DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

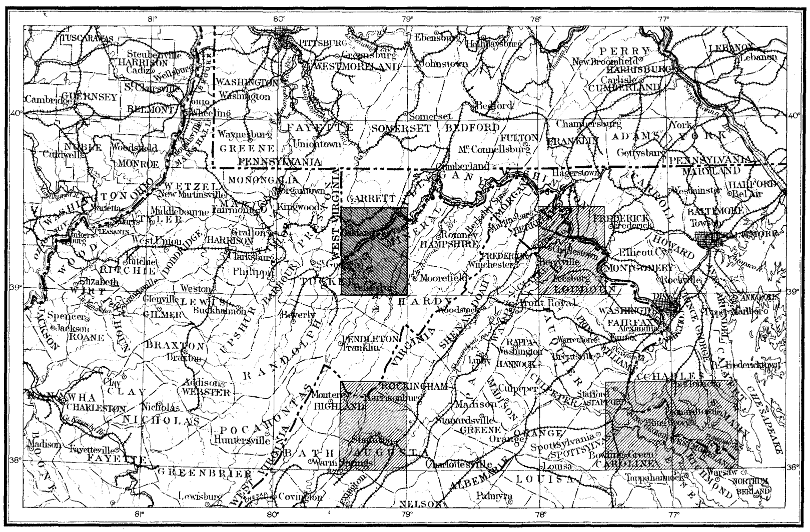
OF THE

UNITED STATES

PIEDMONT FOLIO

WEST VIRGINIA - MARYLAND

INDEX MAP



SCALE: 40 MILES - 1 INCH

AREA OF THE PIEDMONT FOLIO

AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION | TOPOGRAPHY | AREAL GEOLOGY | ECONOMIC GEOLOGY | STRUCTURE SECTIONS

COLUMNAR SECTION

FOLIO 28 | LIBRARY EDITION | PIEDMONT

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

BAILEY WILLIS, EDITOR OF GEOLOGIC MAPS   S. J. KÜBEL, CHIEF ENGRAVER

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:

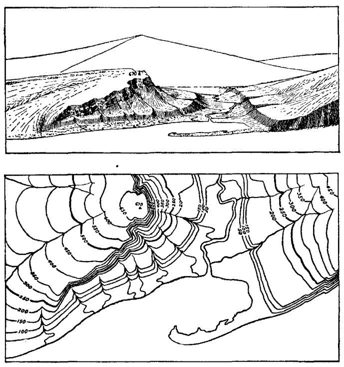


Fig. 1.—Ideal sketch and corresponding contour map.

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 first (Pleistocene) and the last (Archean), 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 those relations is called a *section*, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

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

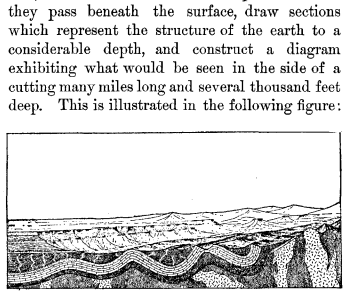


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape above.

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:

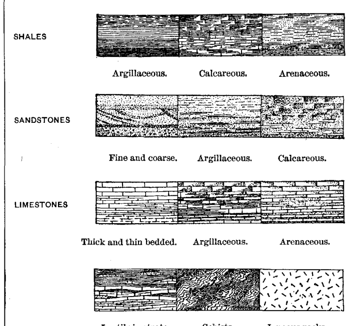


Fig. 3.—Symbols used to represent different kinds of rock.

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 PIEDMONT SHEET.

GEOGRAPHY.

General relations.—The area included in the Piedmont atlas sheet, in extent one-quarter of a square degree, lies between the parallels 39° and 39° 30′ north latitude and the meridians 79° and 79° 30′ west longitude. This area measures approximately 34.45 miles from north to south and 26.85 miles from east to west; it embraces, therefore, on account of the earth's curvature, about 925 square miles. In Maryland it comprises the southern portion of Garrett County and a small area in the southwestern corner of Allegany County. In West Virginia it includes nearly all of Grant County, the western portions of Hardy and Mineral counties, the northeastern portion of Tucker County, and a narrow area of Preston County adjacent to the Maryland boundary line. Its southeastern corner is in a region of Appalachian ridges, and it extends northwestward over the Allegany Mountains and the upper Potomac coal basin to the headwaters of the Youghiogheny River, a branch of the Monongahela.

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. In the southern part it coincides with the belt of folded rocks which forms the Coosa Valley of Georgia and Alabama and the Great Valley of East Tennessee and Virginia. Throughout the central and northern portions of the Appalachian Valley the eastern side only is marked by extensive local valleys—such as the Shenandoah Valley of Virginia, the Cumberland Valley of Maryland and Pennsylvania, and the Lebanon Valley of northeastern Pennsylvania—the western side being a succession of ridges alternating with narrow valleys. This division varies in width from 40 to 125 miles. It is bounded on the southeast by the Appalachian Mountains and on the northwest by the Cumberland Plateau and the Allegany Mountains. Its rocks are almost wholly sedimentary and in large measure calcareous. The strata, which must originally have been nearly horizontal, now intersect the surface at various angles and in narrow belts. The surface differs with the outcrop of different kinds of rock, so that sharp ridges and narrow valleys of great length in some instances follow the narrow belts of hard and soft rock. Owing to the large amount of calcareous rock brought up on the steep folds of this district its surface is more readily worn down by streams and is lower and less broken than the divisions on either side.

The eastern division of the province embraces the Appalachian Mountains, a system which is made up of many minor ranges and 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 Allegany Mountains and the Cumberland Plateau, also extending from New York to Alabama, and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but may be regarded as an arbitrary line coinciding with the Tennessee River from northeast Mississippi to its mouth, and then crossing the States of Indiana and Ohio to western New York. Its eastern boundary is defined by the Allegany Front and the Cumberland escarpment. The rocks of this division are almost entirely of sedimentary origin and remain very nearly horizontal. The character of the surface, which is dependent on the character and attitude of the rocks, is that of a plateau more or less completely worn down. In the southern half of the province the plateau is sometimes extensive and nearly flat, but oftener it is much divided by streams into large or small flat-topped hills. In West Virginia and portions of Pennsylvania the plateau is often sharply cut by streams, leaving in relief irregularly rounded knobs and ridges which bear but little resemblance to the original surface. The plateau once extended much farther westward, but the rocks beyond its present border have been completely removed by erosion, and the surface is now comparatively low and level, or rolling.

Altitude of the Appalachian province.—The Appalachian province as a whole is broadly dome-shaped, 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 decrease to 4,000 or 3,000 feet in southern Virginia, rise to 4,000 feet in central Virginia, and descend to 2,000 or 1,500 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 2,600 or 2,700 feet at its culminating 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 basin, remaining about the same through Pennsylvania. 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 4,700 feet in West Virginia, and decreases to about 2,000 feet in Pennsylvania. From its greatest altitude, along the eastern edge, the plateau slopes gradually westward, although it is generally separated from the interior lowlands by an abrupt escarpment.

Drainage of the Appalachian province.—The drainage of the province is in part eastward into the Atlantic, in part southward into the Gulf, and in part westward into the Mississippi. 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 largely dependent upon the geologic structure. In general they flow in courses which for long distances are parallel to the sides of the Great Valley, following the lesser valleys along the outcrops of the softer rocks. 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 they form the Delaware, Susquehanna, Potomac, James, and Roanoke rivers, 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, in Kentucky and Virginia, 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 southward to northern Georgia the Great Valley is drained by tributaries of the Tennessee River, which at Chattanooga leaves the broad valley and, entering a gorge through the plateau, runs westward to the Ohio. South of Chattanooga the streams flow directly to the Gulf of Mexico.

TOPOGRAPHY AND DRAINAGE.

The Piedmont sheet embraces an area nearly equally divided between the Appalachian Valley and the Cumberland Plateau, the middle and western divisions of the Appalachian province. The Allegany Front, which extends across the area from the northeast corner approximately S. 30° W., marks the line between these two topographic districts. A belt of Devonian rocks occurs between Backbone Mountain and Hoop Pole Ridge, presenting the same topographic features as the valley east of the Allegany Front, but less distinctly marked. Thus the sheet includes four areas of two topographic types, namely: a section of the Appalachian Valley and the Devonian area about Deer Park, showing the longitudinal ridge-and-valley type, and the basins of the North Branch of the Potomac and of the Youghiogheny, which represent the plateau type. The ridge-and-valley country is sharply bounded on the west by the steep rise of the Allegany Front, 1,100 to 2,800 feet high. At the top of this front there is usually a bold escarpment, formed by Carboniferous sandstones. Below this escarpment for 500 to 1,000 feet the slope is smooth, though steep, being carved in soft shales, except where in the middle of the descent hard sandstones and conglomerates of the Hampshire and Pocono formations project in spurs and knobs. Fore-knobs, due to these formations, are characteristic in the southern portion. East of the Allegany Front the structure and lithologic character of the rocks have particularly influenced the development of ridges and valleys. On account of the folded structure of the strata, hard and massive sandstones and limestones remain elevated in New Creek and Patterson Creek mountains, with their skirting lines of ridges and knobs, such as Walker Ridge, Little Mountain, and Knobly Mountain, whereas the valleys of the principal brooks are excavated along the outcrops of soft shales. These are New Creek, the sources of Lunice and Patterson creeks above the gaps through New Creek Mountain, the main branches of Lunice and Patterson creeks between New Creek and Patterson Creek mountains, and the South Branch of Potomac River in the southeastern corner of the quadrilateral. The folds of the strata extend about N. 30° E. and S. 30° W., and the main valleys and mountains are governed in their bearing accordingly. The deep gorges of Greenland, Cosner, and Kline gaps, cut through the mountains at right angles to the general valley system, are features of topography characteristic of this region. These gaps have been sawed by the streams which flow through them. Before any of the now existing valleys had been cut out a plain extended over the country east of the Allegany Front above the top of the present New Creek and Patterson Creek mountains. The hard sandstones of the mountains were then buried beneath shales, which still extend upward on each side of New Creek and Patterson Creek mountains, and which then filled the valleys from crest to crest of the mountains. The altitude of the plain above the sea was low. The whole region was elevated gradually to its present height, and as it rose the streams carved out and widened their valleys. When the hard rocks at the top of the arches in Greenland, Cosner, and Kline gaps were reached they too were sawed down to the present depth. Valleys in soft rocks widen, but the ravines in hard sandstones remain narrow. In the wide valley region intervening between New Creek Mountain and Patterson Creek Mountain many tops rise to an almost uniform elevation. They represent points in another plain which once extended between the higher mountains. The present creeks have cut lower valleys in the floor of the former valley, and the brooks have dissected the plain into numerous small knobs and ridges.

The wide, smooth valley between Backbone Mountain and Hoop Pole Ridge is in the same rocks that occur in the western slope of the valley east of the Allegany Front. The type of topography is the same as that of the valley between New Creek and Patterson Creek mountains: smooth and wide stream basins and gently rounded low hills. Sandstones of the Hampshire formation produce rounded knobs on the slopes of Backbone Mountain and in Hoop Pole Ridge, as they do on the Allegany Front. This wide valley follows upon the axis of an anticlinal fold, and when erosion has continued for sufficient time the massive sandstone which farther east is exposed in New Creek Mountain will be uncovered in this region. Then those streams which continue to cross the valley will cut ravines across the sandstone arch, as Patterson Creek and Lunice Creek have cut them in Greenland, Cosner, and Kline gaps.

Taking valley and mountain together, the country east of the Allegany Front inclines northward. The crest of New Creek Mountain at the southern boundary of the quadrilateral is 3,100 feet high, from which it gradually descends northward to about 1,500 feet at its northern terminus. Charles Knob, in Patterson Creek Mountain, is 2,700 feet high, and the highest point opposite Medley reaches an altitude of 2,800 feet. The valleys at both the southern and the northern limits of the area of the sheet are nearly 900 feet above tide, and they rise to 1,200 and 1,800 feet south of the center, at the sources of New, Patterson, and Lunice creeks. The valley between Backbone Mountain and Hoop Pole Ridge maintains a general level of nearly 2,500 feet.

The two areas of the plateau division of the Piedmont quarter-degree lie, the one between the Allegany Front and Backbone Mountain, and the other west of Hoop Pole Ridge. The plateau is not now a smooth plain, but points in its once nearly flat surface survive in the crests of the high ridges which extend into the central valleys from Backbone Mountain and the Allegany Front. The North Branch of Potomac River and Blackwater River have cut valleys deep into the general level of the plateau. Should the rocks which have been eroded be restored between the crests of the intervening ridges, there would result a generally smooth, flat plain sloping gradually northwestward. The Allegany Front near the southern border of the area of the sheet has an elevation of 4,300 feet, from which it gradually falls northward to about 2,900 feet south of the Potomac gorge. Canaan and Brown mountains are 4,490 and 4,286 feet, respectively, above tide. Northward they decline, and join around the source of Little Blackwater River in the general plain of the plateau. Backbone Mountain in like manner declines from near 3,400 feet in its southern to 2,700 feet in its northern extension.

The bold escarpments which surround the plateau region, facing outward from it, and the gentle slopes within the district are due both to the character of the strata and to their gently tilted attitude. The thick beds of sandstone and conglomerate of the Blackwater formation maintain the crests of all these mountains and dip at a low angle away from the escarpments. The cliffs develop where the soft sandstone and softer shales of the Greenbrier formation, which lie beneath the sandstone and conglomerate, yield readily to erosion and undermine the hard rocks. The gentle inward slopes of the plateau are broad surfaces of hard strata, partly denuded of softer rocks which once overlay them. Where resistant sandstones form the surface, they weather to characteristic assemblings of loose rounded stones, herein called "stonecrops."

The North Branch of Potomac River, beginning at Fairfax Stone, flows northeastward near the axis of the synclinal basin, and with its tributaries between the Allegany Front and Backbone Mountain has cut deep and narrow channels from a few hundred feet to more than 1,000 feet deep. Joining Savage River near the northeast corner of the area of the sheet, the Potomac turns to a southeasterly course through a majestic gorge in the Allegany Front and passes into the central valley region.

The Blackwater River has a peculiar drainage channel. Rising near the southeast corner of the area of the sheet, it flows northeasterly with sluggish meanderings in a wide and nearly level valley. On joining Little Blackwater River, it turns almost directly at right angles to the northwest and flows swiftly through a gorge in Brown Mountain. After passing Brown Mountain the river takes a southwesterly course, and passes the map-limits in a deep and narrow channel.

Westward from Hoop Pole Ridge there is an area of Carboniferous rocks forming a small basin. Conglomerate and sandstone of the Blackwater formation maintain Roman Nose and a line of hills which bear thence southwestward. The same rocks rise on the western side of the basin in a ridge near the northwestern corner of the area of the sheet. The Youghiogheny River flows longitudinally in this basin and has cut a narrow valley with precipitous slopes.

GEOLOGY.

The general sedimentary record.—The rocks appearing at the surface within the limits of the Piedmont atlas sheet are of sedimentary origin—that is, they were deposited by water. They consist of sandstone, shale, and limestone, all 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, chemical precipitates from enclosed seas, and the remains of plants and animals which lived while the strata were being laid down. Some of the beds of limestone were formed in part from the shells of various sea animals, and the beds of coal are the remains of a luxuriant vegetation, which covered extensive swamps.

The rocks afford a record of sedimentation from middle Silurian to late Carboniferous times. Their composition and appearance indicate at what distance from shore and in what depth of water they were deposited. Sandstones marked by ripples and cross-bedded by currents, and shales cracked by drying on mud flats, indicate shallow water; while limestones, especially by the fossils they contain, indicate clear water and scarcity of sediment. The character of the adjacent land is shown by the character of the sediments derived from its waste. The sand and pebbles of coarse sandstones and conglomerates, such as are found in the lower Carboniferous may have been originally derived from higher land, on which stream grades were steep, and they may have been repeatedly redistributed by wave action as the sea migrated back and forth over a rising and sinking coastal plain. Red sandstones and shales, such as make up some of the Silurian, Devonian, and Carboniferous formations, result from the revival of erosion on a land surface long exposed to rock decay and oxidation, and hence covered by a deep residual soil. Limestones, on the other hand, if deposited near the shore, indicate that the land was low and that its streams were too sluggish to carry off coarse sediment, the sea receiving only fine sediment and substances in solution.

The seas in which these sediments were laid down covered most of the Appalachian province and the Mississippi basin. The area of the Piedmont sheet was near their eastern margin at certain stages of sedimentation, and the materials of which its rocks are composed were probably derived largely from the land to the eastward. The exact positions of the eastern shore-lines of these ancient seas are not known, but they probably varied from time to time within rather wide limits.

Pursuing these general ideas more in detail, one finds that the strata of the Appalachian province record many variations in the ancient geography and topography of the continent. In general it is true that fine-grained sediments such as form calcareous shale and limestone are free from coarser detritus, such as sand, only because no sand reached the place of deposit. This condition may arise when materials accumulate far from shore, but it may also extend to areas near shore when the land is low, the rivers are accordingly sluggish, and the waves are inactive along the coast. Therefore, when it is known that the shore was not very remote from the place of limestone deposition, it is reasonable to infer that the coast and a stretch of land behind it were generally low.

Coarse detritus is often largely composed of quartz-sand or quartz-gravel, the most obdurate of stones. Such material is derived from igneous and metamorphic rocks, including quartzite, being set free as they break down. Somewhat steep river slopes are required to carry it to the sea, and it may thus give evidence of elevated lands from which it was derived. But when sands and pebbles are once deposited in a coastal plain such as that which forms the Atlantic Coast from New York to Florida, they may be handled by the waves again and again as the margin of the sea migrates back and forth over the gentle slope. They may thus come to form part of coarse deposits much younger than the date of their first accumulation, and their significance as to the elevation of the land becomes vague. Nevertheless, when formations are of great volume, of somewhat mingled coarse and fine materials, and of rapid accumulation, they indicate a rate of erosion which implies that they represent a mountain range at least of moderate elevation.

Reasoning thus from the texture and bulk of sediments, and also from their distribution, the principal geographic changes of the Appalachian continent can be made out. One of the great events of North American geology is the expansion of the interior sea during Cambrian time. Early in the Cambrian period a narrow strait extended from the region of the Gulf of St. Lawrence southwestward to Alabama. It divided a western land area covering the central States from an eastern continent of unknown extent. The eastern shore of the strait was probably about where the Appalachian Mountains now extend. The great Appalachian Valley approximately coincides with the position of the strait. During Cambrian and Silurian time the Appalachian strait widened westward to Wisconsin and beyond the Mississippi. It probably also expanded eastward, but there is no evidence remaining of its farthest limit in that direction.

Before the widening of the Appalachian strait, in early Cambrian time, the land to the eastward was probably somewhat mountainous. The region of the central States was comparatively low land. The continued activity of the agents of erosion reduced the mountain range, whose bulk is represented in the Cambrian sediments. Before the beginning of deposition of the great Cambro-Silurian limestone the eastern land had become a low plain, whose even surface, subsiding, permitted probably extended transgression of the sea.

Following the Cambro-Silurian limestone in the sedimentary series, there is a mass of shale of widespread occurrence and of great thickness locally in the Appalachian Valley. It marks uplift of the eastern land and erosion of the residual material, perhaps together with the Silurian sediments, then lately accumulated over the surface. Thus there was toward the close of the Silurian period a restoration of moderate elevation to the eastern land and a return of the shore from its eastward excursion to a position approximately along the eastern margin of the Appalachian Valley. The changes of topography and geography from early Cambrian time to this epoch of Silurian time have been called a first cycle in Appalachian history.

The later Silurian sediments are of meager volume as compared with those that preceded them, and of variable coarseness. They represent the varying conditions of a zone across which the shore migrated back and forth. To the eastward lay the generally low continental area, margined by a coastal plain which stored the coarsest detritus of the land. Westward extended the shallow interior sea. The migrations of the shore are marked in variations of coarseness of the sandstones and sandy shales up to and including the Rockwood formation, as well as by overlaps of strata, with an incomplete sequence due to erosion of the missing members.

The moderate elevation of the eastern land had again been canceled by erosion before the beginning of the Devonian, and the low level is recorded in the fine shaly and calcareous deposits of the last Silurian epoch and the widespread black shale herein called the Romney. The intermediate sandstone, the Monterey, marks an oscillation of the shore with contributions of sands from the coastal plain, and an overlap of later strata.

The lowlands of the early Devonian were general from New York to Georgia. This topographic phase continued throughout the Devonian period in the region south of Virginia, but in the northeast, in Pennsylvania, New York, and New England, there occurred an uplift of considerable magnitude. In middle Silurian time the interior sea had been cut off from the Gulf of St. Lawrence by an elevation of New England and northern New York which closed the Lake Champlain strait. The sea, thus limited, received Devonian sediments which attained a maximum thickness of 9,000 feet in Pennsylvania. They are composed of poorly assorted sands and shale, derived from the degradation of a mountain mass, probably several thousand feet in height. These Devonian mountains were possibly higher than those of the early Cambrian, though less extensive. In the interval between the two generations of mountains the land had not attained any considerable elevation.

Above Devonian strata throughout the province occur calcareous shales and fine-grained limestones of early Carboniferous age. This gradation in sediments from heterogeneous, coarse materials to fine silts corresponds to the similar change from lower Cambrian sandstones to Cambro-Silurian limestone; and it marks the degradation of the Devonian mountains to a general low level. In the early Carboniferous time the relations of land and sea were stable, as they had been during much of the Cambro-Silurian periods, and during the early Devonian.

During middle and later Carboniferous time there ensued, however, that general vertical movement of the eastern land area and the region of the interior sea which resulted in the withdrawal of the sea to the Mississippi embayment. The movement was not simple; it was composed of many episodes of uplift and subsidence, among which uplift preponderated. In the repeated oscillations of level the sea swept back and forth over wide areas. It received from the coastal plain the coarse quartz detritus which had accumulated during previous ages, and the waves and currents of the shallow sea spread the concentrated sands and pebbles in beds which alternated with materials of less ancient derivation. The Carboniferous strata include shale and sandy shale, derived more or less directly from lands of moderate elevation, and also the coal beds, each of which marks the prolonged existence of a marsh in which the peat-making plants grew. When the marsh sank beneath the sea the peat beds were buried beneath sands or shales, and the peat by a process of gradual distillation became coal. At the close of the Carboniferous a great volume of varied sediments had accumulated. It represents a correspondingly deep erosion of the land mass, but the uplift thus indicated appears to have gone on slowly, and it may be that the surface was not raised to the height of the mountains of to-day. The vertical movements giving rise to variations in strata, and even to mountain ranges, appear to have been independent of the horizontal movements which caused the folding of the Appalachian strata. There is at least no apparent direct connection between the two phases of earth movement.

STRATIGRAPHY.

The strata exposed in the area of the Piedmont sheet have a thickness of about 11,000 feet. The order of succession of the limestones, shales, sandstones, and coals, and their general character, are given in the columnar-section sheet.

SILURIAN STRATA.

Juniata formation.—The lowest rocks which appear at the surface in the area are exposed in the center of New Creek Mountain, in the gorges cut by the streams at Greenland, Cosner, and Kline gaps. They are red sandstones and shales, which are interbedded in no regular succession. The sandstones are hard, moderately coarse grained, and in part cross-bedded. They vary in thickness from 1 to 30 feet, and are mainly in beds from 1 to 4 feet thick. The shales vary from a thin parting between sandstone layers to beds 6 or 8 feet thick. Much of the formation consists of alternations of 4 or 5 feet of shales and 8 to 10 feet of sandstones. The most extensive exposure is in Kline Gap, along the bottom of the creek in the center of the mountain, where about 750 feet are visible. The beds rise quite high above the road, but in this gap and the others they are mostly hidden by the heavy talus of white quartzite blocks from the cliffs above.

Tuscarora quartzite.—This is a hard, white rock, which constitutes the higher portions of New Creek Mountain. It overlies the Juniata formation and gives rise to the beautiful arches in Greenland, Cosner, and Kline gaps. It consists almost entirely of a homogeneous mass of coarse white or gray sand in a very hard siliceous matrix. Some small pebbles occur widely scattered, and a few were observed which have a diameter of a half-inch. The beds are often very massive, particularly in the upper portion of the formation. At its top and toward the base there are some thinner-bedded members. The thickness is 480 feet in Kline Gap, and it appears to be the same in Cosner and Greenland gaps, although precise measurement could not be made.

Cacapon sandstone.—This sandstone (pronounced Capon) is a red, flaggy rock, somewhat similar in appearance to the sandstones of the Juniata formation, but less massive and of a brighter, red-brown color. It lies along the flanks of New Creek Mountain, and extends across the mountain on the old Morgantown pike, northwest of Maysville. East of Rees Tannery, where the mountain sinks into a range of hills, it covers the arch in a low ridge which is less than a half-mile in width. The thickness of the sandstone averages about 300 feet, as nearly as could be estimated from a number of partial measurements. No complete cross-section exposures were found.

Rockwood formation.—The upper portion of the Cacapon sandstone merges upward into a series of brown and gray shales with thin intercalated layers of sandstone below and of limestones above, and at the top a layer of gray sandstone which is about 15 feet thick. The formation varies in thickness from 525 to 750 feet, but as the shales are usually considerably crumpled, and the basal beds not always exposed, an accurate determination of thickness could not be made. The formation extends in a narrow belt along both sides of New Creek Mountain, lying mainly in the valley between the main mountain and the ranges of foot-hill ridges. In Patterson Creek Mountain it is exposed in small areas east and south of Williamsport. The finest cross-section exposure of fresh beds is in the eastern side of Cosner Gap, where 530 feet were found. They here consist of purplish shales at the bottom, with a few thin sandy beds, green and purplish shales with thin sandy layers, gray shales with sandy layers, gray shales with thin limestone layers, and the top member of 15 feet of gray massive sandstone. In most exposures the shales are weathered to a gray or a gray-buff color. To the northward they appear to thicken to at least 750 feet. Iron ore occurs in most localities as two thin beds in or near the middle of the formation, but no great thickness was observed, and the ore was in greater part too sandy to be of much value. The limestone beds are mostly thin, but they are usually quite pure. They contain abundant fossils of a mixed Clinton and Niagara fauna. The gray sandstone beds which cap the formation are of general occurrence, and often give rise to a small ridge or escarpment. This sandstone is exposed in Patterson Creek Mountain in a small area east of Lahmansville, and in three depressions in the center of the mountain east of Williamsport. In the two larger of these depressions a portion of the underlying shales is also exposed.

Lewistown limestone.—This formation has a thickness of from 1,350 to 1,700 feet, and it comprises several members which are generally distinct. The upper member, consisting of very cherty limestone, and a lower series, of thin-bedded or flaggy limestones, are prominent ridgemakers, particularly in Patterson Creek Mountain. The intermediate beds consist of softer, shaly and massive limestones aggregating about 250 feet in thickness. A basal series, of about the same thickness, consists of calcareous shales and thin-bedded, impure limestones. The formation extends along both sides of New Creek Mountain, on the inner sides of the ridges which flank that mountain (it gives rise to the series of high "knobbly" ridges) and which constitute the central portions of Patterson Creek Mountain. Helderberg fossils occur throughout the formation.

The gray sandstone of the Rockwood formation is overlain by alternations of calcareous shale and thin-bedded limestone which constitute the basal series of the Lewistown limestone. They have a thickness of from 250 to 310 feet in the Piedmont sheet area, but thicken to the northward, and near Hancock and Cumberland their upper beds carry important beds of cement rock, which are extensively worked. Thin beds of the cement rock continue southward, but their quality has not been tested. The series outcrops along both sides of New Creek Mountain, in the valley between the main mountain and its flanking ridges or in the slopes of these ridges. In Patterson Creek Mountain it is exposed at intervals in the elevated valleys along the center of the mountain. Its lowest beds consist of green shales, usually of bright color. Some thin sandy beds, and sandy shales, often occur not far above the basal green shales, but calcareous shales and thin-bedded, hard limestones are the principal features, and they prevail in the upper beds.

The basal series merges upward into the flaggy limestone series, and thin partings of calcareous shale extend for some distance into the predominantly flaggy limestone beds. These flaggy beds are quite pure limestones, dark on fresh fracture, but weathering light-colored on exposure. They are mainly in thin beds from a half inch to 2 inches thick, with smooth surfaces along which the beds readily separate. They thicken to the east and south and attain a thickness of nearly 1,000 feet in Patterson Creek Mountain. There they rise in high ridges along the center of the mountain over an area which extends from Charles Knob to beyond Williamsport. In New Creek Mountain they extend high up the inner slope of the flanking ridges. The intermediate limestone series begins with a basal bed of massive, dark-colored limestone, which is quite sharply separated from the flaggy limestone. It varies from 30 to 60 feet in thickness, and is characterized by irregular wavy partings, which divide the strata into flat, lens-like masses, brought out prominently by weathering. This bed gives place to, or in most cases merges upward into, a thin-bedded or impure, shaly limestone, of which about 100 feet are usually obscurely exposed. They are overlain by heavier-bedded, highly fossiliferous limestones of coarse grain and light color, with thin intercalated beds of cherty limestone at varying intervals toward their upper part. These intermediate beds present considerable local variation in thickness, but their characteristics are quite constant throughout. The clearest exposures observed were in the cliffs a mile and a half north of Rees Tannery, at Mays Gap, and along the east side of Greenland Gap. The cherty limestone, or upper member, is only about 130 feet thick in the ridge near Rees Tannery, and it does not thicken materially along the west side of New Creek Mountain, but to the southeastward it increases in thickness to fully 300 feet in Patterson Creek Mountain. Together with the overlying Monterey sandstone it constitutes the crest of the flanking ridges of both New Creek Mountain and Patterson Creek Mountain, and it is often more prominent than the sandstone. It gives rise to rough, rocky summits and a long talus of chert fragments. The upper beds of the cherty series, and ordinarily also the lower beds, are thin-bedded, less cherty, and contain Helderberg fossils.

DEVONIAN STRATA.

Monterey sandstone.—This sandstone extends along the outer slopes of the ridges which adjoin New Creek and Patterson Creek mountains. It also constitutes a number of small ridges which lie near or extend into the main flanking ridges of Patterson Creek Mountain. It is a very hard, fine-grained, calcareous sandstone of dark-gray or blue-gray color, which weathers to a dirty buff, porous, sandy rock of considerable hardness. Much of the rock, especially in the weathered condition, exhibits large numbers of casts and impressions of fossil molluscan and crustacean remains of the Oriskany fauna. The formation varies in thickness from 215 to 300 feet, with a fairly constant increase to the south and east, as is the case with the underlying cherty limestone. It is extensively exposed in the many gaps through the flanking ridges of New Creek and Patterson Creek mountains, but the most notable exposures are in the Greenland, Cosner, Kline, Antioch, and Robinson gaps, and near Seymourville and Williamsport. In the gaps it gives rise to very narrow gorges, and in most cases the waters fall over its edge.

Romney shale.—Lying on the surface of the Monterey sandstone there is an extensive series of shales, which are dark-colored below and have a thickness of about 1,200 feet. They extend along both sides of New Creek and Patterson Creek mountains, and, owing to their softness, give rise to valleys and areas of low, rounded hills. The valleys of New Creek, Patterson Creek, Lunice Creek, and a portion of the South Branch of Potomac River are excavated in this formation, except that in the vicinity of Laureldale New Creek flows along a valley in the Lewistown limestone for a few miles. The rocks consist of dark shales, black and fissile below, but somewhat lighter and more compact above. Lower Hamilton group fossils occur abundantly in some of the beds. Some of the basal beds are carbonaceous to a moderate degree, and they have been worked at several points with the mistaken idea that they might prove to be coal-bearing. The formation includes occasional thin beds of fossiliferous limestone not far from its base, and the upper members contain alternations of thin, pale-brown or dark-buff, sandy beds, which constitute beds of passage into the next succeeding formation.

The vertical range and stratigraphic position of these passage-beds appear to be somewhat variable, so that there is no definite line of demarcation between the two formations. Owing to this fact, no precise thickness can be assigned to the Romney shales, and on the map the Romney and Jennings patterns have been merged, to indicate the intergrading of the two formations.

Jennings formation.—The Jennings formation outcrops along the slopes of the Allegany Front, extends along the syncline between New Creek and Patterson Creek mountains, and is brought to the surface along a narrow belt in Garrett County by the anticline which passes through Red House and Mountain Lake Park. A narrow belt of transition beds to the Romney shales caps the hills between the South Branch of Potomac River and the southern end of Patterson Creek Mountain. The thickness of the formation averages about 3,300 feet. The lower members are light-colored shales, in which olive-gray and buff tints predominate, with interbedded light-colored sandstones, some of which are moderately thick bedded. The local sequence of beds is somewhat variable. The upper members are mainly sandstones of gray color, with occasional thin layers or lenses of conglomerate. There are extensive outcrops of the formation along the Allegany Front, notably where it is trenched by the North Branch of Potomac River, above Keyser. The upper limits of the formation are not well defined, for there is an extensive series of beds of passage to the next succeeding formation. It is on account of the indefiniteness of the limits of this formation that its boundary on the map is shown by a zone in which the pattern is merged into the patterns of the adjoining formations.

Hampshire formation.—This formation extends along the middle slopes of the Allegany Front, where it passes beneath the Carboniferous rocks which underlie the Potomac coal field, and it rises again to the surface in the area between Backbone Mountain and the Youghiogheny coal field. There it constitutes two lines of foot-hill knobs extending along either side of the narrow belt of glade region underlain by the Jennings formation. One of these lines of knobs lies just east of Deer Park and Red House, and the other passes through Oakland. The thickness of the formation varies from 2,000 to 2,300 feet, the maximum being to the eastward. The rocks are largely sandstone and shale, of red color, with some beds of buff, greenish-gray, and gray colors. The sandstone varies from slabby to massive-bedded, and usually constitutes masses from 15 to 20 feet thick. They are often cross-bedded and merge into shale. The shales are generally of quite bright brownish-red color, fissile, and in masses from a few inches to 10 or 15 feet thick. They occur throughout the formation. Greenish-gray and brown shale are not uncommon, but they are not of great thickness or extent. The relation of sandstones to shales is very irregular, and there appears to be no constant stratigraphic succession of beds. The finest exposures of the formation are along the Baltimore and Ohio Railroad from Deer Park to beyond Frankville, between Piedmont and Keyser, and at Oakland.

CARBONIFEROUS STRATA.

Pocono sandstone.—This basal member of the Carboniferous formations lies next above the Hampshire beds and outcrops in the same region as above described, but it is also brought to the surface in the upper Blackwater Valley east of Cortland, and at Red Creek post-office, in the southwestern corner of the area. Along the Allegany Front it caps a series of knobs which lie about 500 feet below the crest north of Pigeon Roost, and 1,000 feet below farther south. Along the northwest side of Backbone Mountain the Pocono usually gives rise to a narrow terrace lying behind the knobs of Hampshire formation. It consists of hard sandstone or quartzite, which is generally conglomeratic, but in some cases locally it is nearly or quite free from pebbles. It is sharply separated from the Hampshire beds. In the region west of Backbone Mountain it is usually hidden beneath a talus of blocks from the cliffs of Blackwater (Pottsville) conglomerate above, and its character could not often be determined, but in the few outcrops seen it was a conglomerate of small quartz pebbles. In the gorge of the North Branch of Potomac River, between Piedmont and Keyser, it is a gray, cross-bedded sandstone with only a few widely scattered pebbles. In the outcrop extending west of Sunnyside through Oakland and along Hoop Pole Ridge it is mainly conglomeratic, but some beds are locally nearly pure quartzite or sandstone. Along the knobs below the Allegany Front it varies from massive quartzite and conglomerate to a hard, flaggy, cross-bedded sandstone, usually with conglomeratic streaks, but conglomerate prevails. Its upper beds consist of a few feet of gray or brown sandstone and shales. In the Blackwater Valley it varies from sandstone to conglomerate, and the sandstone east of Cortland contains a few thin, irregular layers of coal, from 1 to 6 inches in thickness.

The thickness of the Pocono sandstone gradually increases southward from 30 feet on the North Branch of Potomac River to 80 feet along the southern margin of the area.

The Greenbrier limestone.—This formation rests upon the Pocono sandstone, and varies from less than 200 feet in the northeast corner to more than 450 feet in the southwest corner of the area of the Piedmont sheet. It crops out above the knobs of Hampshire and Pocono rocks in Allegany Front along its entire course. From Allegany Front it passes downward beneath the Potomac coal field and rises to the surface in the west side of Backbone Mountain. This limestone is exposed in each side of Blackwater River in the vicinity of Cortland and at the southern end of Brown Mountain near Red Creek post-office. It dips westward in Hoop Pole Ridge, at Oakland, and in Rhine Fork Valley southwest of Oakland, and extends beneath the Youghiogheny coal basin, rising to the surface in the northwest corner of the Piedmont sheet area. It is almost entirely concealed, both in Allegany Front and in Backbone Mountain, by talus. Its entire thickness was not exposed at any place in Backbone Mountain. In Hoop Pole Ridge it can scarcely be seen above the soil, but its thickness is very nearly the same as at Red Creek.

The Greenbrier formation consists of thin limestone strata interbedded with red clay-shale. The limestone is sandy in the lower part, but purer above. The thickness of the limestone layers as compared with that of the shale lessens toward the top, until the latter preponderates. As this formation extends southward and westward the rocks vary in character as well as in thickness. In the Potomac gorge east of Piedmont the lower portion is a calcareous sandstone 140 feet thick, and the purer limestone is much thinner. Near Red Creek post-office the sandy, lower beds are 100 feet thick, while the upper, purer limestone with interbedded red shale is 350 feet thick.

The Canaan formation.—This formation succeeds the Greenbrier limestone without a clearly defined parting. It thins westward. In the western slope of Backbone Mountain it is estimated to be nearly 700 feet thick, while in Hoop Pole Ridge and west of Oakland its thickness does not exceed 570 feet. It is exposed in the Allegany Front below the crest and above the line of knobs and spurs which extend in a line irregularly along the escarpment 500 to 1,000 feet below the top. From this outcrop the strata dip downward toward the northwest, and rise again in the west slope of Backbone Mountain below the crest and above an array of knobs near its base. On the west side of Hoop Pole Ridge, and in the valley adjoining, these beds are exposed, dipping again westward, and in the northwest corner of the area of the sheet the upper member of the formation rises to the surface. By the elevation due to the Blackwater anticline the formation is completely exposed in Blackwater Valley between Canaan and Brown mountains and in the lower slopes of the escarpments on each side. Red Creek and one of its tributaries enter this formation as they approach the southern limit of the quadrilateral. This formation has very red clay-shales in the lower part, red sandy shales medially, and culminates in brownish-red sandy shales interstratified with greenish-brown to brown, fine sandstone. The sandstone is, in part, micaceous. Greenish bands occur occasionally in the red shale, and dark carbonaceous shale with thin coal has been seen near the top of the formation.

The Blackwater sandstone.—This is the lowest stratum of the regular Coal Measures within the area of the Piedmont sheet. Its thickness varies from nearly 290 feet at Piedmont to 645 feet on Blackwater River below Davis. In the Youghiogheny region it is estimated to be 260 feet thick. This sandstone, through its resistance to erosion, has governed the positions of the Allegany Front and Canaan, Brown, and Backbone mountains. It projects to the surface in their crests in extensive stonecrops and ledges. It is exposed in the valleys of Red Creek and Blackwater River and in hills on the east side of the Youghiogheny River. On the west side of the Youghiogheny basin it outcrops in the hills and dips eastward.

The Blackwater sandstone is composed of three poorly defined sandstone and conglomerate beds, which are separated by two zones of softer, argillaceous sandstone and sandy shale, containing variable and impure coal beds. In the vicinity of Piedmont the uppermost and lowest sandstone beds are conglomeratic, and are 110 and 30 feet thick, respectively, while the medial sandstone is fine-grained and only 14 feet thick. The upper sandstone member on the Blackwater River is 200 feet thick and nearly entirely conglomeratic. The medial sandstone here is 125 feet thick and has a conglomerate band 10 feet thick at its center. The lower bed is 155 feet thick and has a number of variable bands of conglomerate. Much of the sandstone and conglomerate is of pure quartz grains and pebbles in a siliceous matrix, and is a beach deposit. Both the sandstone beds and the intervening strata of impure sandstone and shale are in many places strongly cross-bedded. The sequence and extent of strata are irregular. Instances have been noted of shales with productive coal beds being replaced by thick beds of sandstone in immediately adjacent sections.

Opportunities for studying the Blackwater sandstone were not good in the Youghiogheny basin. Two sandstone divisions with variable shale and thin, unimportant coals were recognized. A coal was located at the base of the lower sandstone, but it was thin and of inferior quality.

The Savage formation.—The rocks of this formation are nearly equally divided between sandstone and shale, though neither the sandstone nor the shale beds have a continued thickness or permanent composition over a wide region of country. The thicker sandstone beds become shaly, and beds of shale divide them locally, so that variability rather than permanency of stratification is their character. The formation varies from 130 to 160 feet in thickness and contains four coal beds, two of which are of economic importance, but are variable locally both in thickness and in quality of coal. The formation and the coals it contains thicken southward. The roof of the coal bed commonly known as the "Six-foot" bed or "Davis" seam is the top of the formation, and the base of the formation is in contact with the upper sandstone and conglomerate of the Blackwater formation. Two thin beds of limestone occur in this formation at Coketon, just outside of the limit of the sheet, south of Thomas. The upper of these is 5 feet thick, is ferruginous, and contains calcareous shale partings. It is 53 feet below the top of the formation. The lower limestone is merely a band of yellow, ferruginous concretions in calcareous shale which is the floor of a coal bed 34 inches thick. In the Youghiogheny Valley this formation contains two beds of limestone, which represent probably those seen at Coketon.

The Savage formation outcrops along the west slope of the Allegany Front, near the crest, dipping westward at 10° to 14°, and after passing beneath the Potomac basin it rises in the east side of Backbone Mountain at nearly the same angle of dip, but eastward. The surface exposure crosses the basin of Red Creek, continues upon the east side of Canaan Mountain to its north end, and thence down Beaver Creek Valley to the border of the quarter-degree at Pendleton. The North Branch of Potomac River has exposed this formation from Glade Run to the gorge below Piedmont. Both Savage River and George Creek have cut through its beds. It outcrops in in the valley of Youghiogheny River from Crellin northward, and in the east side of the ridge near the northeast corner of the area.

The Bayard formation.—This formation is composed of three rock divisions: a lower sandstone member, a middle division of shaly sandstone, shale, coal, and thin limestone, and an upper sandstone having a total thickness of 400 to 475 feet. In the center of the Potomac basin it is nearly 450 feet thick.

The lower sandstone in the vicinity of Piedmont consists of upper and lower massive beds, 80 and 45 feet thick, respectively, with intervening sandstone, shale, sandstone, and thin coal bed; in all, 196 feet. At Thomas the shale is less prominent and the coal is a mere band. Local deposits of conglomerate occur in this sandstone. It is less prominent in the Youghiogheny Valley than in the Potomac Valley. Large blocks of grit and sandstone mark its location in the middle of the slopes of the river valley and along Harrington Creek in the center of the basin.

The middle division of this formation is nearly 200 feet thick, and it bears important workable coal beds at the top and at the bottom, 4 and 3 feet thick, respectively, known locally as the "Fourfoot" and "Threefoot" coals. About Thomas the Threefoot is known as the Thomas bed. The sandstone beds in this division of the formation are usually shaly, often thin, and very rarely exposed at the surface except as small fragments. Near the center there is a coal bed 2 feet thick, of some economic importance. It rests upon massive fossiliferous, calcareous shale, which grades downward into a black limestone. A light-blue limestone occurs a few feet below the highest coal in this division. The limestones weather deeply in this climate, and it was not possible to determine their extent.

The upper sandstone member of the Bayard formation is especially important, both in its stratigraphic and its topographic relations. It is a guide rock to the location of economic coals, and it is unmistakable in its contrast with the superimposed shales of the Fairfax formation. It occurs at the top of the escarpment, bordering the valleys of the North Branch of Potomac River and its tributaries, either as stonecrops or bluffs. It is usually a pure quartz sandstone, and occasionally a conglomerate of small white quartz pebbles in a siliceous matrix occurs in it. Erosion has cut away the succeeding rocks so that large areas of this formation are at the surface in the Potomac basin, and in the Youghiogheny basin higher rocks have been removed entirely.

The Fairfax formation. — The culminating sandstone of the Bayard formation is a beach deposit. Its thickness varies according to the unevenness of its upper surface. The overlying Fairfax formation is composed of very fine sand and mud, deposited off the low and possibly somewhat distant shore. The thickness of the lower members varies with the inequalities of the upper surface of the Bayard formation. Remnants of this once widespread formation are now to be found only in the valley of the North Branch of Potomac River, erosion by the river and its tributary streams having given the present form to what remains.

The Fairfax formation is nearly 300 feet thick. The lower half has thin and impure sandstone beds interstratified with thicker beds of shale, and it contains two thin and poor coal beds, which have rarely been exposed. The upper half of the formation, except an important sandstone bed 20 feet thick nearly 20 feet below the top, is clay-shale with minor bands of sandy shale. An 18-inch coal bed, usually of good quality, occurs 40 to 50 feet below the top of the formation, and there is a variable coal and shale of poor quality 130 feet below the top. The upper limit of the Fairfax formation is drawn at the base of the Elkgarden coal, which is known, also, as the "Fourteenfoot" bed.

The Elkgarden formation.—The floor of the Elkgarden coal is the base of the Elkgarden formation. Everywhere in the Piedmont area its upper limit has been removed by erosion; hence it can not be defined. Except a very small area which forms the top of Fairfax Knob, it is confined to fourteen remnants of the former extensive formation, all of which are within the Potomac basin north of Abram Creek. The most extensive of these areas are upon the Elk Garden Plateau between Deep Run and Abram Creek. The areas in the vicinity of the Franklin and Hampshire mines, northwest and northeast of Westernport, preserve the thickest section of strata, which is nearly 280 feet. Only one small area occurs west of the North Branch of Potomac River. This is in the crest of the ridge between Stony and Elk Lick runs. This formation has the smallest area, yet its coals have given it great economic importance. As with the Fairfax, erosion has removed the greater part of this once extensive formation.

The Elkgarden formation is composed principally of shales, and the surface of the ground is, in general, smooth and gently sloping, though there are several sandstone strata whose fragments occur at the surface. A more prominent sandstone bed occurs in a small area at the top of the hill above the Franklin incline northwest of Westernport. It appears here at the surface only as rough bowlders and stony talus. The shales vary in color from carbon-black to light-gray, and on weathering are brown and yellow. They are variably sandy, and thin flag-like bands of argillaceous sandstone occur interstratified. Variable bands of thin coal and carbonaceous shale occur in the yellow and brown shale near the base above the Elkgarden coal. The Elkgarden coal varies in thickness from less than 14 feet to (locally) nearly 20 feet, in the northern portion of the Potomac basin. In Fairfax Knob this coal has become much thinner or has been separated into two benches by a bed of shale nearly 20 feet thick, which does not occur in the northern end of the basin. Another productive coal occurs 130 feet above the base. Near the top of Franklin and New Hampshire hills north of Piedmont, in the crest of Old Hampshire Hill south of Bloomington, and in the hill south of No. 6 mine near Elk Garden, it has been worked, but is now abandoned.

Post-Carboniferous formations. — There are scattered pebbles and bowlders on the knobs and ridges which define the plain between New Creek Mountain and Patterson Creek Mountain, which are possibly of Neocene age.

STRUCTURE.

Definition of terms.—As the materials forming the rocks of this region were deposited upon the sea bottom, they originally 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.* A bed which dips beneath the surface may elsewhere be found rising; the fold, or trough, between two such outcrops is called a *syncline.* A stratum rising from one syncline may often be found to bend over and descend into another; the fold, or arch, between two such outcrops is called an *anticline.* Synclines and anticlines side by side form simple folded structure. 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 districts where strata are folded they are also frequently broken across, and the arch is thrust over upon the trough. Such a break is called a *thrust,* an *overthrust,* an *overthrust fault,* or simply a *fault.* Fault, however, is a term applied to many forms of dislocations in rocks. If the arch is worn 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 despite the thrust which divides the whole mass. Folds and faults are often of great magnitude, their dimensions being measured by miles, but they also occur on a very small, even a microscopic, scale. In folds strata change their relations mainly by motion on the bedding planes, and overthrusts arise frequently where the direction of such movement intersects the bedding.

Structure of the Appalachian province.—Three distinct types of structure occur in the Appalachian province, each one prevailing in a separate area corresponding to one of the three geographic divisions. In the plateau region and westward the rocks are generally flat and retain their original composition. In the valley the rocks have been steeply tilted, bent into folds, broken by thrusts, and to some extent altered into slates and schists. In the mountain district faults and folds are important features of the structure, but cleavage and metamorphism are equally conspicuous.

The folds and overthrusts of the valley region are generally parallel to one another and to the western shore of the ancient continent. They extend from northeast to southwest, and single structures may be very long. Faults 300 miles long are known, and folds of even greater length occur. The crests of many anticlines continue at nearly the same height for great distances, so that they present the same formations. Often adjacent folds are nearly equal in height, and the same beds appear and reappear at the surface. Most of the beds dip at angles greater than 10°; frequently the dip is over 45° and generally the western dip is overturned beyond 90°. The sides of the folds are sometimes pressed together until they are parallel. Generally the folds are smallest, most numerous, and most closely squeezed in thin-bedded rocks, such as shale and shaly limestone. Perhaps the most striking feature of the folding is the prevalence of southeastward dips. In some sections across the southern portion of the Appalachian Valley scarcely a bed can be found which dips toward the northwest.

Thrusts were developed in the northwestern sides of synclines, varying in extent and frequency with the changes in the thickness of strata above the Cambro-Silurian limestone. With very few exceptions the fault planes dip toward the southeast, and are nearly parallel to the bedding planes of the adjacent rocks. The fractures extend across beds many thousand feet thick, and sometimes the upper strata are pushed over the lower as far as 6 or 8 miles. There is a progressive change in character of deformation from northeast to southwest, resulting in different types in different places. In southern New York folds and faults occur in a relatively narrow area lying mainly east of the Hudson River. The strata have nevertheless been intensely disturbed. Through Pennsylvania toward Virginia, folds become more numerous and steeper. In southern Virginia they are closely compressed and often closed, while occasional faults appear. Passing through Virginia into Tennessee, the folds are more and more broken by thrusts. In the central part of the valley of Tennessee, folds are generally so obscured by faults that the strata form a series of narrow overlapping blocks, all dipping southeastward. Thence the structure remains nearly the same southward into Alabama; the overthrusts become fewer in number, however, and their horizontal displacement is much greater, while the remaining folds are somewhat more open.

In the Appalachian Mountains the southeastward dips, close folds, and faults that characterize the Great Valley are repeated. The strata are also traversed by minute breaks of cleavage and are metamorphosed by the growth of new minerals. The cleavage planes dip to the east at from 20° to 90°, usually about 60° This form of alteration is somewhat developed in the valley as slaty cleavage, but in the mountains it becomes important and frequently destroys all other structures. All rocks were subjected to this process, and the final products of the metamorphism of very different rocks are often indistinguishable from one another. Throughout the eastern 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 the result chiefly of compression, which acted in a northwest-southeast direction, at right angles to the trend of the folds and of the cleavage planes. The force of compression became effective early in the Paleozoic era, and reappeared at various epochs up to its culmination soon after the close of the Carboniferous.

In addition to this force of compression, the province has been affected by other forces which acted in a vertical direction and repeatedly raised or depressed its surface. The compressive forces were limited in effect to a narrow zone. Broader in its effect and less intense at any point, the vertical force was felt throughout the province.

Three periods of high land near the sea and three periods of low land are indicated by the character of the Paleozoic sediments. In post-Paleozoic time, also, there have been at least four and probably more periods of decided oscillation of the land, due to the action of vertical force. In most cases the movements have resulted in the warping of the surface, and the greatest uplift has occurred nearly along the line of 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 a map with this scale it is not possible to show in the sections the minute details of structure; they are therefore somewhat generalized from the dips observed in a belt a few miles in width along the line of the section.

STRUCTURE OF THE PIEDMONT AREA.

There are two structural provinces in the area of the Piedmont sheet, divided almost upon the same lines as are the topographic provinces. There is the country of long, parallel, and sharp ridges with wide valleys lying between, seen east of the Allegany Front,—the valley region. It presents distinctive topographic types, and these are governed by structures seen in the sharp upward folds or anticlines of the narrow-crested ridges and in the wide and undulating downward folds in the valleys.

East of the Allegany Front there rises a steep-sided anticlinal fold which brings to the surface the upper Silurian formations in New Creek Mountain. Its axis lies at the center of this mountain, about 3 miles east of the front, and it extends across the area from north-northeast to south-southwest. It is a relatively simple flexure with considerable uniformity of pitch and dip. To the northward, near Rees Tannery, it pitches down so that the Tuscarora quartzite passes below the surface, and between Greenland and Cosner gaps there is a local depression along the axis of the fold, in which the mountain is of decreased height and the Cacapon sandstone extends entirely over the arch for some distance. From Kline Gap the arch increases in height to the southward, with a corresponding increase in the height of the mountain. In the center of the mountain the anticline is not flexed by minor crenulations, but rises in a mighty arch, which is superbly exhibited by the Tuscarora quartzite in Greenland, Cosner, and Kline gaps. The great sheet of quartzite springs up steeply at either side, and then bends over to form a complete arch, the top of which is about 1,000 feet above the bottoms of gorges. The arch is not perfectly symmetrical, for the dips on either side are not the same, and there is considerable local variation in the form of the flexure. Usually the western limb is considerably steeper than the eastern, notably at Kline Gap and southward, where the dips to the west are nearly vertical. Along the Monterey and Lewistown ridges, which flank the central axis of the mountain, there are occasional small local crumples in the general monocline which these ridges usually represent. They are frequent on the west side of the mountain. The most notable one is in the ridge just east of Rees Tannery, where the Monterey sandstone is flexed to a ∞-like form, with a small basin of Romney shales in the syncline and a small exposure of Lewistown limestones in the arch where it is crossed by the depression. Just east of the basin there is a small fault in the Monterey beds, of which a portion to the eastward lies in another shallow basin of very limited extent. These flexures die out in about 2 miles. On the west side of Greenland Gap a small syncline and anticline are exhibited in the Lewistown limestones, and along the axis of the anticline there is a small fault or overthrust. This flexure extends southward to and along the ridge west of New Creek Mountain, widening the Monterey outcrop and finally developing a small separate anticlinal ridge of Monterey sandstone, which pitches beneath the Romney shales opposite Cosner Gap. In the limestones at the western end of Kline Gap there is an anticline which brings up the basal Lewistown beds over a small area, and the Rockwood shales present many contortions along the stream at the east end of the gap. At the east end of Cosner Gap there is a small anticline in the lower members of the Lewistown limestone, and in the gap 3 miles southeast of Antioch an anticline is exhibited in the sandstone of the Rockwood formation.

Lying east of the anticline of New Creek Mountain is a wide synclinal trough containing a considerable thickness of Jennings formation in its center. It is quite uniform in general width, pitch, and dips, but some of the beds which it contains present many minor crumples of local extent. These are more frequent on the eastern side of the Devonian area, and they are exhibited to a greater or less degree along all the roads and streams. Near the southern margin of the area of the sheet, the beds in the center of the basin pitch up to the north, owing to an anticline which rises into Cave Mountain to the south.

The next flexure to the east is the wide corrugated anticline of Patterson Creek Mountain, which brings to the surface the Monterey, Lewistown and Rockwood formations, in a range of high, knobby hills. The central axis of this flexure rises rapidly from the South Branch Valley just east of Petersburg, attains its culmination from opposite Seymourville to Williamsport, and then pitches downward to the north. Along its sides it carries a number of small corrugations of variable size and extent. They give rise to ridges of Monterey sandstone, which in most cases eventually join the main mountain mass, but are separated for some distance by shallow basins of Romney shales. The principal ridges of this character are the two which cross the South Branch east of Petersburg, one east of Kissell, another east of Seymourville, and another extending from south of Medley to Williamsport.

From Charles Knob north to opposite Williamsport the central ridges of the mountain consist of the slabby beds of the Lewistown limestone, constituting a great arch, which is, however, more irregularly eroded than the arch of hard Tuscarora quartzite in New Creek Mountain. In the deeper depressions toward Williamsport the Rockwood shales are bared in the center of the mountain, and the basal shaly beds of the Lewistown limestone outcrop over long, irregular areas in the higher valleys between the limestone knobs.

East of the anticline of Patterson Creek Mountain there is a synclinal valley occupied by Romney shales and transition beds to the Jennings formation, which covers the southeastern corner of the Piedmont sheet area.

The second structural province begins with the Allegany Front and extends west. This is the plateau region, and it is characterized by low folds of wide amplitude. In this province the structures and topographic types do not conform as they do in the valley region. Valleys follow upon both the anticlinal and the synclinal axes, while the mountains remain between upon the dip of the strata or limb of the fold. These characters are clearly illustrated by the structure sections upon the map.

The North Potomac synclinal fold is the first west of the valley region, and extends between the New Creek Mountain and Deer Park Valley anticlines. Rocks in the Allegany Front dip down steeply toward the north-northwest at 18° to 60°, but they rapidly change in dip to a few degrees, and pass across the valley of the North Branch of Potomac River almost horizontally. In Backbone Mountain the same rocks rise, dipping east-southeast 15° to 25°. This wide synclinal basin of the North Potomac inclines or pitches north-northeast nearly 45.7 feet per mile. It widens southward, and divides near the center of the Piedmont quadrilateral. One prong—the Stony River syncline—is in the valleys of Stony River and Red Creek, between the Allegany Front and Canaan Mountain. The other prong is a direct continuation of the North Potomac basin, and its axis passes almost through Fairfax Knob. This interruption and division of the North Potomac syncline is due to the Blackwater anticlinal fold. This anticline enters the area nearly in the southwest corner and extends northward approximately parallel to the Allegany Front. The Blackwater sandstone and Greenbrier formation, which once closed in an arch over the Blackwater Valley, have been removed by erosion, and the wide valley between Canaan and Brown mountains now extends along the axis of the arch. The Blackwater anticline pitches northward, down into the North Potomac syncline, and is lost near the center of the basin. Structure sections E. F. and G. H. illustrate the relations of these folds. Local disturbances of minor folding are indicated by dip of the rock in the Potomac Valley near Gorman and Stoyer, and in Stony River Valley above the falls on each side of the Blackwater anticline where it dies out down the pitch, but they are too small to apparently affect the general structure or to be recognized in structure sections. West from Backbone Mountain the rocks rise toward the west to the center of the valley along a line nearly through Sunnyside and Mountain Lake Park. Beyond the central line which marks the axis of the anticline the rocks extend downward until the strata which occur in Backbone Mountain dip to the west in Hoop Pole Ridge and the valley of Youghiogheny River. Rocks of the Jennings and Hampshire formations, which dip steeply into the Allegany Front, pass beneath the valley of the North Branch of Potomac River, come to the surface, and form the valley between Backbone Mountain and Hoop Pole Ridge. Like the Blackwater anticline, this fold is occupied by a valley.

A narrow and shallow synclinal fold extends north-northeast across the northwest corner of the area of the Piedmont sheet, west of Hoop Pole Ridge. Strata of the Blackwater formation dip westward in the ridge bordering the east side of the valley of the Youghiogheny River, and appear again, dipping east, in the ridge in the northwest corner of the area of the sheet. Rocks of the Savage and Bayard formations are slightly flexed in the center of the basin.

MINERAL RESOURCES.

The mineral resources of the region embraced within the limits of the Piedmont sheet are coal, iron ore, limestone, building stone, road material, and clays.

Coal.—Three formation, the Savage, Bayard, and Elkgarden, contain workable coals which may be exploited on a commercial scale. Coals occur in the Blackwater and Fairfax formations which may be worked profitably for local consumption. The Savage formation contains three beds of coal, of which the one at the top of the formation merits special consideration. This coal in the North Branch of Potomac Valley is known as the Sixfoot bed. In the Blackwater Valley it is the Davis seam. In the North Potomac Valley it varies little from 6 feet, and is rendered almost unprofitable by thin seams of shale and bone. A thicker stratum of shale occurs near the center of the bed, which locally swells to several feet. This coal thickens southward and at the same time improves in quality. Shale seams disappear, and with them pyritous concretions, which are especially objectionable. The upper contact of the Savage formation on the map marks approximately the outcrop of this coal. It passes beneath the North Branch of Potomac River near Stoyer. Opposite Chaffee this coal is 6 feet 6 inches thick, in two benches separated by a thick band of shale. On Stony River at the falls, and at the source of Sand Run west of Wilson, the same bed is 8 feet 11 inches thick. Several shale partings occur, but the quality of the coal is good. At Coketon and Thomas this seam is 10 feet 8 inches thich. Three bands of shale occur, and the total thickness of coal is 8 feet 10 inches. The quality is excellent as a coking coal, and it is mined and coked extensively. In the Youghiogheny basin two productive coals occur in this formation, separated by 70 feet of strata. These coals are mined at Corinth on the west side of the basin, and the upper one is found to possess coking quality. The upper bed is put at the top of the formation by reason of its relations to overlying strata. The area of this coal is approximately 265.5 square miles.

There are two workable coals in the Bayard formation, one at the top of the lower and one at the base of the upper sandstone division. These coal beds are known locally as the Threefoot and Fourfoot coals, respectively. The Threefoot coal in the North Branch of Potomac Valley is classed as the Thomas coal in Blackwater River Valley at Thomas. In the escarpment bordering the North Potomac River and in the valleys of its tributaries this coal outcrops 140 to 185 feet above the base of the Bayard formation. It has been extensively prospected, but is not worked except for local consumption. The coal thickens southward, and its structure varies. A bed of bony, impure coal, alternating in bands, usually forms the roof in the North Branch of Potomac Valley. In the Blackwater Valley the thin bands of coal in the roof increase in thickness and purity, and are economically worked. In the escarpment above Blaine this coal is 4 feet 3 inches thick. At Bayard it is 5 feet 6 inches, and at Thomas 7 feet 2 inches, in thickness. The main bench at the base remains nearly 3 feet thick throughout the region. The structure at Bayard and that at Thomas are identical. This coal has an area of 196 square miles. The Fourfoot bed varies in thickness from 4 to 5 feet, and is worked only at the Black Bear mine west of Bloomington, except for local consumption. Its quality is better than other coals of the Savage or Bayard formations in the North Branch of Potomac Valley. Its area is 103.9 square miles. The neglect of the workable coals in the Savage and Bayard formations is due principally to the large and profitable output of the Elkgarden coal. A coal bed locally known as the "Dirty Ninefoot," occurs near the center of the Fairfax formation. It is composed of two benches, the lower nearly 4 feet thick in places, and separated from the upper by a variable and usually thick bed of shale. It is not worked.

The Elkgarden coal is at the base of the Elkgarden formation. It occupies relatively a small area of the Piedmont quarter-degree, yet it is a source of great profit. The workable bed is 10 feet to 12 feet 6 inches thick at the Franklin and Hampshire mines north of Piedmont, and thickens southward to nearly 14 feet at Elk Garden. Locally it swells to nearly 20 feet, and, excepting a thin shale parting near the base, it is all productive. The line on the map limiting the Elkgarden formation is approximately upon the crop of the Elkgarden coal, and includes 1.96 square miles.

Two workable beds occur above the Elkgarden coal, but they remain only above the Old Hampshire mine south of Bloomington and in the areas north of Piedmont. They are not worked and the quality of the coal is not known.

The sum of the areas of the productive coal beds is approximately 567 square miles.

Iron ore.—The iron ore of the Rockwood formation appears to be present along both sides of New Creek Mountain and in small areas in the center of Patterson Creek Mountain. It is rarely to be seen in natural exposures, but a number of shallow prospect pits and trenches have been sunk in the New Creek Mountain areas. So far as explored the beds were found too thin to be economically worked for smelting, unless the ore should be found of higher grade. Proper testing and treatment may prove this ore valuable as a producer of mineral paint. Some of the beds of Cacapon sandstone are very ferruginous and may locally contain iron ore sufficient to seem of economic value, but they are too siliceous to be profitably worked. Ferruginous shale and nodular iron ore of low grade occur in the Blackwater formation along the valley of North Fork of Potomac River. Bands of low-grade ore also occur in the Fairfax and Elkgarden formations, but no ores of economic value were found in Coal Measure rocks.

Limestone.—Very thick deposits of Lewistown limestone occur in the flanking ridges of New Creek Mountain and in Patterson Creek Mountain, which are generally exposed. The massive medial beds are of best quality, and the greater part of the flaggy beds are also usable. The cherty beds are too impure for either lime or flux. The Greenbrier limestone crops out in the escarpments of Allegany Front and Backbone Mountain, in the valley of Blackwater River between Brown and Canaan mountains, in the valley lying at the western base of Hoop Pole Ridge, and in a small area in the northwest corner of the quadrilateral. It is rarely exposed, though it occurs in numerous beds, many of which are of sufficient purity for good lime. Limestones in the Coal Measures are thin; with one exception they are too impure to be of any value. One bed of limestone, varying in thickness from 6 to 18 feet, lying below the Fourfoot coal and about 100 feet below the top of the Bayard formation, is of economic importance. It is light-blue when freshly broken, and weathers light-yellow. It was exposed in few localities, and its areal extent is not known.

Building stone.—There is no building stone of high grade in the region of the Piedmont sheet. The thinner beds of the Juniata formation, which consist of red and reddish-gray sandstone, should produce fair-grade building stone. Their areas of outcrop are small and limited to the three localities above described. Except for foundations and for fencing, the Carboniferous sandstones are not valuable.

Road material. — There is abundant road material in this region. The cherty beds of the Lewistown limestone disintegrate deeply to a finely divided talus of angular fragments, which is material of high grade for ballast and for macadam roads. Sandstones of the Carboniferous formations produce fair-grade material for roads.

Clays.—Clays of the valley region east of Allegany Front and similar clays of the valley between Backbone Mountain and Hoop Pole Ridge have not been tested. Surface characters show them to be impure. Clays underlie the principal coal beds. The physical characters of some of these beds suggest their availability for the production of fire brick, but they have not been developed. Few of these beds attain a thickness of 5 feet. In the upper part of the Savage formation in the Youghiogheny basin there is 10 feet of chalky, white, and apparently pure clay. It crops out south of Corinth and one-fourth of a mile south of the bridge over the Youghiogheny River, near the northern limit of the map. Alluvial clays of the stream valleys within the area of the Coal Measures are too siliceous for making good brick. Large deposits of excellent brick loams occur in the wider alluvial valleys along the South Branch, notably about Petersburg.

SOILS.

The soils of the region are closely related to the underlying rocks, for they are in greater part the residuary products of the rock decay. The exceptions are on the flats along the streams, where there are mixtures of various materials derived from the higher lands, brought down largely at times of freshet, and the wash and talus on slopes. These exceptions are relatively unimportant, as such soils occupy but small areas. Soils are also affected by topography, for on steep slopes they are thin and usually sandy. Limestones and the purer shales give rise to clay soils; the sandstones and sandy shales, to sandy soils; and the finer stream deposits are sands or sandy loams. Owing to the frequent variations in character of the rocks in nearly all the formations, there are corresponding changes in the character of the soils derived from them, but on the whole the general relations of rock and soil are so intimate that the geologic map of the region is also a soil map for the principal types of soil. These types are shale soils, limestone soils, and sandstone soils; and there are, also, alluvial soils.

Shale soils.—The shales of the region give rise to the largest areas of fertile soils, and a part of these are not more than moderately productive. They are mixtures of sand and clay, which vary considerably in relative amounts. In parts of the region these soils are calcareous, and in such areas they are most productive. The shales of the Rockwood formation are calcareous, and they produce soils that are quite fertile. There are many small farms on these shales in the valleys between New Creek Mountain and its flanking ridges. The Romney shales, also, are in part calcareous, and their soil is fairly productive. They flank both sides of New Creek Mountain, and many excellent farms in Patterson Creek Valley are on them. The shales and sandstones of the Jennings formation give rise to soils which are rather too sandy to be highly productive, but in the valley west of Backbone Mountain they produce excellent meadow and cereal lands. Along the Allegany Front the Jennings formation crops out in steep slopes, so that the soils are thin and usually overlain by sandstone talus from higher strata. The shales of the Greenbrier formation crop out in the steep escarpment of the Allegany Front and Backbone Mountain. The soil from this shale is in a large measure overplaced by sandstone and conglomerate talus from the Blackwater formation. In the outer margin of the valley of Blackwater River between Canaan and Brown mountains and in the valley west of Hoop Pole Ridge the soil is favored by gentle slopes and is well adapted to cultivation. The soils of the Fairfax formation belong to this class, and they form the largest part of the farming area of the plateau. The surface is usually rolling and smooth; it affords fair meadow land, and is well adapted to the production of buckwheat.

Limestone soils.—The principal limestone areas are in the central portion of Patterson Creek Mountain and along the inner sides of ridges which flank New Creek Mountain. In these areas the soils, although thin, are fertile, but they usually lie on such steep slopes that they are available for pasturage only. Much of the land is rocky, owing to the hardness of the lower, slabby layers and the top, cherty beds of the Lewistown limestone. The top, cherty limestone often gives rise to an extensive talus of loose chert fragments, which cover large portions of these limestone soils. The limestone of the Greenbrier formation has fertile soil, but it generally lies in a steep slope and is overplaced by sand and fragments from the overlying sandstones. In the upper Blackwater region it crops out over a wide, level region in which the soils are rich and well adapted to farming.

Sandstone soils.—The narrow belts of sandstone and quartzite in New Creek Mountain, and the Monterey sandstone and chert ridge, have sandy soils which are generally too thin and barren for agriculture. Much of the land is steep and rocky, and it is not possible to cultivate it profitably. The Hampshire formation in the east side of Hoop Pole Ridge and the west side of Backbone Mountain produces ridges and knobs with thin sandy soils which are in part more fertile. Along the eastern side of the Allegany Front it lies in the steep rocky slope below the Pocono Knobs, and is not farmed. Sandstones predominate over shales in the Blackwater sandstone and the Savage and Bayard formations, and their soils are sandy. The soils of the Blackwater sandstone are entirely sandy, and to a great extent very stony, so that they are entirely unfit for agriculture. Where the strata of the Savage and Bayard formations crop out in the ridges extending from the Allegany Front and Backbone Mountain, and in the region of the Youghiogheny River, large areas of thin soils are tillable, and many farms are located upon them. Along belts where the more massive sandstone beds are exposed the soil is rocky. In the valleys and escarpments which border them talus and stone-crops prohibit cultivation of the soil.

Alluvial soils.—The South Branch of Potomac River, Lunice Creek, Patterson Creek, New Creek, and the larger streams in the valley between Backbone Mountain and Hoop Pole Ridge, also Blackwater River between Canaan and Brown mountains, have alluvial valleys of considerable area and fair fertility. These soils are derived largely from the waste of shale and calcareous rocks. The alluvial valleys of other streams in the region are of no importance. The North Branch of Potomac River and its tributaries have deposited along their courses very little except sand and gravel.

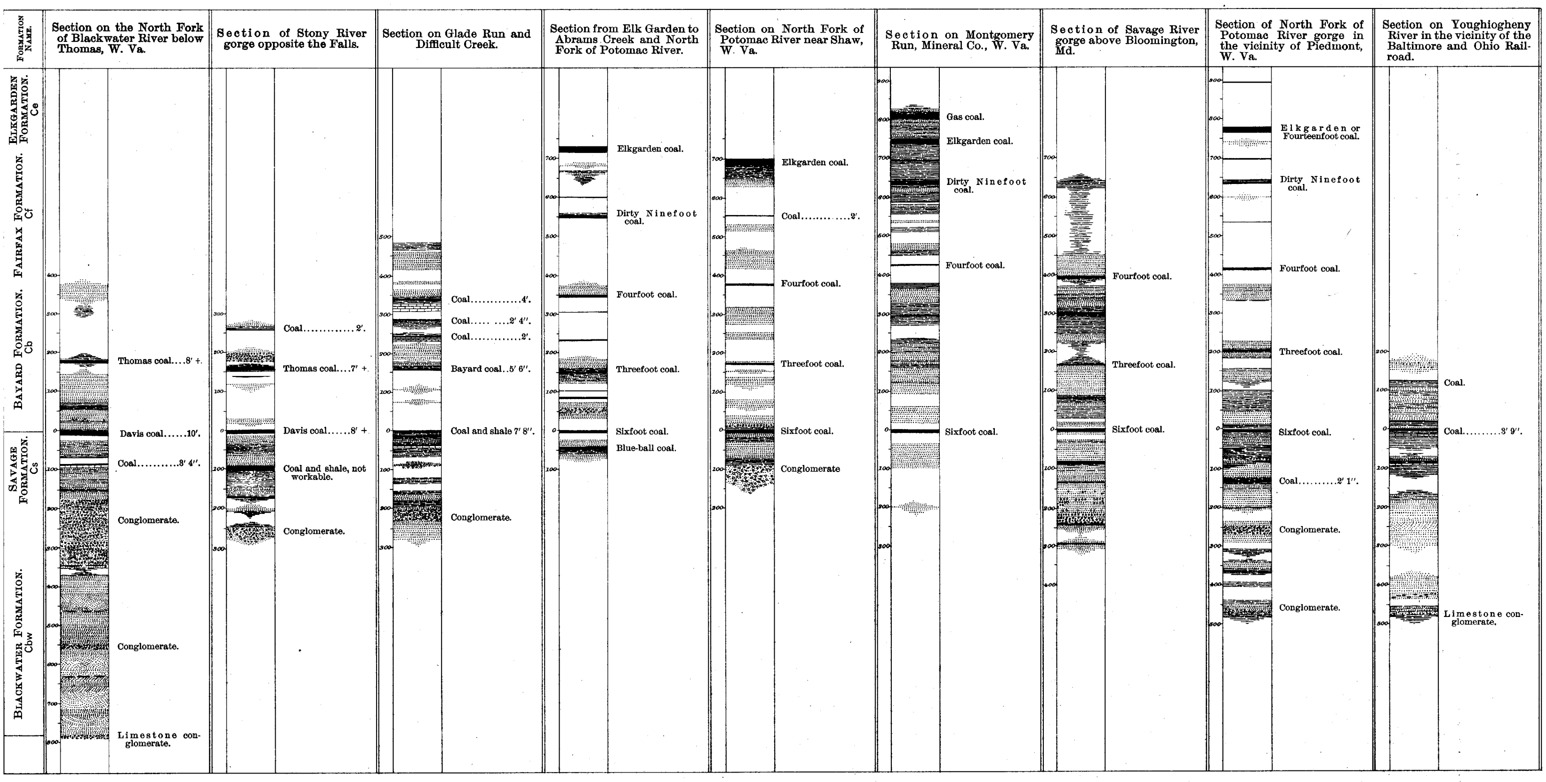
N. H. DARTON,
JOSEPH A. TAFF,
Geologists.
BAILEY WILLIS,
Geologist in Charge.

August, 1895.

VERTICAL SECTIONS, SHOWING THE POSITIONS AND THICKNESSES OF COAL BEDS.

SCALE: 250 FEET = 1 INCH.

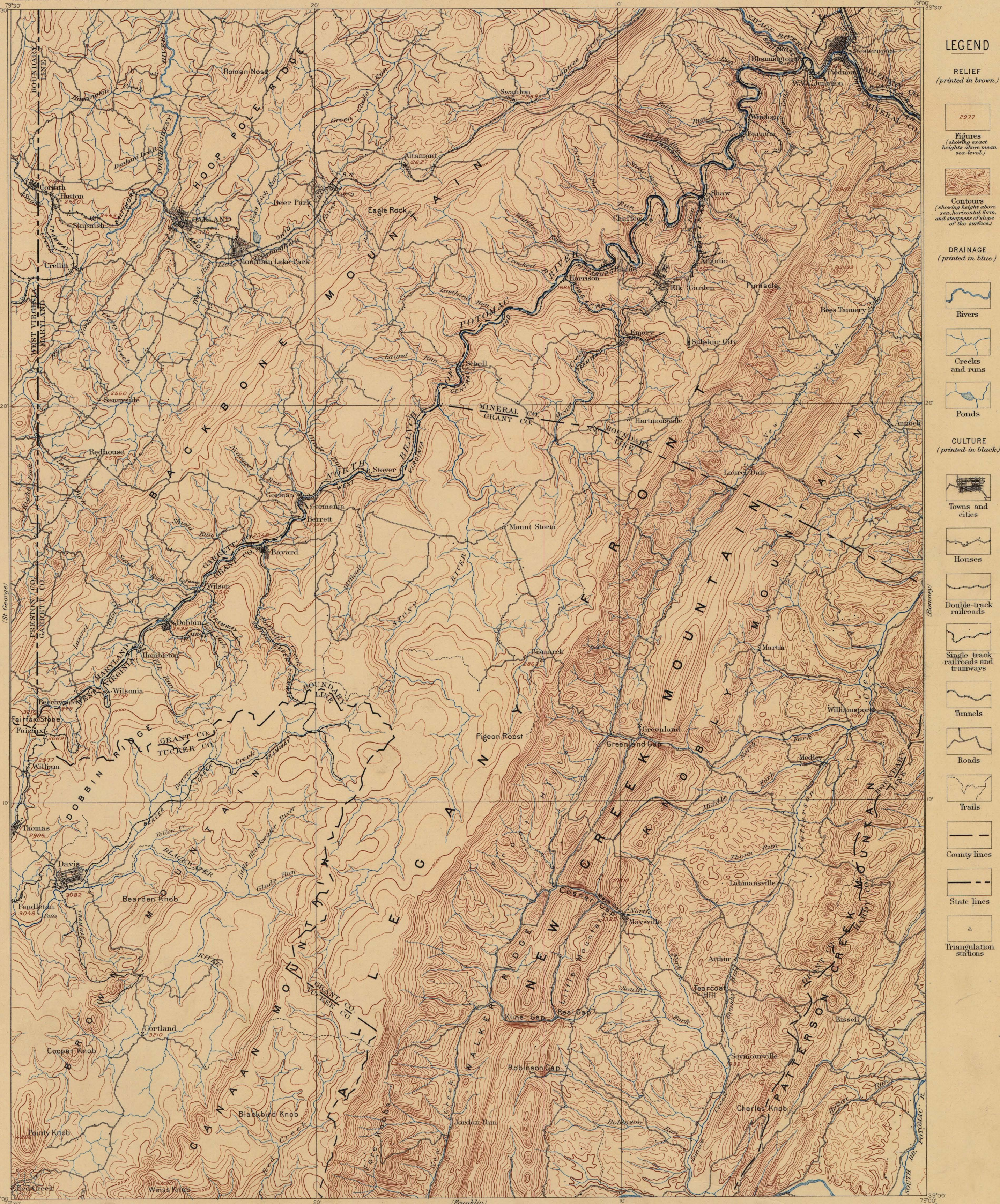
VERTICAL DISTANCES ARE MEASURED FROM THE TOP OF THE SAVAGE FORMATION BY MEANS OF THE ANEROID BAROMETER.



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

TOPOGRAPHY

MARYLAND - WEST VIRGINIA
PIEDMONT SHEET



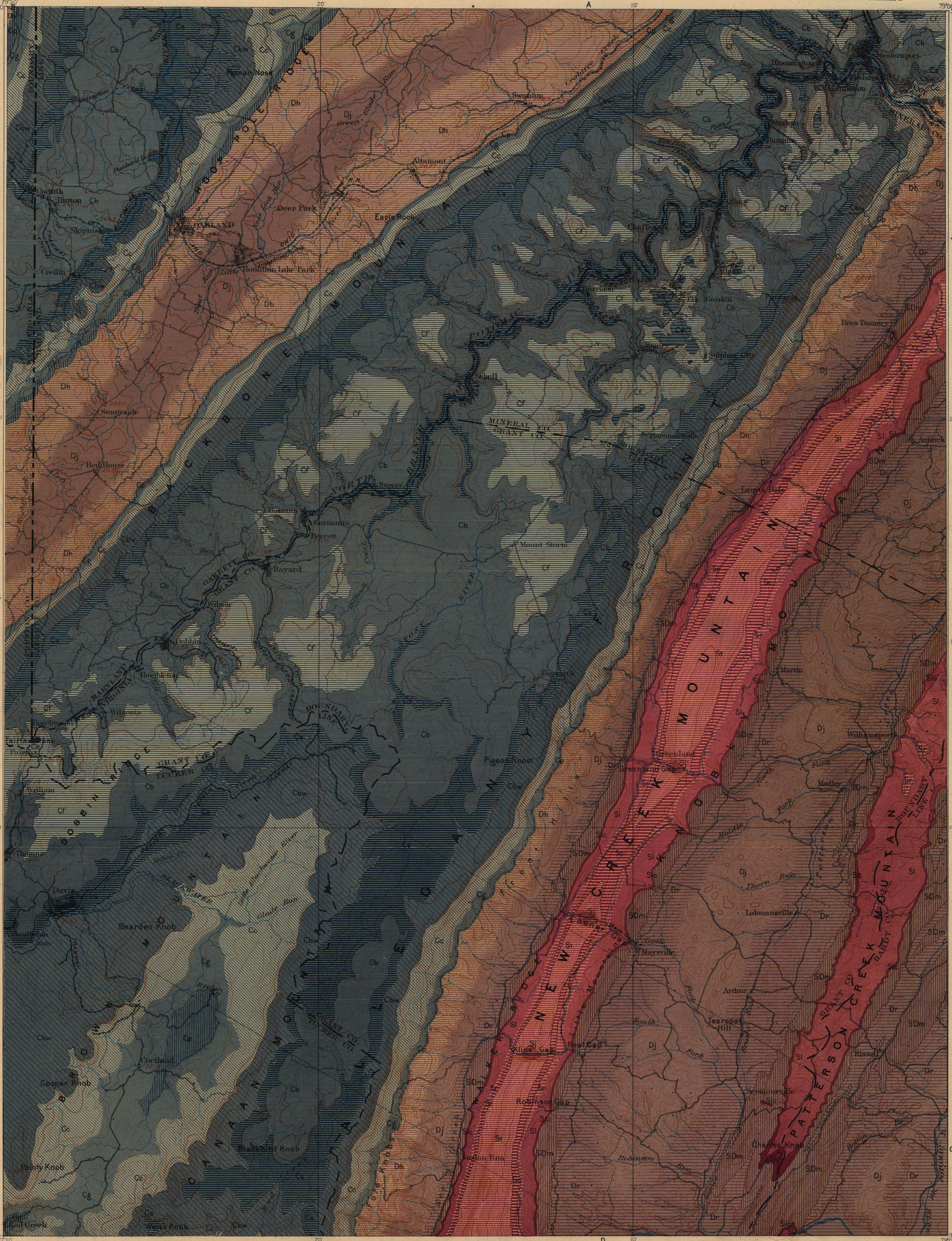
Henry Gannett, Chief Topographer.
H. M. Wilson, Chief Geographer in charge.
Triangulation by W. T. Griswold.
Topography by M. Hackett and R. H. Chapman.
Surveyed in 1894.

Scale 1/125000

Contour Interval 100 feet
Datum is mean Sea level
Edition of Mar. 1896.

AREAL GEOLOGY

MARYLAND - WEST VIRGINIA
PIEDMONT SHEET



LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

- XV — **Ce** Elkgarden formation *(shale and thin sandstone containing the Elkgarden coal bed, now worked)*
- XIV — **Cf** Fairfax formation *(shale and thin sandstone containing the Nine-foot and Little Pittsburg coal beds, generally not workable)*
- XIII — **Cb** Bayard formation *(sandstone and shale containing the Four-foot coal bed and the Three-foot, elsewhere called Bayard, or Thomas, coal bed; now worked)*
- **Cs** Savage formation *(sandstone and shale containing thin coal seams and the Six-foot, or Davis, coal bed; now worked)*
- XII — **Cbw** Blackwater formation *(conglomerate, sandstone, and shale containing thin coal seams, locally workable)*
- XI — **Cc** Canaan formation *(red and green shale and greenish and brown sandstone)*
- **Cg** Greenbrier limestone *(limestone, shale, and sandstone)*
- X — **Cp** Pocono sandstone *(gray sandstone, in places conglomeratic)*

DEVONIAN

- IX — **Dh** Hampshire formation *(shale and sandstone mainly red)*
- VIII — **Dj** Jennings formation *(gray, olive, and buff shale and gray sandstone)*
- **Dr** Romney shale *(dark shale with thin limestone beds near the base)*

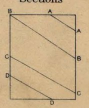
TRANSITIONAL

- VII — **SDm** Monterey sandstone

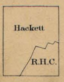
SILURIAN

- VI — **Slc** Lewistown chert-lentil *(constituting the upper bed of the Lewistown limestone)*
- **Sl** Lewistown limestone *(limestone including at its base shaly and impure limestones with thin beds of cement rock)*
- V — **Sr** Rockwood formation *(thin sandstone at the top and shale with iron ore below)*
- IV — **Sc** Cacapon sandstone
- **St** Tuscarora quartzite
- **Sj** Juniata formation *(red sandstone and shale)*

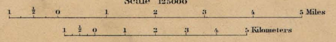
Sections



Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by W.T. Griswold.
Topography by M. Hackett and R.H. Chapman.
Surveyed in 1894.



Scale $\frac{1}{125000}$



Contour Interval 100 feet.
Datum is mean Sea level.

Edition of Mar. 1896.

Geology by
Bailey Willis, Geologist in charge,
Nelson H. Darton, and
Joseph A. Taff.
Surveyed in 1894.

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

ECONOMIC GEOLOGY

MARYLAND - WEST VIRGINIA
PIEDMONT SHEET

LEGEND (continued)

⚒ Coal mines (unless otherwise marked)

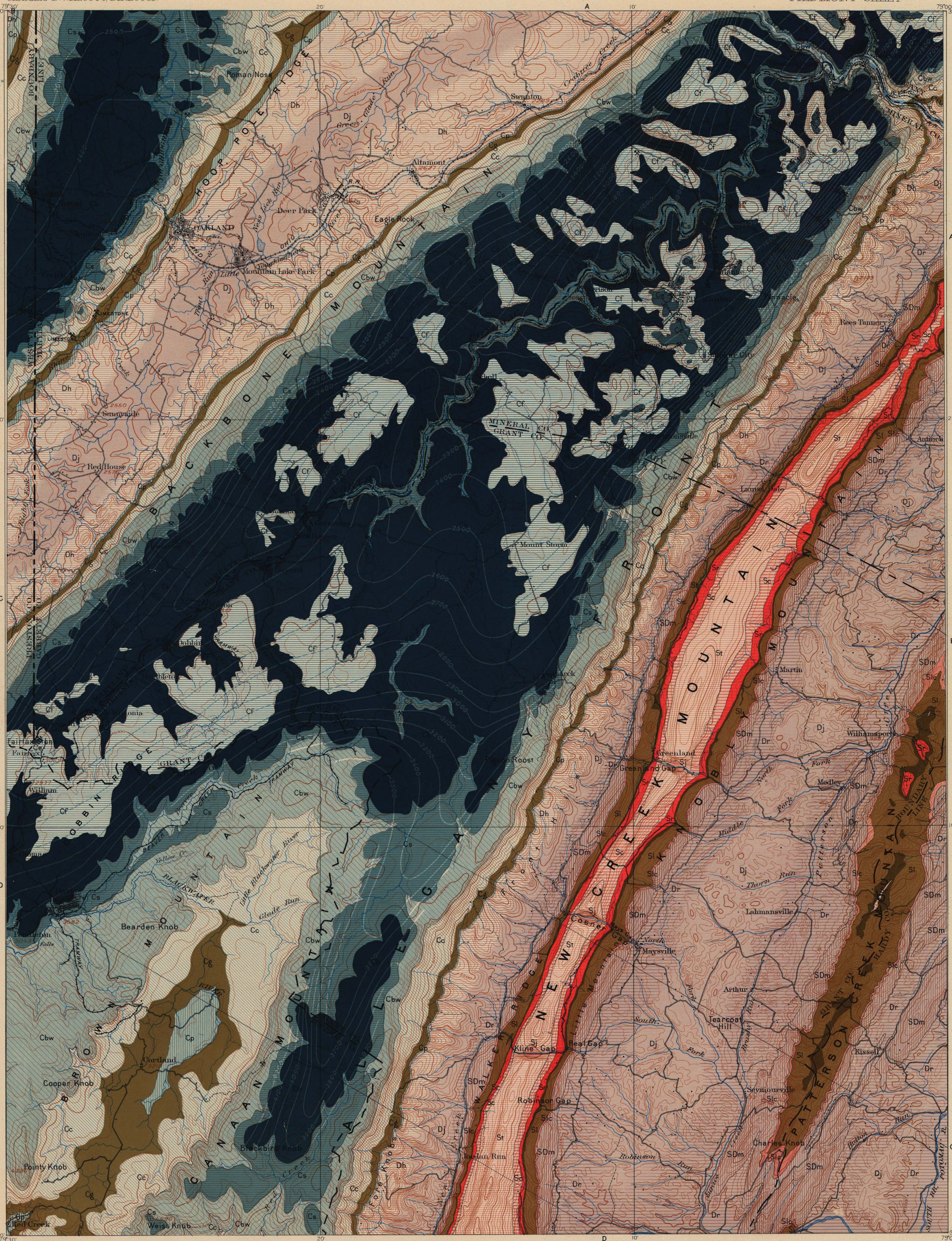
× Coal prospects

⚒ Quarries (when marked limestone)

Known productive formations

- Ce — *Elkgarden formation* (containing the Elkgarden coal bed)
- Cb — *Bayard formation* (containing the Four-foot coal bed, and the Three-foot, elsewhere called Bayard, or Thomas, coal bed)
- Cs — *Savage formation* (containing the Six-foot, or Davis, coal bed)
- *Limestone*
- *Cement rock* (thin beds in impure limestone and shale)
- *Red hematite iron ore* (thin beds in shale)

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



LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

- XV — Ce — Elkgarden formation (shale and thin sandstone containing the Elkgarden coal bed, now worked)
- XIV — Cf — Fairfax formation (shale and thin sandstone containing the Nine-foot and Little Pittsburg coal beds, generally not workable)
- XIII — Cb — Bayard formation (sandstone and shale containing the Four-foot coal bed and the Three-foot, elsewhere called Bayard, or Thomas, coal bed; now worked)
- Cs — Savage formation (sandstone and shale containing thin coal seams and the Six-foot, or Davis, coal bed; now worked)
- XII — Cbw — Blackwater formation (conglomerate, sandstone and shale containing thin coal seams, locally workable)
- XI — Cc — Canaan formation (red and green shale and greenish and brown sandstone)
- Cg — Greenbrier limestone (limestone, shale, and sandstone)
- X — Cp — Pocono sandstone (gray sandstone, in places conglomeratic)

DEVONIAN

- IX — Dh — Hampshire formation (shale and sandstone mainly red)
- Dj — Jennings formation (gray, olive, and buff shale and gray sandstone)
- VIII — Dr — Romney shale (dark shale with thin limestone beds near the base)

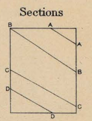
TRANSITIONAL

- VII — SDm — Monterey sandstone

SILURIAN

- VI — Slc — Lewistown chert-lentil (constituting the upper bed of the Lewistown limestone)
- Sl — Lewistown limestone (limestone including at its base shaly and impure limestones with thin beds of cement rock)
- V — Sr — Rockwood formation (thin sandstone at the top and shale with iron ore below)
- Sc — Cacapon sandstone
- IV — St — Tuscarora quartzite
- Sj — Juniata formation (red sandstone and shale)

Sections



Legend is continued on the left margin.

Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by W.T. Griswold.
Topography by M. Hackett and R.H. Chapman.
Surveyed in 1894.

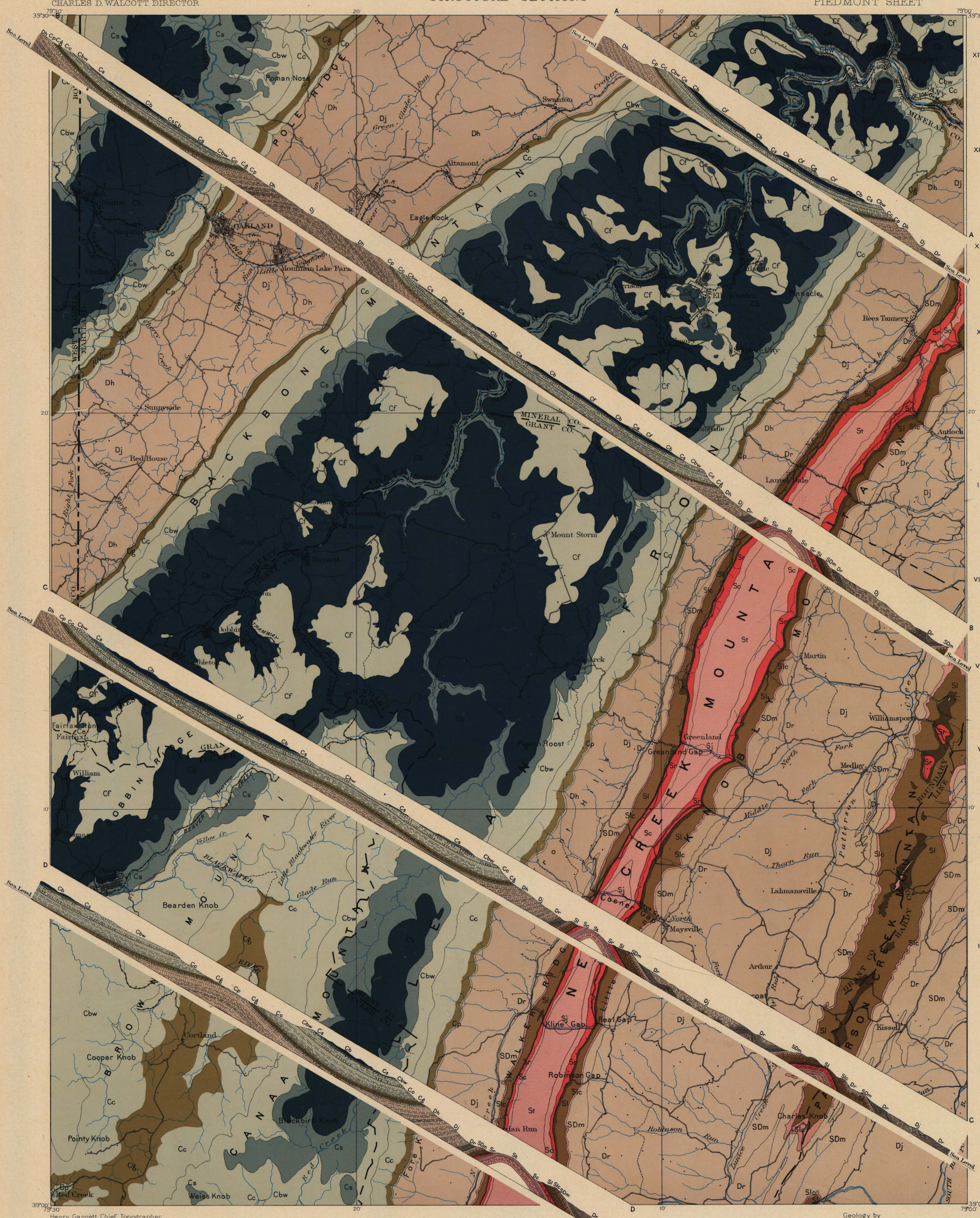
Scale 1/125000

Contour Interval 100 feet.
Datum is mean Sea level.

Edition of Mar. 1898.

Geology by
Bailey Willis, Geologist in charge,
Nelson H. Darton, and
Joseph A. Taff.
Surveyed in 1894.

STRUCTURE SECTIONS



LEGEND

SEDIMENTARY ROCKS

CARBONIFEROUS

XV — Ce — Elkgarden formation (shale and thin sandstone containing the Elkgarden coal bed, now worked)

XIV — Cf — Fairfax formation (shale and thin sandstone containing the Nine-foot and Little Pittsburg coal beds, generally not workable)

XIII — Cb — Bayard formation (sandstone and shale containing the Four-foot coal bed and the Three-foot, elsewhere called Bayard, or Thomas, coal bed; now worked)

Cs — Savage formation (sandstone and shale containing thin coal seams and the Six-foot, or Davis, coal bed, now worked)

XII — Cbw — Blackwater formation (conglomerate, sandstone, and shale containing thin coal seams, locally workable)

XI — Cc — Canaan formation (red and green shale and greenish and brown sandstone)

Cg — Greenbrier limestone (limestone, shale, and sandstone)

X — Cp — Pocono sandstone (gray sandstone, in places conglomeratic)

DEVONIAN

IX — Dh — Hampshire formation (shale and sandstone mainly red)

Dj — Jennings formation (gray, olive, and buff shale and gray sandstone)

VIII — Dr — Romney shale (dark shale with thin limestone beds near the base)

TRANSITIONAL

VII — SDm — Monterey sandstone

SILURIAN

VI — Slc — Lewistown chert-lentil (constituting the upper bed of the Lewistown limestone)

Sl — Lewistown limestone (limestone including at its base shaly and impure limestones with thin beds of cement rock)

V — Sr — Rockwood formation (thin sandstone at the top and shale with iron ore below)

Sc — Cacapon sandstone

IV — St — Tuscarora quartzite

Sj — Juniata formation (red sandstone and shale)

Known productive formations

Ce — *Elkgarden formation* (containing the Elkgarden coal bed)

Cb — *Bayard formation* (containing the Four-foot coal bed, and the Three-foot, elsewhere called Bayard, or Thomas, coal bed)

Cs — *Savage formation* (containing the Six-foot, or Davis, coal bed)

Limestone

Cement rock (thin beds in impure limestone and shale)

Red hematite iron ore (thin beds in shale)

Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by W.T. Griswold.
Topography by M. Hackett and R.H. Chapman.
Surveyed in 1894.

Hackett
R.H.C.

Scale 1/125000
Miles
Kilometers

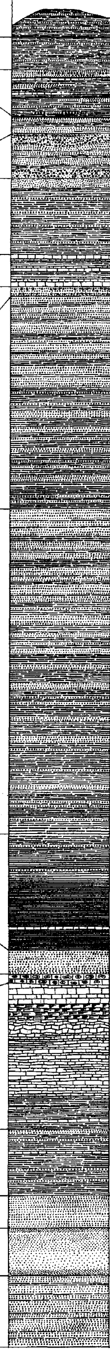
Edition of Mar. 1896.

Geology by
Bailey Willis, Geologist in charge,
Nelson H. Darton, and
Joseph A. Taff.
Surveyed in 1894.

COLUMNAR SECTION

GENERALIZED SECTION FOR THE PIEDMONT SHEET.

SCALE: 1000 FEET = 1 INCH.



Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soils.
CARBONIFEROUS	Elkgarden formation.	Ce		280+	Gray and black shale, thin sandstone, and coal.	Generally smooth hilltops. Gray to yellow sandy clay-soil.
	Fairfax formation.	Cf		300	Shale, sandy shale, minor sandstone beds, and thin coal.	Undulating uplands and hill-slopes. Gray to yellow sandy clay-soil.
	Bayard formation.	Cb		400-475	Sandstone and conglomerate. Sandstone, sandy shale, and thin limestone, with beds of coal.	Steep stony slopes of gorges and mountain-sides. Sandy and usually stony soil.
	Savage formation.	Cs		130-160	Sandstone and sandy shale, with beds of coal and carbonaceous shale.	Lower slopes of North Potomac gorge above Piedmont and stony hillsides. Overplaced sandy soil.
	Blackwater formation.	Cbw		260-645	Conglomerate and sandstone. Sandstone, sandy shale, thin coal, and conglomerate.	Cliffs and stony upper slopes of escarpments of mountains and ridges. Very thin sandy soil.
	Canaan formation.	Cc		550-750	Red clay-shale, sandy shale, and thin sandstone.	Middle and lower slopes of escarpments. Red to yellow sandy clay-soil.
	Greenbrier limestone.	Cg		200-450	Light-blue limestone and red clay-shale.	
	Pocono sandstone.	Cp		30-80	Conglomerate and sandstone.	Crests of spurs, ridges, and knobs on mountain-sides. Thin sandy soil.
DEVONIAN	Hampshire formation.	Dh		2000-2300	Sandstone and shale, mainly red in color.	Mountain-slopes and rounded ridges and knobs. Red and gray sandy soil.
	Jennings formation.	Dj		3300	Gray to buff sandstone and gray, olive, and buff shale.	Mountain-slopes and rounded ridges. In Garrett County, "glades" and undulating areas. Soil usually sandy.
	Romney shale.	Dr		1100-1300	Shale, black and fissile below, lighter-colored and more sandy above. Thin limestone.	Wide valleys and low rounded ridges. Thin soil, usually clayey. In the wider valleys, alluvial deposits of varying width.
	Monterey sandstone.	SDm		215-300	Massive calcareous blue-gray sandstone, usually weathered to a brown porous sandstone.	Knobs and ridges, mainly along the base of higher mountains. Thin sandy or cherty, barren soil.
SILURIAN	Lewistown chert-lentil.	Slc		130-300	Cherty limestone.	
	Lewistown limestone.	Sl		20-80	Massive light blue-gray limestone with some chert.	Knobby ridges and elevated valleys. Thin but rich clay-soil.
				100	Shaly limestone.	
				30-60	Dark-colored limestone.	
				450-980	Flaggy limestone.	
				250-310	Thin beds of impure limestone with alternations of greenish and gray calcareous shale.	Fertile slopes. Soil usually thin.
	Rockwood formation.	Sr		12-20	Gray sandstone.	Slopes and narrow valleys. Thin, fertile shale-soil.
				525-750	Gray, brownish, and greenish shale with iron ore and thin limestone beds.	
	Cacapon sandstone.	Sc		300	Red sandstone, mainly thin-bedded.	Rocky slopes. Thin sandy soil.
	Tuscarora quartzite.	St		480	White or gray massive quartzite.	Rocky mountain summits and slopes. Mainly bare rock surfaces.
	Juniata formation.	Sj		750+	Brownish-red sandstone and shale.	Gorges of New Creek Mountain. Mainly covered by rock talus.

NAMES OF FORMATIONS.

SHOWING THE NAMES APPLIED BY VARIOUS AUTHORS TO THE STRATA OF THE PIEDMONT AREA. THE IMPLIED CORRELATIONS WITH OTHER STRATIGRAPHIC AREAS ARE NOT NECESSARILY ACCEPTED.

Period.	Names and Symbols used in this Folio.		Names which have been used by Various Authors.	Names used by H. D. Rogers in the First Report of Pa., 1836, and by W. B. Rogers in The Virginias, 1838, and later.	Names used by H. D. Rogers in the Final Report of Pa., 1858.
CARBONIFEROUS	Elkgarden formation.	Ce	Upper Coal Measures.	XV.	Seral.
	Fairfax formation.	Cf	Lower Barren Measures.	XIV.	
	Bayard formation.	Cb	Lower Coal Measures.	XIII.	
	Savage formation.	Cs			
	Blackwater formation.	Cbw	Pottsville conglomerate.	XII.	
	Canaan formation.	Cc	Mauch Chunk shales.	XI.	Umbral.
	Greenbrier limestone.	Cg	Greenbrier limestone.		
	Pocono sandstone.	Cp	Montgomery grits. Pocono sandstone.	X.	Vespertine.
DEVONIAN	Hampshire formation.	Dh	Catskill.	IX.	Ponent.
	Jennings formation.	Dj	Chemung.	VIII.	Vergent.
	Romney shale.	Dr	Hamilton		Cadent.
	Monterey sandstone.	SDm	Oriskany.	VII.	Meridian.
SILURIAN	Lewistown limestone.	Sl	Lower Helderberg.	VI.	Premeridian.
			Salina.		
			Niagara.		
	Rockwood formation.	Sr	Clinton.	V.	Surgent.
	Cacapon sandstone.	Sc	Medina.	IV.	Levant.
	Tuscarora quartzite.	St			