms the Coosa Valley of Georgia and Alabama and the Great Valley of East Tennessee. Throughout the northern and central portions the eastern side only is marked by great valleys, such as the Shenandoah Valley of Virginia and the Cumberland and Lebanon valleys of Maryland and Pennsylvania, while the western portion is but a succession of narrow ridges with no continuous or broad intermediate valleys. This division varies in width from 40 to 125 miles. It is sharply outlined on the southeast by the Appalachian Mountains and on the northwest by the Cumberland Plateau and the Alleghany Mountains. Its rocks are almost wholly sedimentary and in large measure calcareous. The strata, which must originally have been nearly horizontal, now stand at various angles and intersect the surface in narrow belts. With the outcrop of different kinds of rock the surface changes, so that sharp ridges and narrow valleys of great length follow the narrow belts of hard and soft rocks.

The eastern division of the province embraces the Appalachian Mountains, a system made up of many individual ranges, which, under various local names, extends from southern New York to central Alabama. Some of its prominent parts are the South Mountain of Pennsylvania, the Blue Ridge and Catoctin Mountain of Maryland and Virginia, the Great Smoky Mountains of Tennessee and North Carolina, and the Cohutta Mountains of Georgia. Many of the rocks of this division are more or less crystalline, being either sediments which have been changed to slates and schists by varying degrees of metamorphism, or igneous rocks, such as granite and diabase, which have solidified from a molten condition.

The western division of the Appalachian province embraces the Cumberland Plateau and the Alleghany Mountains and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but may be regarded as coinciding with the Mississippi River as far up as Cairo, and thence extending northeastward across the States of Illinois and Indiana. Its eastern boundary is sharply defined by the Alleghany front and the Cumberland escarpment. The rocks of this division are almost entirely of sedimentary origin and remain very nearly horizontal. The surface, is that of a plateau more or less completely worn down. In the southern half of the province the plateau is sometimes extensive and perfectly flat, but it is oftener much divided by streams into large or small areas with flat tops. In West Virginia and portions of Pennsylvania the plateau is sharply cut by streams, leaving in relief irregularly rounded knobs and ridges which bear but little resemblance to the original surface. The western portion of the plateau has been completely removed by erosion, and the surface is now comparatively low and level.

Altitude of the Appalachian province.—The Appalachian province as a whole is broadly arched, its surface rising from an altitude of about 500 feet along the eastern margin to the crest of the Appalachian Mountains, and thence descending westward to about the same altitude on the Ohio and Mississippi rivers.

Each division of the province shows one or more culminating points. Thus the Appalachian Mountains rise gradually from less than 1,000 feet in Alabama to more than 6,600 feet in western North Carolina. From this culminating point they descend to 3,000 feet in southern Virginia, rise to 4,000 feet in central Virginia, and again descend to 2,000 feet on the Maryland-Pennsylvania line.

The Appalachian Valley shows a uniform increase in altitude from 500 feet or less in Alabama to 900 feet in the vicinity of Chattanooga, 2,000 feet at the Tennessee-Virginia line, and 2,500 or 2,700 feet at its highest point, on the divide between the New and Tennessee rivers. From this point it descends to 2,200 feet in the valley of New River, 1,500 to 1,000 feet in the James River basin, and 1,000 to 500 feet in the Potomac and Susquehanna basins. These figures represent the average elevation of the valley surface, below which the stream channels are sunk from 50 to 250 feet, and above which the valley ridges rise from 500 to 2,000 feet.

The plateau, or western, division increases in altitude from 500 feet at the southern edge of the province to 1,500 feet in northern Alabama, 2,000 feet in central Tennessee, and 3,500 feet in southeastern Kentucky. It is between 3,000 and 4,000 feet high in West Virginia, and descends to about 2,000 feet in Pennsylvania. The plateau slopes gradually westward, although it is generally separated from the interior lowlands by an abrupt escarpment.

Drainage of the Appalachian province.—All of the western, or plateau, division of the province, except a small portion in Pennsylvania and another in Alabama, is drained by streams flowing westward to the Ohio. The northern portion of the eastern, or Appalachian Mountain, division is drained eastward to the Atlantic, while south of the New River all except the eastern slope is drained westward by tributaries of the Tennessee or southward by tributaries of the Coosa.

The position of the streams in the Appalachian Valley is mainly dependent upon the geologic structure. In general they flow along the outcrops of the softer rocks in courses which for long distances are parallel to the mountains on either side. These longitudinal streams empty into a number of larger, transverse rivers, which cross one or the other of the barriers limiting the valley. In the northern portion of the province these transverse rivers are the Delaware, Susquehanna, Potomac, James, and Roanoke, each of which passes through the Appalachian Mountains in a narrow gap and flows eastward to the sea. In the central portion of the province, these longitudinal streams form the New (or Kanawha) River, which flows westward in a deep, narrow gorge through the Cumberland Plateau into the Ohio River. From New River to northern Georgia the valley is drained by tributaries of the Tennessee River, which at Chattanooga leaves the broad valley on its westward course to the Ohio. South of Chattanooga the streams flow directly to the Gulf of Mexico.

Topography of the Appalachian province.—The different divisions of the province vary much in character of topography, as do also different portions of the same division. This variation of topographic forms is due to several conditions which have modified the work of erosion. In the Appalachian Valley, differences in rock character and geologic structure are the conditions which chiefly govern erosion. In the Appalachian Mountains and the Cumberland Plateau, structure plays but a secondary part, and the rocks are frequently so nearly homogeneous as to have but little effect on the topography. Throughout the entire province the forms produced are largely controlled by the altitude of the land, which varies in relation to sea-level as the surface is worn down by erosion or is uplifted by movements of the earth's crust. If the land is high the streams descend rapidly to the sea, corrading narrow gorges nearly to the baselevel of erosion. By lateral corrasion these narrow gorges are gradually widened and the sides reduced from precipitous cliffs to gentle slopes. The divides between adjacent streams are, little by little, worn away, and the surface gradually approaches baselevel and becomes a peneplain. But this process is carried to completion only in case there is a constant relation of land and sea. This relation may be changed by earth movements which either raise or lower the land. When erosion is thus interrupted in any stage of its development, some of the characteristic topographic forms remain among features of later development, and they constitute a record of the conditions to which they belonged.

In the Appalachian province there are remnants of peneplains which indicate two periods of relative stability of the surface of the earth. The exact time at which these features were formed is not known, but their relation to the sediments around the margin of the province serves, in a general way, to fix their ages. The earlier and more extensive peneplain was formed in the Cretaceous period. During a very long epoch of erosion without marked uplift the surface was worn down to an almost featureless plain. This period of tranquillity was interrupted by gradual earth movements which extended over most of the province and which raised the surface far above its former position, but the elevation was unequal and the plain was warped. In the Eocene and Neocene periods other peneplains were formed, but the time during which the relation of land and sea remained constant was short, and only the softer rocks were worn down nearly to the baselevel of erosion. Again the process of baseleveling was terminated by an uplift which affected the entire province and which warped the later peneplains in a manner similar to the warping of the Cretaceous plain.

The more recent history of the province is one of general elevation accompanied by oscillations, which have caused the margin of the sea to vary in different portions of the epoch. During this time the modern river gorges were cut and much of the low-level topography was produced.

Relief of the Pocahontas area.—This territory includes portions of the Cumberland Plateau and the Appalachian Valley. The irregular ridges and valleys of the Flat Top Mountain region are characteristic topographic features of the central portion of the Cumberland Plateau, and the succession of parallel ridges in the southern part of the territory are equally characteristic of the Appalachian Valley in Virginia. In this district the surface was reduced to the level of the Cretaceous peneplain, except a few of the higher summits, which now stand from 3,300 to 4,200 feet above sea-level. Clinch Mountain, west of Burke Garden, is the most conspicuous of these high points and in Cretaceous time probably constituded a ridge rising from 500 to 700 feet above the plain. The highest summits of East River and Big Walker Mountains also probably stood in low relief above this plain, the surface of which is represented by portions of the crest-line of Cove, Little Walker, Big Walker, Brushy, Rich, and East River mountains and the higher summits of the coal field of West Virginia.

Although raised to a considerable elevation by the uplift that warped the Cretaceous peneplain, the Pocahontas district, located upon the principal divide of the Appalachian Valley, was so far removed from the main drainage lines that its surface was subsequently carved into valleys and ridges only. The hills were not planed away during Neocene time, although the valleys in the southern part of the area were probably slightly widened; but even there there is no definite plain remaining. North of East River Mountain a peneplain is recognizable in the gently rolling surface which stands at an elevation of about 2,600 feet. Standing above and clearly separated from the plain are several elevations which in some manner have been protected more than the surrounding areas and to-day remain as *monadnocks*,* or unreduced remnants of a once greater altitude of the land.

The amount of uplift which this region has suffered in late geologic time is easily determined by the elevation at which the various peneplains now stand above sea-level, from which they formerly sloped gently upward. The total uplift since Cretaceous time has been from 3,000 to 3,500 feet, the sum of two general movements, of which the later was 2,600 feet. Besides the general peneplains described above, this region possesses a well-developed local baselevel, entirely independent of the general surrounding conditions. This is Burke Garden, a unique feature, a garden in a wilderness of sharp ridges and narrow valleys. It is a limestone area surrounded by mountainous walls of hard sandstone. Wolf Creek has cut a gorge on its northern side, through which its surplus waters are discharged, but the removal of the calcareous rocks within the barrier progresses as fast as the creek can cut its gorge; hence the floor of the garden is planed to the level of the outlet of the draining stream.

The topographic forms produced by the various conditions outlined above are very well shown in this area. In the Virginia portion, geologic structure has been the most influential of the conditions modifying the action of erosion. The ridges formed by the upturned edges of the hard rocks are generally very narrow and straight, and between them narrow valleys are excavated in the softer rocks. The steepness of the slopes, and the great depth to which these valleys are eroded, indicate that a large portion of the elevation already described has occurred in very recent times. The most important valleys in this territory are (1) Bland-Sharon Springs Valley, (2) Burke Garden, and (3) Clinch River Valley. The last is more important in the region west of that represented by this sheet, but it continues eastward past Bluefield and disappears in the rugged region about Ingleside. North of this line the surface is more regular, being gently rolling over most of the area between East and Bluestone rivers. In the coal field the country is barren in the extreme, and before the development of its coals barely furnished food for the scanty population. This region, originally a table-land, is now almost completely dissected. The streams flow in narrow V-shaped ravines, above which the divides rise from 500 to 1,000 feet, in narrow, irregular lines of knobs showing little resemblance to the original even surface.

Drainage of the Pocahontas area.—The major portion of this territory is within the New River basin and is drained by Bluestone and East rivers and Wolf and Big Walker creeks. Bluestone River is the largest of these streams. From its source on the divide between Springville and Five Oaks, in Tazewell County, it flows northeast to Graham, where it is joined by Wright Valley Creek. At this point the river turns from its course along the strike of the rocks and crosses the Stony Ridge syncline to Bluestone Junction. Again it resumes its northeastward course and unites with New River 4 miles above Hinton, West Virginia. The tributaries entering the Bluestone from the north are generally small, but have become important on account of the coal exposed within their valleys. Below Bluestone Junction the best known are Mill, Simmon, Flip-

* *Monadnock*, a term applied to an elevation remaining above the general level of a peneplain; so called from Mount Monadnock, a height in New Hampshire which survived the planation of the surrounding region.

ping, Crane, Widemouth, Rich, and Camp creeks. The valley of Bluestone River is everywhere narrow and sharply cut, but below Spanishburg it becomes a canyon with precipitous sides, so that the wagon roads can neither follow nor cross the stream.

East River is a small stream heading at Bluefield and following east along the foot of East River Mountain to New River. Wolf Creek, rising in Burke Garden, flows east along the southern base of Rich Mountain to Rocky Gap, where it is joined by Clear Fork and Laurel Creek, forming quite a large stream. From this point of junction it flows directly to New River along a sharply cut valley at the northern base of Wolf Creek Mountain. Big Walker Creek drains the broad open valley about Bland, and east of this territory unites with Little Walker Creek, which drains the area between Big and Little Walker mountains. South of Big Walker Mountain a small area is drained by Reed Creek, another branch of New River.

The North Fork of the Holston River drains the region south of Clinch Mountain and west of Sharon Springs. North of Clinch Mountain and west of a line drawn from Hutchinson Rock to Tip Top are a few of the head branches of Clinch River. This stream and the North Fork of the Holston are the only representatives of the Tennessee River system in this territory.

In the coal basin west of the Flat Top divide the drainage is divided between the Guyandot and Big Sandy rivers. The portion north of Indian Ridge, or Wyoming County, is in the drainage basin of the former; while McDowell County is wholly within the limits of the latter. Tug Fork, rising near the Peeled Chestnut Gap, passes off this territory about due west of its source and constitutes the main head stream of the Big Sandy River. The area drained by this stream is insignificant in size, but is destined to become of importance when mining is begun on the coal which outcrops around its basin. The best-known valley in McDowell County is that of Elkhorn Creek, which is now the center of coal and coke production in the already famous Pocahontas or Flat Top field. In Wyoming County the principal stream is Pinnacle Creek, one of the head branches of Guyandot River.

GEOLOGY.

STRATIGRAPHY.

The general sedimentary record.—All of the rocks appearing at the surface within the limits of the Pocahontas atlas sheet are of sedimentary origin—that is, they were deposited by water. They consist of sandstone, shale, and limestone, having an average total thickness of 17,000 or 18,000 feet and presenting great variety in composition and appearance. The materials of which they are composed were originally gravel, sand, and mud, derived from the waste of older rocks, and the remains of plants and animals which lived while the strata were being laid down.

The sea in which these sediments were laid down covered most of the Appalachian province and the Mississippi basin, but it propably varied from time to time within rather wide limits.

As a rule, the younger rocks are limited in their outcrop to the northwestern side of the Appalachian Valley, whereas the older rocks are more generally exposed along its southeastern side. Whether this is due to the more extensive folding of the latter portion, by which the lower rocks have been brought within reach of erosion, or to the early folding and elevation above sea-level of the southeastern portion and the non-deposition of the later sediments over this land area, is as yet an unsettled question. In this territory, however, Cambrian rocks occur on the northern edge of the valley at the eastern end of an extensive anticline which, as it extends westward, is faulted in such a manner that the Cambrian rocks are thrust upon the Coal Measures.

CAMBRIAN STRATA.

Russell formation.—The outcrop of Cambrian rocks above referred to occurs north of Witten Mills in Tazewell County, Virginia, and consists of variegated shale and impure limestone. The total thickness exposed probably does not exceed 300 feet, though farther west there are certainly visible 1,000 feet of the same formation. In this territory the series is apparently unfossiliferous, but in its fuller development it contains the Olenellus fauna of Lower Cambrian age. This formation, so named because its greatest development is in Russell County, Virginia, is probably equivalent to the Rome formation and the Apison shale of southern Tennessee, described in the Chattanooga and Ringgold folios.

CAMBRO-SILURIAN STRATA.

Shenandoah limestone.—The great sheet of Cambro-Silurian limestone which is almost coextensive with the Appalachian Valley is well exposed in the southern half of this territory. It immediately overlies the Russell formation and extends upward to the well-known fossiliferous Chickamauga limestone. This was called by Rogers the Valley limestone, or No. II, and has heretofore been frequently correlated with the Knox dolomite of eastern Tennessee, but in mapping the intervening territory the Knox is found to represent but a part of the Shenandoah limestone. In the northern part of East Tennessee the formation of the Knox was preceded by the deposition of several distinct beds of limestone and calcareous shale, having at the Tennessee-Virginia line a thickness of about 1,500 feet. Northeastward from this line the shales become more calcareous and at varying distances are replaced by limestone. The upper, or Nolichucky, shale retains its character as far east as the western edge of the Pocahontas territory, but at that point it changes to limestone, which, together with the other members of the alternating series of Tennessee, helps to make up the great mass of the Shenandoah limestone. Thus the last-named formation can not be correlated with the Knox dolomite, for it comprises not only the whole of that formation but at least 1,500 feet of Cambrian strata beneath it.

Throughout southwestern Virginia this formation shows considerable change in character across the strike, or in a northwest-southeast direction. On the northern side of the valley it probably does not exceed 2,500 feet in thickness, and carries chert at various horizons. It is generally a heavy-bedded, gray dolomite, containing considerable blue limestone near its top, and dark, sandy limestone near its base. In the southern portion of the valley the chert almost wholly disappears; the limestone becomes light-colored and siliceous, and at many horizons carries thin beds of shale. In thickness it certainly reaches, and possibly exceeds, 4,000 feet.

In many places the top of the Shenandoah limestone is marked by a conglomerate composed of a calcareous matrix with pebbles of chert, sandstone, vein quartz, and quartzite. Nowhere in this territory are the pebbles known to exceed 1 inch in diameter, but on Stony Creek in the vicinity of New River the pebbles attain a diameter of 3 or 4 inches. Generally chert, more or less angular, predominates, and the matrix is a red, earthy limestone. This occurs at about the same horizon as the Birmingham breccia of Georgia and Alabama, and, like that stratum, probably records an uplift and erosion of the sea bottom. The dolomite of some adjacent zone, probably lying to the eastward, was elevated to form part of the shore. On the ancient shorelines the chert, as it weathered out, was broken up, assorted by the waves and currents, and with pebbles of other kinds was again deposited in the calcareous mud off the coast.

This limestone is named from the great Shenandoah Valley in northern Virginia, where it outcrops over extensive areas.

SILURIAN STRATA.

Chickamauga limestone.—This limestone is named from Chickamauga Creek in Walker and Catoosa counties, Georgia, and is probably equivalent to the base of Rogers's No. III. The line of separation between it and the underlying Shenandoah limestone is frequently well marked by the bed of conglomerate already described. Where that is absent the separation is not easy, but in a general way it can be made at the point where the white, impure limestone of the Shenandoah is replaced by the blue, fossiliferous beds of the Chickamauga. As a rule, the latter increases in thickness toward the northwest, having its greatest development near the margin of the Appalachian Valley. In this territory the variation is not much, ranging from 800 feet on the northern face of East River Mountain to 700 feet on Big Walker Mountain. It is generally a blue, flaggy, fossiliferous limestone which, becoming heavier-bedded toward the base, is with difficulty separated from the underlying limestone. Its base is generally marked by a heavy, blue bed carrying black chert, which serves to fix the boundary in many places. Toward the southeast this formation becomes more shaly in its upper portion, and on the southern line of the valley it is probably largely represented by the shales of the Sevier formation. This limestone is important, since it is the great marble-producing formation of the South. In this territory there are small areas of marble, but it is coarse-grained and of a gray color, and not valuable except for building purposes.

Moccasin limestone.—The transition from the hard, blue limestone of the Chickamauga to the calcareous shale of the Sevier formation is marked by a belt of red, earthy limestone, named from Moccasin Creek, Scott County, Virginia. It varies from 300 to 500 feet in thickness, and generally occupies a position geographically intermediate between the great development of limestone on the northwestern and of shale on the southeastern side of the valley. These red limestones are quite conspicuous, for they generally outcrop on the steep slopes of the valley ridges and give a pronounced color to the landscape.

Sevier shale.—Forming the steep northwestern slopes of the larger valley ridges is this shale formation, named from Sevier County, Tennessee. It is the upper portion of No. III according to Rogers's classification, and in thickness it varies from 1,250 to 1,500 feet. As a rule it is calcareous at its base and sandy in its upper portion, showing a gradual transition from the limestone below to the sandstone above.

Bays sandstone.—The sandstones and shales immediately overlying the preceding formation are distinguishable chiefly by their red color. They generally consist of thin-bedded sandstone at the top, passing downward into sandy shale, still retaining the prevailing color, and merge with the sandy beds of the Sevier shale. This sandstone is named from Bays Mountain, in northern Tennessee, and is equivalent to the lower portion of No. IV of Rogers's classification. Usually the crest of the ridges is formed by the Clinch sandstone, with the Bays outcropping just below, but in some cases the Clinch is worn back in the low gaps and the summit is formed by the red sandstone of the Bays formation.

Clinch sandstone.—All of the important valley ridges owe their existence to this plate of heavy sandstone, which has preserved their summits at or near the general level of the old Cretaceous peneplain, while the areas immediately adjacent have been worn down to form the present valleys. This sandstone varies from 125 to 250 feet in thickness, and, from its massive character, is easily separable from the formations both above and below. It was called by Rogers the Medina sandstone, or No. IV, but it is here given a local name from Clinch Mountain, the highest ridge in this area. It frequently forms picturesque ledges, such as Dial and Hutchinson rocks.

Rockwood formation.—Immediately overlying the Clinch sandstone and forming the southern slope of the ridges is a mass of shale and sandstone, varying in thickness from 15 feet in Cove Mountain, on the Wytheville and Bland turnpike, to probably 400 feet on East River Mountain. The larger part of the formation is composed of sandy shale and ferruginous sandstone or fine conglomerate. In Cove Mountain, where the minimum measure of 15 feet was obtained, the base of the formation, consisting of sandy shale, is alone preserved; the upper portion appears to be entirely absent, either through non-deposition or through subsequent erosion. A coarse, white sandstone, about 40 feet in thickness, forms the extreme top of the Rockwood formation. Occurring as it does between easily erodible formations, it is frequently the only stratum showing in outcrop, and affords an excellent guide to the stratigraphy. This is quite important, since the two adjacent formations are the principal ore-bearing strata of the region. This formation constitutes a portion of No. V of Rogers's classification.

Giles formation.—Above the heavy Rockwood sandstone occurs a group of strata of very diverse characteristics but practically inseparable in the field. In the Kimberling Wilderness, near the eastern edge of the area, the series is about as follows: (1) Overlying the Rockwood sandstone are 30 or 40 feet of blue limestone, varying from blue calcareous shale at the base to heavy blue limestone at the top. (2) This is succeeded by a very coarse ferruginous sandstone, greatly resembling some of the heavier beds of the Rockwood formation. At Holly Brook it is 15 or 20 feet in thickness, and is made up of quartz pebbles about one-eighth of an inch in diameter, cemented by iron oxide. (3) Above the sandstone is a cherty limestone, or rather, a mass of chert 30 or 40 feet in thickness, which is everywhere present along the line of outcrop of this formation and is frequently the only guide to the subjacent strata. (4) Above the chert is an indefinite thickness of yellow or green fossiliferous sandstone. In the Kimberling Wilderness, east of this area, pebbles of limestone, evidently derived from the lowest number of this series, are found imbedded in the green sandstone. The thickness of the sandstone could not be determined, since it outcrops over a level valley and is so erodible that it wears down regularly, leaving no cliffs by which it can be measured. It is probably less that 100 feet in thickness, but, owing to its light dip, covers a wide area.

The limestone portion of this formation is generally classed as Lower Helderberg, or No. VI, and the upper, sandstone portion as the Oriskany, No. VII. This is no doubt correct, and were they everywhere as plain as on No Business Creek, they could be separated into two formations. They generally outcrop in the valley at the southern base of the Clinch ridges, and are usually badly covered by the débris from the sandstones forming the crest. Under such conditions, two members are usually seen in outcrop—the chert and the ferruginous sandstone—and the observer is left to determine the presence or absence of the other members from the soil on the hill slopes. Such determinations have but little value, and would be misleading if expressed; so it was decided to be inexpedient to map the upper sandstone as a separate bed, but to map the whole as a single formation, named from Giles County, Virginia. The upper sandstone was seen at about six places in this territory. In other places where its supposed line of outcrop was crossed it was impossible to determine whether it was present or not. The existence of the conglomerate at this horizon on No Business Creek indicates that immediately following the deposition of the limestone occurred an elevation of at least a portion of this region above sea-level, and that from the land thus formed were derived the limestone pebbles already described. If this be correct, parts of the Pocahontas territory may have been dry land, upon which the green sandstone was never deposited, while other portions of it may not have been so affected and deposition may there have gone on uninterruptedly. Hence it would be incorrect to show the formation over the whole area, and, owing to the peculiar conditions under which it outcrops, the observer can never be assured whether the rock is present or not; consequently it is mapped together with the limestone and ferruginous sandstone, some member of which is always present. This method of grouping includes strata of both Devonian and Silurian age in one formation, but this is preferable to a possible misstatement regarding their areal distribution.

DEVONIAN STRATA.

Romney shale.—Overlying the Giles formation is a great series of Devonian shales, probably corresponding to Rogers's No. VIII. These begin at the base with black, carbonaceous shale, which is replaced higher up by green, sandy shale, and this in turn by thin-bedded, green sandstones, shale, and conglomerate. The black, carbonaceous shale at the base is a variable stratum from 400 to 600 feet in thickness, which passes into the green shale above by insensible gradations and interbedding. No definite line of demarkation between them can be drawn, and they are shown on the map by the merging of patterns, without a definite boundary-line. The formation is named from Romney, Hampshire County, West Virginia. This shale, being easily erodible, forms valleys, among which those of Little Walker, Hunting Camp, Wolf, Laurel, and Dry creeks are the most prominent.

Kimberling shale.—The upper portion of the great Devonian shale series could not be subdivided. It is practically a lithologic unit, except that it grows more sandy toward the upper portion. It is named from Kimberling Creek, which, in Bland County, flows through a wild and rugged region formed by these shales, and widely known as the Kimberling Wilderness. The base, as already described, is indefinite, and the upper limit is somewhat uncertain. The green sandstones, sandy shales, and conglomerates pass almost imperceptibly into the sandstones and shales of the coal-bearing formation of Lower Carboniferous age. There is usually a slight difference in color and character of the sandstones of these formations, which determines the boundary-line. The heavy beds of the Price sandstone are typical Coal Measure sandstones—coarse, yellow, and cross-bedded. All beneath are green and thin-bedded except the conglomerates.

The great increase in thickness of the Devonian shales in passing from south to north is one of the most striking features in the stratigraphy of the Appalachian province. Thus, the entire Devonian series is probably wanting in the vicinity of Anniston, Alabama; at Chattanooga it does not exceed 25 feet, a thickness which it holds over a large area in that vicinity; northward it swells to at least 800 feet at the southwestern end of Clinch Mountain, 15 miles north of Knoxville; from this it increases rapidly, reaching 1,800 feet in Clinch Mountain on the Virginia-Tennessee State-line, and about 2,000 feet at Little Moccasin Gap; on the western edge of the Pocahontas territory it is about 3,500 feet, increasing to nearly 4,000 feet on its eastern edge, and to at least 5,000 feet on New River.

CARBONIFEROUS STRATA.

Price formation.—The division-line between Devonian and Carboniferous rocks in this region is arbitrary, depending upon minor differences in the sandstones, which may or may not be constant over larger areas. But since the shales below are clearly Devonian, and the coal-bearing strata above clearly Carboniferous, it is highly desirable to separate them, even though the line be drawn arbitrarily. The coal-bearing formation, corresponding to No. X of Rogers, is named from Price Mountain, in Montgomery County, Virginia, where the coals have been mined for a number of years. The formation consists of sandstones, shales, and coals, and in general appearance is almost identical with the measures in the coal field to the northwest. It is limited in its outcrop to the southern portion of the territory, across which it is exposed in two lines of outcrop. One, north of Big Walker Mountain, extends westward from Bland across the entire territory; and the other, south of the same mountain, crosses the southeastern corner of the territory, forming the southern slope of Little Walker Mountain.

Pulaski shale.—The upper portion of the Price formation is usually absent through faulting, so that the next succeeding formation has but a limited outcrop. It is a bright-red shale, which attains a great development in the vicinity of Pulaski, Pulaski County, Virginia, from which it is named. In thickness it varies from a maximum of 300 feet on the eastern side of this territory to 20 feet or less on the western edge, and probably is wanting altogether a short distance beyond the limit of the territory.

Greenbrier limestone.—This formation consists generally of heavy, blue limestone, cherty at some horizons, and always abundantly fossiliferous. Toward the top it becomes shaly and passes into the calcareous shale of the base of the formation above. The limestone shows only in three lines of outcrop, and in but one of these is its full thickness present. In Abbs Valley it outcrops in a small area, but, being on the crest of an anticline, only its upper layers are visible. The belt of limestone along East River Valley is faulted on its southern side, so that its upper portion alone is present. In the southeastern corner of the territory it again shows, but is here apparently folded upon itself, and it is uncertain whether the top of the formation is present or not. Assuming it to be present, the thickness is about 1,700 feet, whereas the northern line probably averages about 1,200 feet. This formation is the limestone portion of No. XI of Rogers, and was subsequently named by him Greenbrier limestone.

Bluefield shale.—This shale, the upper portion of Rogers's No. XI, is named from Bluefield, Mercer County, West Virginia, the most important town in the Pocahontas area. It is truly a transition series between the limestone below and the sandy beds above. It varies in character from prevailingly calcareous at base to sandy at top, and is limited above by a bed of heavy quartzite, which forms Stony Ridge. This shale is confined to two areas—one along the line of railroad, and the other in Abbs Valley, where it appears on the anticlinal fold already noted. So far as could be determined, it varies but little in thickness, ranging from 1,250 to 1,350 feet.

Hinton formation.—Extending upward from the base of the quartzite forming Stony Ridge, through a variety of beds of calcareous shale, impure limestone, red argillaceous shale, sandy shale, and sandstone, to the base of a thin but extensive bed of conglomerate, is the Hinton formation. In this heterogeneous formation there is no bed which could be identified and mapped, and, though ranging from 1,250 to 1,350 feet in thickness, it is regarded as a single formation. West of Littlesburg it outcrops along three lines, but east of that point the two northern areas unite around the anticlinal point and expand into a wide area covering the entire country east of Princeton. It is named from Hinton, West Virginia, where it is well exposed along New River.

Princeton conglomerate.—This is a small stratum, probably nowhere exceeding 40 feet in thickness, but a very important one in determining stratigraphic relations. It makes an extensive showing at Princeton, from which it is named, and at various points along its line of outcrop. In the northeastern corner of the territory it is nearly horizontal, and, being more resistant than the adjacent beds, forms a table-land in which the Bluestone River has cut a deep and rugged gorge. Where crossed by the railroad below Graham, the base is a conglomerate, the matrix of which contains considerable calcareous matter, and the pebbles are quartz, sandstone, and impure limestone. At this point the upper layer is a massive-bedded sandstone, which has been quarried for heavy masonry.

Bluestone formation.—Above the Princeton conglomerate occurs a series of rocks similar to the Hinton formation, except that it is thinner, probably not exceeding 800 feet in thickness. This formation is, in general, composed of red shale, but contains many beds of impure limestone, sometimes conglomeratic, and sandstone of varying thickness and character. At Pocahontas this formation extends upward to the coal-bearing series, whose base is generally marked by a heavy bed of sandstone. In this vicinity, and probably throughout the area of this sheet, this heavy sandstone marks the upper limit of the red shales,—a point at which occurs a pronounced change from the calcareous sediments of the Bluestone formation to the coal-bearing or sandy beds of the formations above. This line of division can not be carried eastward, since the red shales extend several hundred feet higher in the series on New River than at Pocahontas; but it is an important local line of division, and hence is used in this region.

The base only of the Bluestone formation is present in the Hurricane Ridge syncline, and also in Bent Mountain north of Concord Church. The main line of outcrop is along the Bluestone River. It disappears a few miles west of Pocahontas, being cut off by the fault which develops in the Abbs Valley anticline.

In the valley of Tug Fork the coal-bearing rocks lie so high that the streams have cut entirely through them, exposing for a long distance the red shale of the Bluestone formation. Near the edge of the territory the dip of the rocks becomes greater than the gradient of the stream, and the red shale passes beneath water-level.

COAL-BEARING STRATA.

In the Pocahontas region all the rocks above the red shales of the Bluestone formation belong to this class, and are included in No. XII of Rogers's classification. They consist of interbedded sandstones, shales, and coals, with no perceptible order of recurrence and with no bed possessing very marked characteristics; consequently their subdivision into formations is extremely difficult and of uncertain value. The formations will depend largely upon local features, and hence are necessarily limited to the small area throughout which the local feature is prominent. The Pocahontas seam of coal is the most prominent feature, and, since it has been carefully traced throughout the entire coal field of this territory, forms a reliable local horizon for mapping purposes. All the rocks, from the top of the red shales up as far as the roof of the Pocahontas seam, are included in one group and named from the place at which this important coal was first opened.

Pocahontas formation.—Two or three coal seams are known in the lower portion of this formation, but conditions do not appear to have become especially favorable for the growth of coal plants until the close of the deposition of the formation and the beginning of the deposition of the vegetable matter which has since been consolidated into the Pocahontas coal. This seam varies in thickness from about 10 feet at Pocahontas to 4 feet 6 inches on the headwaters of the Guyandot River, in the northern part of the field. The Pocahontas formation appears to hold a constant thickness of 360 feet throughout this entire area. Its principal lines of outcrop are as follows: (1) It extends along the southeastern side of the field from the northern edge of the territory to Pocahontas, where it is cut off by the Abbs Valley fault. (2) In the valley of Tug Fork and its head tributaries the arching of the strata has been so pronounced, and the cutting of the streams so deep, that but small areas of the formation are left uneroded on the spurs and ridges; and the Pocahontas seam itself, being at the extreme top of the formation, is wholly gone over a large portion of this valley. (3) In the Elkhorn Valley, only the upper portion of the formation is exposed, but the Pocahontas coal is best disposed for economic mining. From Coaldale, at the northern end of the railroad tunnel, there is a continuous outcrop of this seam to the western edge of the territory, besides an extended exposure in the valley of the North Fork of the same stream. The coal is nowhere more than 200 feet above the stream, and ranges from that elevation down to the level of the water. (4) On the head branches of the Guyandot River the Pocahontas seam is exposed in places, but the strata are so depressed that but little more than the coal shows, and that in irregular outcrop.

Clark formation.—The strata above the Pocahontas seam do not differ essentially from those below. They consist of alternating sandstones, shales, and coals, but with no marked beds. Immediately overlying the Pocahontas seam is a heavy ledge of sandstone, 50 or 60 feet in thickness, which has served as an excellent guide in prospecting for this seam. Above this sandstone is the same monotonous succession of beds for a distance of 380 feet to a second general coal horizon, which has been traced continuously to New River and found to be equivalent to the celebrated Quinnimont seam. This occurs generally at the top of a ledge of sandstone about 40 feet in thickness and of remarkable persistency. The line of division is drawn at the top of this sandstone, and therefore at the bottom of the Quinnimont seam. The formation so delimited reaches from one well-known seam to the other, but includes neither. It carries, however, several small seams, but nothing of importance in this region. The formation is named from Clark Gap, in Flat Top Mountain, where the series is quite well exposed. The formation follows in outcrop the sinuous windings of the formation below, except in a few places where the divides have been cut deep enough to allow this formation to outcrop continuously from one drainage basin to another.

Quinnimont formation.—No well-marked stratum occurs in the rocks of this field for a distance of 300 feet above the top of the sandstone forming the upper limit of the Clark formation. It is, in general, a shale interval, but with many beds of sandstone and some coal seams. This formation is exposed on the crests of most of the spurs and ridges in the field, except the highest summits of Flat Top Mountain and Indian Ridge. It is named from the town of Quinnimont, on New River, where the coal at its base has been mined for many years. At this point the seam is just thick enough to mine, but it is very irregular, and probably does not exist in workable thickness in the Flat Top field. On the southern side of the coal field, west of Smith Store, there are several seams of coal at about the Quinnimont horizon, which have been called the Horsepen group. A heavy seam has been opened at Smith Store which has long been a puzzle to the prospectors of the region. In appearance it resembles the Pocahontas seam in its best development, but no one has succeeded in tracing its outcrop to where the Pocahontas is positively known. By its fossil plants, as well as by stratigraphic evidence, it is now known to be in the Quinnimont formation, and is probably equivalent to one of the upper Horsepen coals. It is therefore above the Quinnimont coal horizon.

Raleigh sandstone.—Immediately overlying the Quinnimont formation is the heaviest and best-marked sandstone in the series exposed in this field. It is about 80 feet in thickness, and develops both in thickness and coarseness eastward to New River, where it varies from 100 to 150 feet in thickness, and much of its mass is composed of quartz pebbles. It is named from Raleigh County, a large portion of the surface of which is made up of this heavy bed. In the Pocahontas region it is a coarse, massive sandstone which, under favorable conditions, forms cliffs upon the exposed points of the spurs. It caps Flat Top Mountain near the northern edge of the territory, and is the principal bed in the same mountain south of Peters Gap. All the western portion of Indian Ridge owes its elevation to this resisting stratum.

Sewell formation.—Throughout the coal field in the Pocahontas region there are but few rocks remaining above the Raleigh sandstone. These outcrop on Flat Top Mountain south of Peters Gap, and on a few high points of Indian Ridge. This formation is named from the town of Sewell, on New River, where a coal seam 70 feet above the Raleigh sandstone has been mined for a number of years. In the Pocahontas region but a small portion of the base of this formation is preserved. It contains a few seams of coal, but the area covered by the formation is too small to be of much value.

Although no pebbly sandstones occur within the limits of this field, the coal-bearing rocks belong to the Conglomerate or Pottsville series. This opinion has been held by all who have worked in this region, but it was verified through studies by David White of the fossil flora of the Pocahontas field, as well as by continuous tracing of the beds eastward to New River, where the Pottsville series is clearly differentiated from the strata both above and below.

STRUCTURE.

Definition of terms.—As the materials forming the rocks of this region were deposited upon the sea bottom, they must originally have extended in nearly horizontal layers. At present, however, the beds are usually not horizontal, but are inclined at various angles, their edges appearing at the surface. The angle at which they are inclined is called the *dip*. In the process of deformation the strata have been thrown into a series of arches and troughs. In describing these folds the term *syncline* is applied to the downward-bending trough and the term *anticline* to the upward-bending arch. A synclinal axis is a line running lengthwise in the synclinal trough, at every point occupying its lowest part, toward which the rocks dip on either side. An anticlinal axis is a line which occupies at every point the highest portion of the anticlinal arch, and away from which the rocks dip on either side. The axis may be horizontal or inclined. Its departure from the horizontal is called the *pitch*, and is usually but a few degrees. In addition to the folding, and as a result of the continued action of the same forces which produced it, the strata along certain lines have been fractured, allowing one portion to be thrust forward upon the other. Such a break is called a *fault*. If the arch is eroded and the syncline is buried beneath the overthrust mass, the strata at the surface may all dip in one direction. They then appear to have been deposited in a continuous series. Folds and faults are often of great magnitude, their dimensions being measured by miles, but they also occur on a very small scale.

Structure of the Appalachian province.—Each subdivision of the province is characterized by a distinctive type of structure. In the plateau region and westward the rocks are generally horizontal and retain their original composition. In the valley the rocks have been steeply tilted, bent into folds, broken by faults, and to some extent altered into slates. In the mountain district faults and folds are important features of the structure, but the form of the rocks has been changed to a greater extent by cleavage and by the growth of new minerals. In the valley region the folds and faults are parallel to the old shoreline along the Blue Ridge, extending in a northeast and southwest direction for very great distances. Some of these faults have been traced 300 miles, and some folds even farther. Many folds maintain a uniform size for great distances, bringing to the surface a single formation in a narrow line of outcrop on the axis of the anticline, and another formation in a similar narrow outcrop in the bottom of the syncline. The folds are also approximately equal to one another in height, so that many parallel folds bring to the surface the same formations. The rocks dip at all angles, and frequently the sides of the fold are compressed until they are parallel. Where the folds have been overturned, it is always toward the northwest, producing southeastern dips on both limbs of the fold. In the southern portion of the Appalachian Valley, where this type of structure prevails, scarcely a bed can be found which dips toward the northwest.

Out of the overturned folds the faults were developed, and with few exceptions the fault planes dip toward the southeast and are parallel to the bedding planes. Along these planes of fracture the rocks moved to varying distances, sometimes as great as 6 or 8 miles.

There is a progressive increase in degree of deformation from northeast to southwest, resulting in different types of structure in different localities In southern New York the strata are but slightly disturbed by a few inconspicuous folds. Many new folds are developed in Pennsylvania, and all are of increased magnitude, but the folds are open, and, as a rule, the dips are gentle. This structure holds as far south as central Virginia, where a few folds on the eastern side of the Great Valley have been compressed to such an extent that faulting has ensued. In southern Virginia and northern Tennessee faults become more common, and open folds are the exception. From central Tennessee to Georgia and Alabama almost every fold is broken, and the strata form an imbricated structure, in which all of the beds dip to the southeast. Throughout Alabama the faults are fewer in number, their horizontal displacement is much greater, and the folds are somewhat more open.

In the Appalachian Mountains the same structure is found that marks the Great Valley, such as the eastward dips, the close folds, the thrust faults, etc. In addition to these changes of form, which took place mainly by motion on the bedding planes, there was developed a series of minute breaks across the strata, producing cleavage, or a tendency to split readily along these new planes. These planes dip southeast, usually about 60°. As the breaks became more frequent and greater, they were accompanied by growth of new minerals out of the fragments of the old. All rocks, both sedimentary and original crystalline, were subjected to this process, and the final products of the metamorphism of very different rocks are often indistinguishable. Throughout the entire Appalachian province there is a regular increase of metamorphism toward the southeast, so that a bed quite unaltered at the border of the Great Valley can be traced through greater and greater changes until it has lost every original character.

The structures above described are manifestly the result of horizontal compression which acted in a northwest-southeast direction, at right angles to the trend of the folds and cleavage planes. The compression began in early Paleozoic time and probably continued at intervals up to its culmination after the close of the Carboniferous.

In addition to the horizontal force of compression, the province has been subjected to forces which have repeatedly elevated and depressed its surface. In post-Paleozoic time there have been at least three and probably more periods of decided oscillation of the land, due to the action of vertical forces. In every case the movements have resulted in the warping of the surface, and the greatest uplift has generally coincided with the Great Valley.

Structure sections.—The sections on the structure sheet represent the strata as they would appear in the sides of a deep trench cut across the country. Their position with reference to the map is on the line at the upper edge of the blank space. The vertical and horizontal scales are the same, so that the actual form and slope of the land and the actual dips of the strata are shown. These sections represent the structure as it is inferred from the position of the strata observed at the surface. On the scale of the map the minute details of structure, can not be represented and therefore the sections are somewhat generalized from the dips observed in a belt a few miles in width along the line of the section.

Faults are represented on the map by a heavy, solid or broken line, and in the section by a line whose inclination shows the probable dip of the fault plane, the arrows indicating the direction in which the strata have moved on its opposite sides.

Structure of the Pocahontas area.—According to geologic structure, this territory may be divided into two portions corresponding to the topographic divisions already made for the entire province. The line along which this division may be made corresponds with Bluestone River and Laurel Creek.

North of this line the strata are nearly horizontal and without break of any kind. A light northwestern dip is maintained over most of the field, but it is not regular and in several places is replaced by opposing dips. The shallow basin of the coal-bearing rocks is traversed by a number of slight undulations, which cause great variation in the dips of the rocks. These irregularities are shown on the economic sheet by contour lines of light color in the darker tints, with a vertical contour interval of 100 feet.

South of this line the strata are highly contorted, forming in some places folds with a breadth of several miles; in other places the folds have broken and the southern limb of the anticline has been thrust upon the northern limb of the syncline.

The first important structural feature on the northwestern side of the Appalachian Valley is the Abbs Valley anticline. On the eastern side of the territory this fold is broad and gentle, with its axis in the vicinity of Concord Church. From this point its course is southwest, parallel to the principal structural features of the region. Three or four miles above Pocahontas, a fault develops in the vertical measures on the northwestern side of the fold, which, near the western boundary of the territory, cuts off the Princeton conglomerate, the Bluestone formation, and the Pocahontas formation, leaving the Hinton formation in contact with the Quinnimont formation. Southeast of the anticline, and parallel with it, is a synclinal basin, of which the two Stony ridges are the upturned edges. East of Bluestone River, the northern ridge disappears, because that side of the basin has become too flat to form a ridge and the southern Stony Ridge is merged in the steep escarpment facing East River.

South of this belt of moderate folding occurs a belt of faulted and highly tilted strata. This is limited on the north by a fault which, in general, follows the line of the railroad and will be referred to as the Graham fault. As a rule, along this line the Greenbrier limestone is in contact with the Kimberling shale, and dips conformably under it. On the southern side of the belt the Kimberling shale is usually in contact with the Silurian or Cambrian limestones. The fault which separates them is approximately parallel to the Graham fault, and will be called the St. Clair fault.

South of the faulted belt occurs a broad basin in which there is intense minor folding. The northwestern or but slightly disturbed limb of the syncline forms East River Mountain; and the southeastern or intensely folded limb produces Buckhorn Mountain. In the eastern portion there is a comparatively open basin of Devonian shales, limited on the east by the high knob at the intersection of the ridges and on the west by Big Ridge, a cross range connecting the two mountains. West of Big Ridge there is a smaller basin of the same Devonian rocks, known as Nye Cove. West of this cove the folding has been very severe and the broad basin is corrugated with many minor folds. In these the Clinch sandstone has been bent back upon itself in horizontal folds in a remarkable manner. The edges of these folds have been eroded, leaving three horizontal plates of the sandstone outcropping at various altitudes in the mountain. The structure in this region is still further complicated by a small fault, which extends from Nye Cove westward nearly to the edge of the territory. The plane of this fault, as shown in Section C C, dips to the northwest, being the only exception to the general rule of southeastward-dipping fault planes. East of Rocky Gap the structure of Buckhorn Mountain is also extremely complicated. It consists of a number of irregular, closely appressed folds which have been badly crushed and thrust upon other folds in a similar condition, the whole forming a most confused mass of broken and folded rocks. This belt is limited on the southeast by a fault which originates near Shawver Mills and develops eastward, until at Rocky Gap the stratigraphic throw of the fault is such that the Shenandoah limestone is brought in contact with the Bays sandstone.

The next succeeding belt, limited on the northwest by the Rocky Gap fault and on the southeast by the Bland fault, is one of broad, open folding. In general it is a flat synclinal basin with its southern limb cut off by the Bland fault. In this broad basin numerous arches or dome-shaped anticlines have developed, which form a most interesting part of the structure. At the eastern edge of the territory this fold is a simple syncline, but very broad and shallow. East of Kimberling Springs a low dome brings up, in a limited area, the Romney black shale and the cherty member of the Giles formation. At Hicksville a very pronounced arch breaks the monotony of the syncline, and forms, by its gentle uplift, the peculiar mass called Round Mountain. The axis of this fold pitches down opposite Grapefield, forming a neck between Round Mountain and Burke Garden. Again it expands in a large dome-shaped anticline from which erosion has produced Burke Garden. This fold dies out irregularly to the west in several small folds, all of which end before reaching the edge of the territory. A nearly symmetrical anticline, known as Thompson Valley, is slightly offset from this fold and extends westward for a great distance. The southern limb of the anticline forms Clinch Mountain, which extends southwestward nearly to Knoxville, Tennessee. The basin deepens as it approaches the Bland fault, and the basal member of the Carboniferous series comes in next to that line. This fault is quite irregular, having two pronounced offsets corresponding to the great northerly bend in Big Walker Mountain. The latter mountain is but the northern limb of a similar synclinal fold which has been almost obliterated by the faulting of its southern limb and the overthrust of Cove Mountain upon this trough.

Big Walker Mountain exhibits a peculiar cross-fault opposite Effna, in which the strata east of the fault have been thrust farther northwest than those west of the break. The cause of this break is probably connected with the change in the direction of the ridge at this point.

Of the seven longitudinal faults occurring in this territory, at least two are far-reaching toward the southwest, where faults are the rule and open folds the exception. These extensive breaks are the St. Clair and Bland faults. The others simply disappear in anticlinal folds or merge with the more extensive faults already named.

MINERAL RESOURCES.

The importance of the Pocahontas region is chiefly due to its mineral resources. These are not varied, but, so far as known at present, include coal, iron, marble, clay, and stone. By far the most prominent of these is coal, which has given to this region its economic importance.

Coal.—The northern portion of the Pocahontas territory embraces almost all of the developed portion of the Pocahontas or Flat Top coal field. This is by far the most important mineral district in the region, and it is an important factor in the coal production of the United States. Although of comparatively recent development, the field has experienced continued and unprecedented prosperity. In 1882 the New River branch of the Norfolk and Western Railroad was constructed to Pocahontas and mining on a commercial scale was begun. From that time it has grown, until in 1894 the total output of the district, according to the report "Mineral Resources of the United States, 1894," is 3,096,867 tons of 2,240 pounds each. The opening of new mines and the building of coke ovens still continue, and probably in the near future will extend to other valleys than those in which operations are at present carried on.

The formations in which coal beds occur are the Pocahontas, Quinnimont, and Sewell, having a total thickness of 1,190 feet. These contain a number of seams of workable thickness, but the great No. III or Pocahontas seam overshadows all the others, rendering them insignificant by comparison. In the portion of the field represented by this sheet the upper coals probably will never be worked, for, as the coal is removed from the Pocahontas seam, the roof is allowed to fall, breaking and dislocating all of the rocks above. After this has occurred the upper seams can not be worked; so all of the mining done on No. III is at the expense of the various overlying seams. Farther within the coal field, toward the northwest, the Pocahontas seam sinks below water-level, and the upper coals will doubtless receive the attention of the operators.

It is impossible to show, on the economic sheet, the outcrop of an individual seam, but since the base of the Clark formation is the roof of the Pocahontas seam, the boundary-line between the Clark and Pocahontas formations represents the line of outcrop of that seam.

The general northwestward dip of the rocks in the coal field is shown by the structure sections, but in the systematic tracing of the Pocahontas seam numerous undulations were developed which can not be shown on so small a scale. In order to represent these slight deviations from the regular basin structure, contours with a vertical interval of 100 feet have been drawn on the floor of this seam, and the result is shown on the economic sheet. The seam dips, in general, northwestward from an altitude of 2,700 feet above tide at Pinoak to 1,600 feet at Vivian, but the contour sheet shows that this dip is far from regular. In places it descends but 100 feet in 3 or 4 miles, and in others its descent is about 200 feet per mile. The contours also show a cross arch from Spanishburg to the head of Burk Creek, and a longitudinal one extending west from Cooper. This fold extends 20 or 30 miles beyond the limit of this territory, and is parallel to the fault which bounds the field on the south. South of this arch there is a trough, the deepest point of which in this area is 600 feet below the crest of the arch on the north. The Pocahontas seam has been depressed below the surface in the region southwest of Pocahontas, and on the southern edge of the field has been engulfed by the fault, so that it does not appear in outcrop.

In the valley of Elkhorn Creek the seam descends gently toward the northwest, having altitudes of 2,340 feet at the western end of the railroad tunnel at Coaldale, 2,250 feet at Maybeury, 1,890 feet at the mouth of the North Fork of Elkhorn Creek, and 1,500 feet where it passes beneath water-level a mile beyond the western edge of the territory. On the Tug Fork its elevation is greater, and consequently the area underlain by coal is much less. It is so far above the creek that the Bluestone formation shows in the bottom of the valley throughout most of its extent in this region. The rate of descent down the stream is about the same as on Elkhorn Creek, but not sufficient to carry the coal below water-level in this territory. North of Elkhorn Creek, on the head branches of Guyandot River, this seam appears for a few miles, but soon sinks beneath the level of the creeks. Throughout the entire region the dip is sufficient to provide natural drainage for the mines, and generally they can be so arranged that the main entry will be level or have a slight down grade, so that transportation to the mouth of the mine is reduced to the least possible cost.

The Pocahontas seam varies in thickness from 4 to 10 feet, attaining its maximum at the original point of opening on Coal Creek at Pocahontas. From this point it diminishes in thickness in all directions, but most rapidly toward the northeast.

A coal seam bearing a striking resemblance to the Pocahontas, in structure and thickness has long been known near Smith Store. At this outcrop it shows the following section:

	Ft.	In.
Coal	2	2
Shale	0	6
Coal	2	5
Bone	0	3
Coal	3	8
Total	9	0

There has been doubt about the identity of this seam, but the fossil plants collected from its roof shales, corroborated by stratigraphic evidence, clearly show that it is not the same as No. III, but belongs to a considerably higher horizon.

The character of the Pocahontas coal is too well known to require a full discussion here. It has acquired foremost rank as a steam coal, and finds a ready market at the seashore in supplying ocean steamers. It also produces an excellent coke, which, however, generally requires to be crushed in order to yield the best results. As a rule the lump coal is placed directly upon the market for general purposes, while the slack and fine coal goes direct to the ovens and is coked.

There is a small coal field in the southern portion of this territory in which the coals are of Lower Carboniferous or Pocono age and are found in the Price sandstone. The seams are, as a rule, small and much broken up by partings; the rocks are frequently highly tilted and more or less crushed; and the coals are generally high in their percentage of ash. From time to time they have attracted considerable attention and efforts have been made to develop them, but so far without success. Coal seams in the Price sandstone are known in the vicinity of Bland and Sharon Springs and near the southwestern corner of the territory; also in rocks of the same age south of Little Walker Mountain, on Reed Creek.

Iron ores.—In this territory the principal ores of iron are associated with the Rockwood and Giles formations. The former is the great ore-bearing formation of the South, and is widely known from the red fossil ore which it generally contains. In the Pocahontas region this ore is of poor quality. Most of the sandstones of the Rockwood formation carry a large amount of iron, but the siliceous material with which it is associated would prevent its use in the furnace. In many places the shales of this formation carry a hematite ore of promising appearance, and apparently in sufficient quantity to be of commercial value. At present it is undeveloped and but little is known regarding its quality or quantity. Ore occurs in the Giles formation, probably in small quantities only. This is the famous Oriskany ore of northern Virginia, but in the Pocahontas field it appears to be more intimately associated with the limestone stratum than with the sandstone. From the presence of limestone pebbles in the Oriskany sandstone, as well as from the mode of occurrence of the ore itself, it seems probable that the ore is due to subaerial disintegration of the limestone which then formed a land surface and the segregation of the ferruginous matter in the residual clay. This probably occurred contemporaneously with the deposition of the sandstone; so the ore may be classed as Oriskany in age, though formed directly from the Helderberg limestone.

Marble.—The Chickamauga limestone, which in East Tennessee carries the great deposits of variegated marble, is, in the Pocahontas region, generally a blue limestone, carrying marble at but one locality. This is at the northern base of Big Walker Mountain, in the great bend between Bland and Sharon Springs. The marble is coarsely crystalline and of a light-gray color. It occurs in massive beds, and may be a fine building stone. It has never been developed, except for local use, and will necessarily remain undeveloped until transportation can be secured.

Limestone.—Throughout most of this territory, limestone for burning into lime or for road metal is very abundant, but as yet has not been utilized to any extent.

Building stone.—This also exists in abundance, but the demand has not been sufficient to lead to quarrying, except for immediate and local needs.

Brick clays.—These have been utilized at Tip Top in Wright Valley, but not to any great extent. Suitable clays doubtless can be found in many of the limestone or shale valleys, should the demand be sufficient to attract capital to their development.

SOILS.

In this territory the soils are almost as clearly differentiated as the rocks from which they are derived, and a map of the areal geology will suffice to show the general distribution of the different kinds of soil. The soils are the result of decay and disintegration of the rocks immediately beneath; hence there is a close agreement between the character of the soil and the original rock from which it is derived. It is not intended by this statement to convey the idea that the soil has all the chemical constituents of its parent rock, for by the very process of soil-making a large proportion of the more soluble material is removed, leaving the bulk of the soil composed of the less soluble residue. Sedimentary rocks, such as are found in this region, suffer decay by the removal of the cement which binds the particles together. If the cement be siliceous, as in quartzites and some sandstones, the rock resists solution efficiently and is but slowly altered; but if the cement be calcareous it is soon removed and the rock broken down. Thus calcareous sandstones are soon reduced by this process to a mass of sand, and calcareous shale to clay. In limestones the calcareous matter is dissolved and the solution is carried off by running water, either on the surface or through the various underground passages; while the residue, consisting mainly of sandy and clayey material, remains to form the soil.

Knowing, then, something of their genesis, soils may be classified according to the underlying rocks, and the geologic map be made to do duty as a map of soils. True, there are some small exceptions to this rule. In a country whose slopes are as steep as those of the Pocahontas territory, there must be considerable overplacement of soil by washing down of material derived from the overlying formations. Since the crests of the ridges are always formed by beds of sandstone, the overplaced soil is universally sandy and detrimental to the soil of the valley below.

Sandy soils.—Such formations as the Bays, Clinch, Rockwood, Price, and Princeton sandstones, together with much of the coal-bearing rocks, give a poor soil, varying slightly as the rocks vary from which it is derived. Pure sandstone, like the Clinch and some beds in the Carboniferous series, produces nothing but white or yellow sand, whereas other sandstones associated with shales give a very sandy clay soil.

Soils derived from shales.—Since there are in general three kinds of shale—arenaceous, aluminous, and calcareous—it follows that the resulting soils will range from sandy clay to a rich limestone clay, with all the intervening grades. The Kimberling shale gives the poorest soil of the region, but little of its outcrop being cultivated. Many of the coal-bearing shales form but little better soils. The great shale formations of the Lower Carboniferous produce much better soils, for many of their beds are strongly calcareous, and in general the country along the line of their outcrop is more gently rolling and better adapted to farming. The Sevier shales are quite rich in calcareous matter and form good soils; but generally they are quite inaccessible, since they universally outcrop on the steep northerly slopes of the Clinch sandstone ridges. The Bluefield shale is equally rich in lime, and the surface is much more level, forming excellent farming lands.

Soils derived from limestones.—As a rule, these are the best soils of the region. Ranking highest as a producer of rich soils is the Chickamauga limestone, which has made Tazewell County famous as a blue-grass region. There are five principal areas of Chickamauga limestone in this territory, but these differ considerably as to richness of soil. Probably the most noted of these is Burke Garden, the floor of which is composed almost entirely of this limestone. The extreme richness of this area is largely due to the present baseleveled condition, which doubtless has prevailed for a long time, and has resulted in the deep decay of the rocks, with a great accumulation of the residual products of the limestone and of vegetable mould. The next area in importance is west of Dial Rock, in the vicinity of Tazewell. Farther west this merges with the Thompson Valley area, forming a broad and rich valley, but much more deeply cut than Burke Garden. The areas along East River and Wolf Creek Mountains are too narrow and sharply cut to be of great value, except in favored localities where the rocks are flatter and erosion is less active. Along the northern face of Big Walker Mountain the dips are light and the outcrop covers a wider area, giving in places excellent farms.

Second in importance as a soil producer is the Greenbrier limestone, but in this territory its outcrop is so restricted that it becomes of minor importance. In Abbs Valley it gives a rich soil, but the area covered by its outcrop is very small. The narrow strip along the railroad produces some very good soil, but in general it is a rugged region and but poorly adapted to agriculture. In the Cove, its broadest area, there are some good farms, but the soil is not so rich as farther northwest.

The Shenandoah limestone ranks next in importance, but the soil derived from it is generally siliceous and comparatively poor. In many places the chert from this limestone is a great detriment to the soil, for it decays very slowly and in the course of ages accumulates as a complete mantle over the surface. Near the western edge of the region, on the divide between the Tennessee and Kanawha basins, the outcrop of this formation is well adapted to farming; but toward the eastern edge the streams have cut deeply into the surface and little level land remains; consequently the country is poorly fitted for agricultural pursuits.

Considered as a whole, the territory may be divided into three agricultural districts: (1) The region northwest of Bluestone River and Laurel Creek, in which the soil is prevailingly poor, capable of producing but little more than meets the requirments of the present scanty population outside of the mining districts. (2) The eastern half of the territory, including the southern half of Mercer, the western part of Bland, and a small portion of Wythe counties. This is an area of medium value. It has a few rich valleys, but on the whole the soil is rather poor and agriculture is not in a flourishing condition. (3) Tazewell County, one of the richest agricultural districts of Virginia, and long famous for its live stock.

MARIUS R. CAMPBELL,
Geologist.

April, 1895.

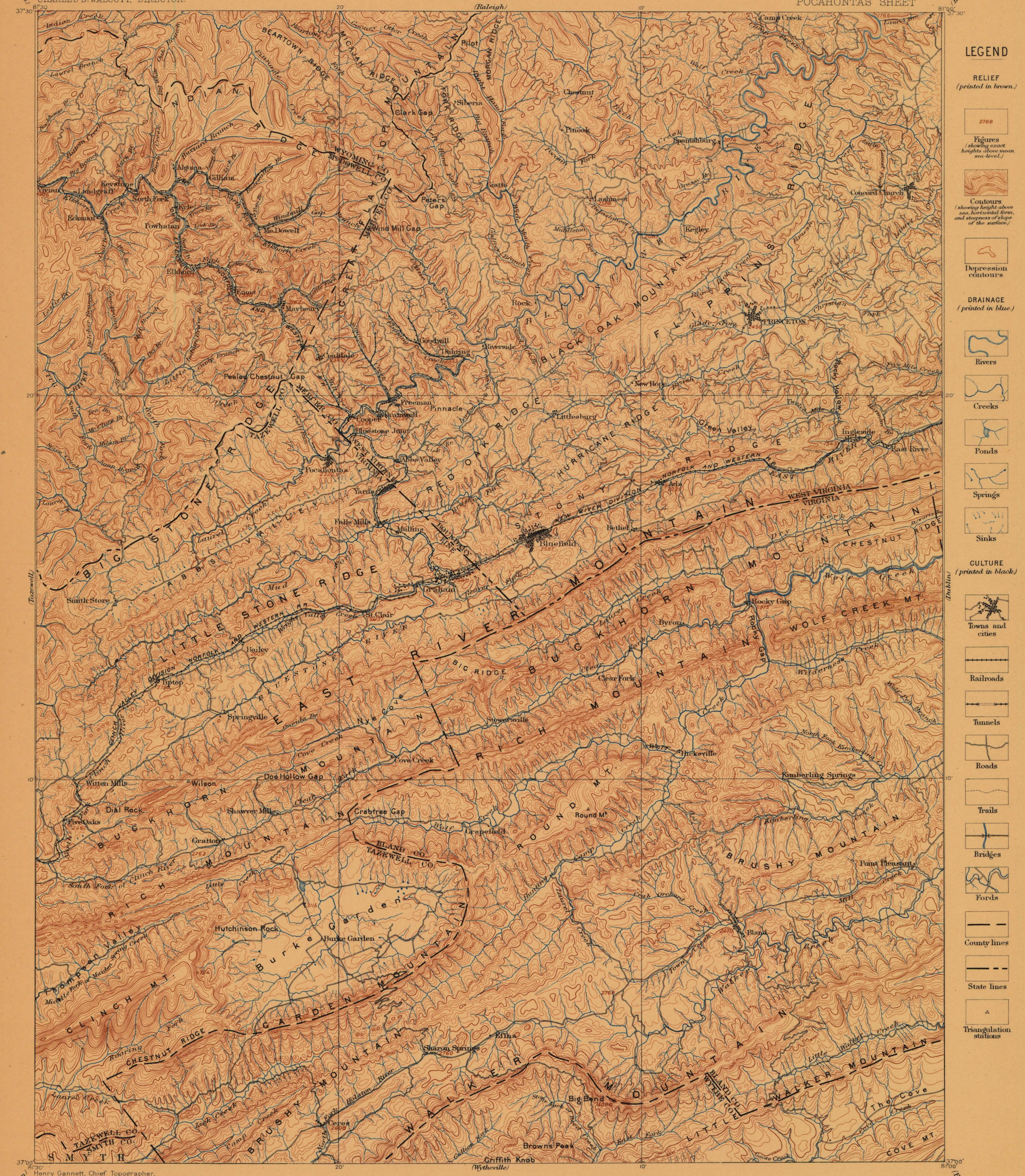
NAMES OF FORMATIONS.

	Names and Symbols used in this Folio.		Rogers; The Geology of the Virginias. 1884.		Stevenson; A Geological Reconnaissance of Bland, Giles, Wythe, and Portions of Pulaski and Montgomery Counties of Virginia. 1887.
Carboniferous	Sewell formation. Raleigh sandstone. Quinnimont shale. Clark formation. Pocahontas formation.	Cs Cr Cq Cc Cph	Great Conglomerate and Conglomerate Coal group.	XII	Lower Coal Measures.
	Bluestone formation. Princeton conglomerate. Hinton formation. Bluefield shale.	Cbl Cpr Chn Cbf	Greenbrier shale.	XI	Umbral shale.
	Greenbrier limestone.	Cgr	Greenbrier limestone.	XI	Umbral limestone.
	Pulaski shale.	Cpk	(Not described.)		(Not described.)
	Price sandstone.	Cpc	Montgomery grits.	X	Vespertine.
Devonian	Kimberling shale. Romney shale.	Dk Dr	Catskill. Chemung. Portage. Genesee. Hamilton. Marcellus.	IX VIII VIII VIII VIII VIII	Chemung. Hamilton.
	Giles formation.	SDg	Oriskany.	VII	Oriskany.
			Lower Helderberg.	VI	Lower Helderberg.
Silurian	Rockwood formation.	Sr	Clinton.	V	Clinton.
	Clinch sandstone.	Scl	Medina	IV	Upper Medina.
	Bays sandstone.	Sb			Lower Medina.
	Sevier shale. Moccasin limestone.	Ssv Smc	Hudson River. Utica.	III III	Hudson.
	Chickamauga limestone.	Sc	Trenton.	III	Trenton limestone.
Camb.	Shenandoah limestone.	€Ss	Chazy. Levis. Calciferous.	II II II	Knox limestone.
	Russell formation.	€rl	?		Knox shale.

U. S. GEOLOGICAL SURVEY.
CHARLES D. WALCOTT, DIRECTOR.

TOPOGRAPHY

VIRGINIA - WEST VIRGINIA
POCAHONTAS SHEET



Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer in charge.
Triangulation by J. H. Gore.
Topography by A. E. Murlin.
Surveyed in 1892.

Scale 1/125000

Contour Interval 100 feet
Datum is mean Sea level
Edition of Oct. 1895.

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AREAL GEOLOGY

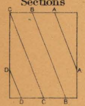
VIRGINIA – WEST VIRGINIA
POCAHONTAS SHEET

LEGEND (continued)

SPECIAL SYMBOLS

Faults

Sections



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Scale $\frac{1}{125,000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour Interval 100 feet
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Geology by Marius R. Campbell.
Assisted by David White.
Surveyed in 1893.

LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

XII
- **Cs** — Sewell formation *(sandy shale and thin-bedded sandstone with small coal seams)*
- **Cr** — Raleigh sandstone *(heavy-bedded, coarse sandstone)*
- **Cq** — Quinnimont shale *(sandy shale and thin-bedded sandstone with several coal seams)*
- **Cc** — Clark formation *(heavy-bedded sandstone at the top; shales and sandstone with coal seams in the lower portion)*
- **Cph** — Pocahontas formation *(Pocahontas coal at the top; shales and sandstones with coal seams in the lower portion)*

XI
- **Cbl** — Bluestone formation *(red and green shale, sandstone and impure limestone)*
- **Cpr** — Princeton conglomerate *(massive, coarse sandstone or conglomerate, sometimes calcareous)*
- **Chn** — Hinton formation *(red and green shale and sandstone; heavy sandstone at the base)*
- **Cbf** — Bluefield shale *(sandy shale at top, grading downward into blue, calcareous shale)*
- **Cgr** — Greenbrier limestone *(blue limestone, shaly at the top and heavy-bedded and cherty at the bottom)*

X
- **Cpk** — Pulaski shale *(red shale)*
- **Cpc** — Price sandstone *(shales and sandstones containing coal seams)*

DEVONIAN

IX? VIII
- **Dk** — Kimberling shale *(grading from sandstone and conglomerate at the top to green, sandy shale at the bottom)*
- **Dr** — Romney shale *(black shale)*

VII VI
- **SDg** — Giles formation *(green or yellow sandstone and blue, cherty limestone)*

SILURIAN

V
- **Sr** — Rockwood formation *(shale and sandstone, containing local deposits of red hematite iron ore)*

IV
- **Scl** — Clinch sandstone *(coarse, white, heavy-bedded sandstone)*
- **Sb** — Bays sandstone *(red sandstone and shale)*

III
- **Ssv** — Sevier shale *(sandy at the top, grading into blue calcareous shale at the bottom)*
- **Smc** — Moccasin limestone *(red and green, impure limestone)*
- **Sc** — Chickamanga limestone *(blue limestone)*

CAMBRIAN

II
- **CSs** — Shenandoah limestone *(grey dolomite, generally heavy-bedded)*
- **Crl** — Russell formation *(red and green, sandy shales and impure limestone)*

U.S. GEOLOGICAL SURVEY
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ECONOMIC GEOLOGY

VIRGINIA – WEST VIRGINIA
POCAHONTAS SHEET

LEGEND
(continued)

SPECIAL SYMBOLS

Faults

Sections

Coal mines

Known productive formations

Cs — *Sewell formation* *(overlying Pocahontas coal by 750 feet or more)*

Cq – Cc — *Quinnimont shale and Clark formation* *(directly overlying Pocahontas coal)*

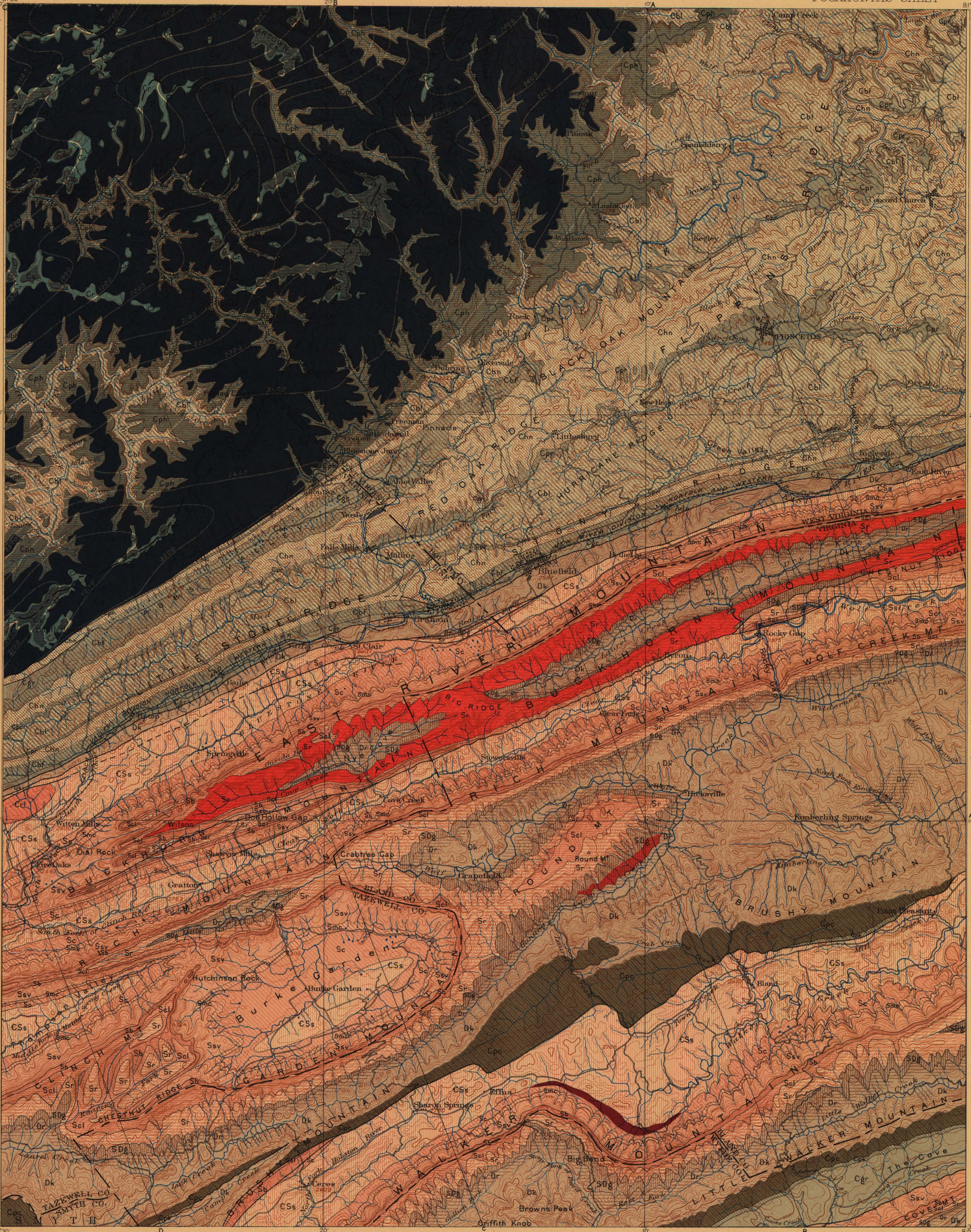
Cph — *Pocahontas formation* *(contains Pocahontas coal at the top)*

Cpc — *Price sandstone* *(contains small coal seams)*

Red hematite iron ore

Marble

White contour lines and figures show the lay of the Pocahontas coal and indicate its elevation above sea, under ground, and also in its former extension where it has been eroded



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1 ½ 0 1 2 3 4 5 Miles

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Contour Interval 100 feet

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IX? VIII

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Dr — Romney shale *(black shale)*

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SILURIAN

V

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Ssv — Sevier shale *(sandy at the top grading into blue calcareous shale at the bottom)*

Smc — Moccasin limestone *(red and green, impure limestone)*

Sc — Chickamauga limestone *(blue limestone)*

CAMBRIAN

II

ƐSs — Shenandoah limestone *(grey dolomite, generally heavy-bedded)*

Ɛrl — Russell formation *(red and green, sandy shales and impure limestone)*

U. S. GEOLOGICAL SURVEY
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STRUCTURE SECTIONS

VIRGINIA - WEST VIRGINIA
POCAHONTAS SHEET

LEGEND
(continued)

SPECIAL SYMBOLS

Faults

Known productive formations

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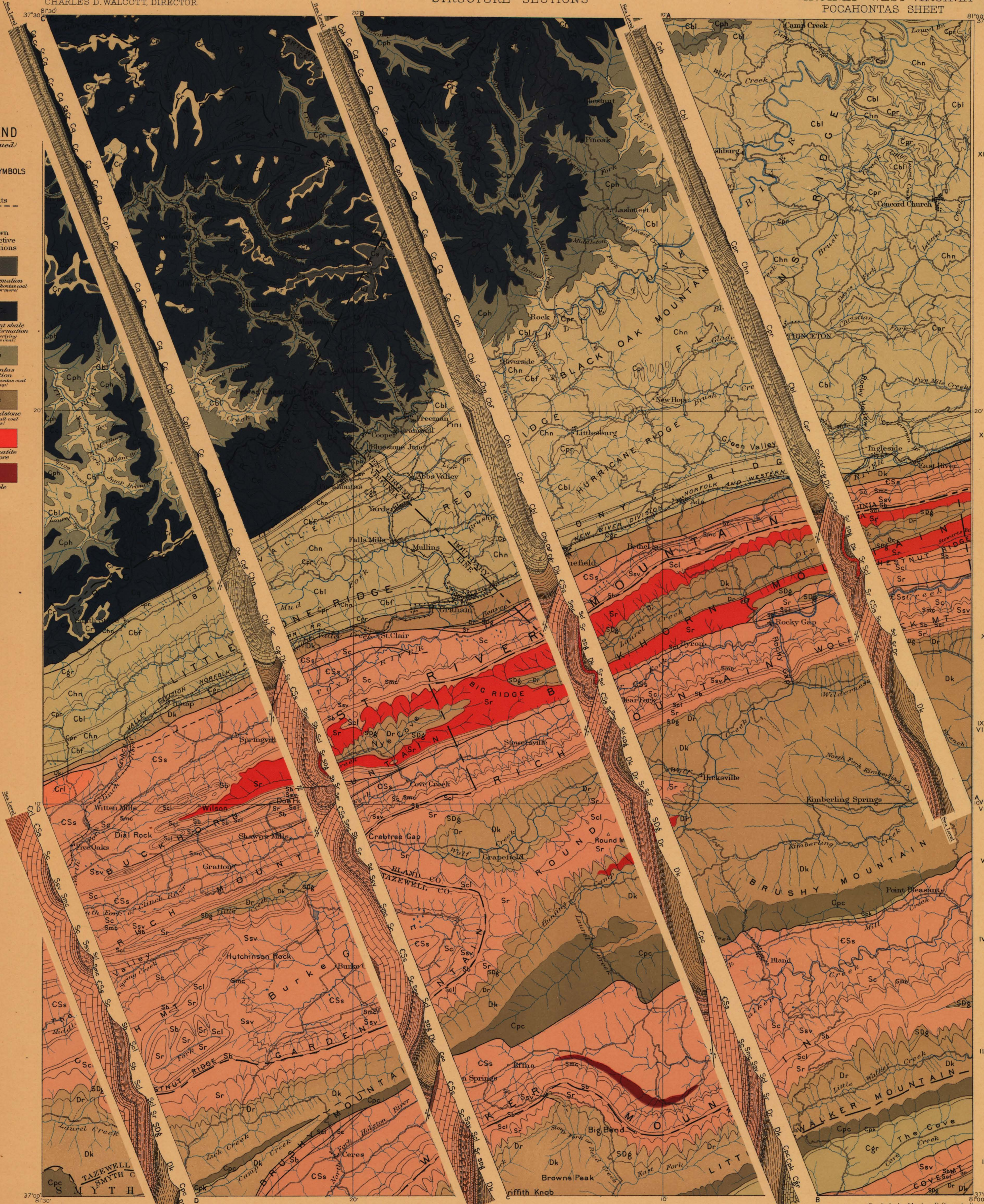
Red hematite iron ore

Marble



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1 ½ 0 1 2 3 4 5 Miles

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LEGEND

SEDIMENTARY ROCKS

CARBONIFEROUS

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Cpk — Pulaski shale *(red shale)*

X

Cpc — Price sandstone *(shales and sandstones containing coal seams)*

DEVONIAN

IX? VIII

Dk — Kimberling shale *(grading from sandstone and conglomerate at the top to green, sandy shale at the bottom)*

Dr — Romney shale *(black shale)*

A
10 VII
VI

SDg — Giles formation *(green or yellow sandstone and blue, cherty limestone)*

SILURIAN

V

Sr — Rockwood formation *(shale and sandstone containing local deposits of red hematite iron ore)*

IV

Scl — Clinch sandstone *(coarse, white, heavy-bedded sandstone)*

Sb — Bays sandstone *(red sandstone and shale)*

III

Ssv — Sevier shale *(sandy at the top grading into blue calcareous shale at the bottom)*

Smc — Moccasin limestone *(red and green, impure limestone)*

Sc — Chickamauga limestone *(blue limestone)*

CAMBRIAN

II

CSs — Shenandoah limestone *(grey dolomite, generally heavy-bedded)*

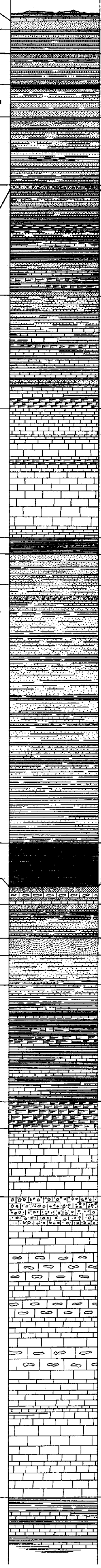
Crl — Russell formation *(red and green, sandy shales and impure limestone)*

COLUMNAR SECTION

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

VIRGINIA – WEST VIRGINIA
POCAHONTAS SHEET

GENERALIZED SECTION FOR THE POCAHONTAS SHEET.
SCALE: 1000 FEET = 1 INCH.



Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
CARBONIFEROUS	Sewell formation.	Cs		100+	Sandy shale.	Irregular knobs on the ridges. Poor soil.
	Raleigh sandstone.	Cr		80	Coarse sandstone in heavy beds.	Ridges and mountains. Sandy soil.
	Quinnimont shale.	Cq		300	Shale with thin beds of sandstone and a few coal seams. Quinnimont coal seam.	Steep slopes. Little or no soil.
	Clark formation.	Cc		380	Sandstone with some shale and coal seams. Heavy beds at the top and bottom.	Steep slopes. Poor soil.
	Pocahontas formation.	Cph		360	Pocahontas or No. 3 seam of coal. Gray and green, argillaceous sandstone, and sandy shale.	Generally steep slopes. Poor soil.
	Bluestone formation.	Cbl		800	Purple shale and thin, red sandstone, with calcareous beds, sometimes taking the form of limestone conglomerate, toward the base.	Ridges and plateaus sharply cut by streams. Good soil where lime predominates.
	Princeton conglomerate.	Cpr		40	Coarse sandstone or conglomerate with calcareous matrix in places.	Ridges and cliffs. Sandy soil.
	Hinton formation.	Chn		1250–1300	Purple shale, green and purple sandstone, and impure limestone or calcareous shale. Heavy sandstone or quartzite.	Gentle hills with rounded slopes. Some good farming lands. The "Stony Ridges."
	Bluefield shale.	Cbf		1250–1350	Sandy shale at the top, graduating into argillaceous shale below. Calcareous shale. Blue limestone and calcareous sandstone.	Steep slopes of the "Stony Ridges." Gentle slopes. Pasture lands. Valleys. Rich soil.
	Greenbrier limestone.	Cgr		1500	A series of alternating shaly and heavy-bedded, blue, fossiliferous limestones. Heavy beds at the base which carry some black chert.	Undulating valleys. Generally rich soil.
	Pulaski shale.	Cpk		20–300	Bright-red or purple shale.	Gentle slopes.
	Price sandstone.	Cpc		200–300	Coarse, yellow sandstone interbedded with sandy shale and coal seams.	Ridges. Poor soil.
DEVONIAN	Kimberling shale.	Dk		3000–3250	Green, sandy shale and thin sandstone containing one or more beds of quartz conglomerate. Generally sandy shale or thin-bedded, green sandstone. Green, sandy shale.	Steep, serrate ridges, generally capped by a bed of conglomerate. Steep slopes. Poor soil, almost destitute of vegetation. Gentle slopes. Poor soil.
	Romney shale.	Dr		400–600	Black, carbonaceous shale.	Valleys. White, poor soil.
	Giles formation.	SDg		30–200	Coarse, yellow sandstone. Cherty limestone. Coarse, reddish sandstone. Blue limestone.	Valleys or gentle slopes. Good soil where not cherty.
SILURIAN	Rockwood formation.	Sr		20–400	Heavy sandstone or quartzite. Sandy shale and ferruginous sandstone, with siliceous, red fossil ore and hematite.	Gentle slopes of the high, valley ridges. Poor soil.
	Clinch sandstone.	Scl		150–250	Coarse, white sandstone or quartzite.	Mountainous ridges.
	Bays sandstone.	Sb		250–350	Red sandstone and sandy shale.	Very steep slopes.
	Sevier shale.	Ssv		1250–1500	Yellow, sandy shale. Yellow or blue shale, slightly calcareous. Calcareous shale with beds of limestone.	Steep slopes. Rich soil.
	Moccasin limestone.	Smc		300–400	Red, earthy limestone.	Gentle slopes. Good soil.
	Chickamauga limestone.	Sc		550–850	Blue, flaggy limestone. Heavy-bedded blue limestone, locally containing beds of gray marble. Black chert.	Valleys. Best farming lands in the region.
? CAMBRIAN	Shenandoah limestone.	€Ss		3000–4000	Limestone conglomerate with red or white matrix and chert pebbles, sometimes replaced by red shale. Gray, magnesian limestone with cherty horizons. Thin bed of blue, calcareous shale, limited to the western part of the district and representing the Nolichucky shale of Tennessee. Dark, siliceous limestone.	Rolling valleys and chert ridges. Good soil where not cherty.
	Russell formation.	€rl		500+	Variegated shale, with beds of impure limestone	Low hills. Pasture lands.