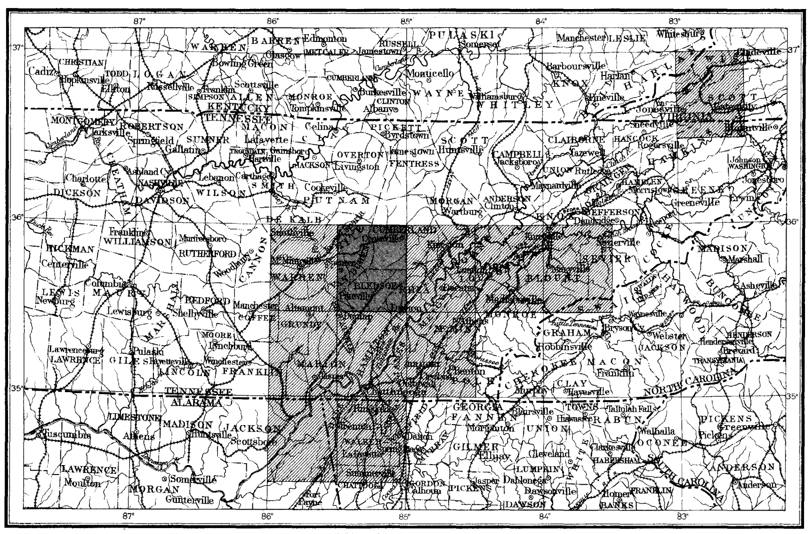
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS OF THE UNITED STATES

PIKEVILLE FOLIO

TENNESSEE

INDEX MAP



SCALE: 40 MILES-1 INCH

AREA OF THE PIKEVILLE FOLIO

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FOLIO 21 | LIBRARY EDITION | PIKEVILLE

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

EXPLANATION.

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

THE TOPOGRAPHIC MAP.

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

Relief.—All elevations are measured from mean sea-level. The heights of many points are accurately determined, and those which are most important are stated on the map by numbers. It is desirable to show also the elevation of any part of a hill, ridge, or valley; to delineate the horizontal outline, or contour, of all slopes; and to indicate their grade, or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the constant vertical space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

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

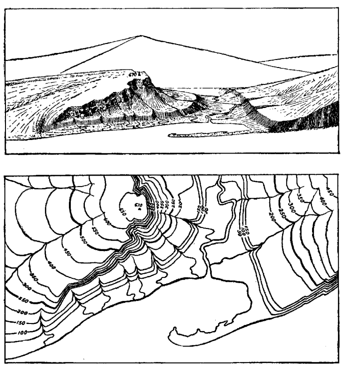


Fig. 1.—Ideal sketch and corresponding contour map.

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

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

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

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

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

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

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

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

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

Atlas sheets.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. These areas correspond nearly to 4,000, 1,000, and 250 square miles, respectively.

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

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

THE GEOLOGIC MAP.

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

KINDS OF ROCKS.

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

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

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

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

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

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

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

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

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

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

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

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

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

AGES OF ROCKS.

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

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

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

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

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

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

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

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

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, with the exception of the Pleistocene, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the

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

period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations. Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

The legend is also a partial statement of the geologic history. The formations are arranged according to origin into surficial, sedimentary, and igneous, and within each class are placed in the order of age, so far as known, the youngest at the top.

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

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface.

In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits 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:

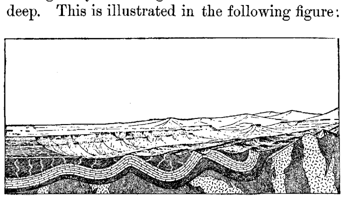


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape above.

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:

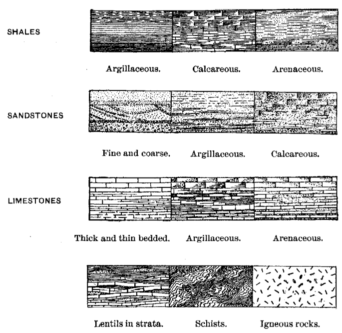


Fig. 3.—Symbols used to represent different kinds of rock.

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 PIKEVILLE SHEET.

GEOGRAPHY.

General relations.—The Pikeville atlas sheet comprises an area bounded by the parallels 35° 30′ and 36° and the meridians 85° and 85° 30′. The region mapped embraces, therefore, a quarter of a square degree of the earth's surface. Its dimensions are 34.5 miles from north to south and 28 miles from east to west, and it contains nearly 980 square miles. The adjacent atlas sheets are Standing Stone on the north, Kingston on the east, Chattanooga on the south, and McMinnville on the west. The area lies wholly within the State of Tennessee and contains portions of White, Cumberland, Van Buren, Grundy, Sequatchie, Bledsoe, and Rhea counties.

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 the eastern side only is marked by great 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 sharply outlined on the southeast by the Appalachian Mountains and on the northwest by the Cumberland Plateau and the Alleghany Mountains. Its rocks are almost wholly sedimentary and in large measure calcareous. The strata, which must originally have been nearly horizontal, now 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 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 Cumberland Plateau and the Alleghany Mountains, 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 a somewhat arbitrary line coinciding with the Tennessee River from the northeastern corner of Mississippi to its mouth, and thence crossing the States of Indiana and Ohio to western New York. Its eastern boundary is sharply defined along the Appalachian Valley by the Alleghany front and the Cumberland escarpment. The rocks of this division are almost entirely of sedimentary origin and remain very nearly horizontal. The character of the surface, which is dependent on the character and attitude of the rocks, is that of a plateau more or less completely dissected, or, elsewhere, of a lowland. In the southern half of the province the surface of the plateau is sometimes extensive and perfectly flat, but oftener it is much cut by stream channels into large or small, flat-topped hills. In West Virginia and portions of Pennsylvania the plateau is sharply cut by its streams, leaving in relief irregularly rounded knobs and ridges which bear but little resemblance to the original surface. The western portion of the plateau has been completely removed by erosion, and the surface is now comparatively low and level, 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 4,000 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 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.

The country embraced by the atlas sheet lies almost wholly within the western division of the Appalachian province, as above defined. Its extreme southeastern portion lies in the great Appalachian Valley, here occupied by the Tennessee River, and the Sequatchie Valley also crosses its southeastern corner. The latter is located upon the westernmost of the sharp folds which characterize the central division, and might properly be regarded as its western limit, except that Walden Ridge, lying to the eastward, has all of the characteristics of the western or plateau division. The greater portion of the area of the sheet is occupied by the Cumberland Plateau and its outlier, Walden Ridge. The plateau here has an altitude varying from 1,700 to 1,900 feet. Above this general level rise small isolated hills or mesas from 100 to 500 feet higher. These appear as hills rising above a level plain. The western side of the plateau is extremely irregular. The streams that drain its surface have their sources within a short distance of the Sequatchie Valley, flow westward in shallow channels for several miles, and then plunge into deep, narrow canyons which they have carved within the plateau. Numerous remnants of the plateau, almost or quite isolated, fringe its western side.

Walden Ridge, as already stated, has most of the characteristics of the plateau west of Sequatchie Valley. It is somewhat higher, having an altitude between 1,900 and 2,000 feet. Its streams rise near the edge of the Sequatchie Valley and flow southeastward in shallow channels until near the eastern escarpment, where they plunge into narrow gorges.

The northwestern portion of the area of the sheet lies within the highland rim of middle Tennessee. The surface is somewhat rolling, but in general has an altitude of less than 1,000 feet. The slopes between this lower plain and the plateau are very abrupt, the upper portions being in many places vertical cliffs.

The Sequatchie Valley extends in a perfectly straight line across the area mapped. It is about 4 miles in breadth, and is bounded by escarpments a thousand feet high. Its position and form are directly dependent upon the geologic structure, which will be more fully explained later. On the area of the adjacent Kingston sheet a range of mountains falls directly in line with the Sequatchie Valley, and the manner in which the valley was formed is there admirably shown. The hard rocks forming the surface of the plateaus on either side formerly arched continuously across, so that a long, narrow ridge then occupied the position of the present valley. The hard rocks are underlain by limestones, which are easily removed by solution. When the agents of erosion had worn down the top and sides of this ridge through the covering of hard rocks, so that the waters had access to the underlying limestone, erosion was then more rapid upon the limestones than on the sandstones of the adjacent plateaus, and hence the surface was more rapidly lowered, and in time a valley was formed. This process is still going on in the Crab Orchard Mountains, toward the northeast. Here the protecting cap of sandstone is not entirely removed, but wherever it has been removed coves are formed in the underlying limestone. In some cases these are entirely surrounded by a rim of sandstone, beneath which their waters flow in subterranean channels.

The position and direction of the streams of this region were determined while a ridge still occupied the position of the Sequatchie Valley. This ridge formed a divide which turned the waters toward the northwest and southeast. As the ridge was removed and a valley eroded in its place, the streams retained their original positions, heading upon the immediate edge of the valley.

The foregoing description and an examination of the topographic map show that in this region there are two plains whose surfaces are nearly parallel and are separated by a vertical distance of about 1,000 feet. The lower plain is apparent in the level portions of the highland rim, in the Sequatchie Valley, and in the Tennessee Valley. The upper plain is the general surface of the plateau, below which the streams flow in more or less deeply cut channels and above which rise a few isolated hills or mesas.

Areas of these two plains have been recognized over nearly the entire Appalachian province, separated by a varying vertical distance, and their relations throw much light upon the history of the province during the later geologic ages. This region formerly stood much lower than now, so that the present plateau, the higher plain, was near sea-level. The land was worn down by streams flowing upon its surface till it was reduced to a nearly even plain, with only here and there a low hill remaining where the rocks were unusually hard or where they were protected from erosion by their position. Since the surface was not perfectly reduced this is called a *peneplain*, and since it was formed near the lowest possible level of erosion it is called a *baselevel peneplain*. After the surface of the land had become reduced nearly to sea-level this region was elevated about 1,000 feet and at the same time tilted southward. The streams, which had become sluggish, were at once stimulated to renewed activity and began rapidly to sink their channels into the peneplain. Erosion progressed most rapidly upon soft rocks, so that on the western part of this area, where the sandstone capping was thin, and in the Sequatchie anticline, where limestone formed the surface, the streams quickly sunk their channels down nearly to the new baselevel of erosion, and then, by broadening their valleys, began the formation of a new peneplain. The old peneplain was preserved at the higher level where the hard rocks capped the plateau. After the formation of the second peneplain was well advanced upon areas of soft rocks, the region was again lifted and the streams began cutting their present channels within the last-formed peneplain.

GEOLOGY.

STRATIGRAPHY.

The sedimentary record.—All the rocks appearing at the surface within the limits of the Pikeville atlas sheet are of sedimentary origin; that is, they were deposited by water. They consist of sandstones, shales, and limestones, 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, or the remains of plants and animals which lived while the strata were being laid down. Thus some of the great beds of limestone were formed largely from the shells of various sea animals, and the beds of coal are the remains of a luxuriant vegetation which probably covered low, swampy shores.

The rocks of this portion of the Appalachian province afford a record of almost uninterrupted sedimentation from early Silurian to late Carboniferous time. Their composition and appearance indicate the nearness to shore and the depth of water in which they were deposited. Sandstones marked by ripples and cross-bedded by currents, and shales cracked by the sun on mud flats, indicate shallow water; while limestones, especially by the fossils they contain, indicate greater or less depth of water and absence of sediment. The character of the adjacent land is also shown by the character of the sediments derived from its waste. Coarse sandstones and conglomerates, such as are found in the Coal Measures, were derived from high land, on which stream grades were steep, or they may have resulted from wave action as the sea encroached upon a sinking coast. Red sandstones and shales, such as make up some of the Cambrian and Silurian formations a few miles to the east, 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 sea in which these sediments were laid down covered most of the Appalachian province and the Mississippi basin. The area of the Pikeville sheet was near its eastern margin, and the materials of which its rocks are composed were therefore derived largely from the land to the eastward. The exact position of the eastern shore-line of this ancient sea is not known, but it probably varied from time to time within rather wide limits.

SILURIAN ROCKS.

The oldest rocks exposed within the limits of the Pikeville sheet belong to the Silurian, or possibly the upper Cambrian, period. Probably the older Cambrian rocks, which are brought to the surface by the steep folds a few miles eastward, extend beneath the whole of this area and far beyond its western limit, but since they have never been brought to light by natural or artificial means nothing is definitely known as to their character.

Knox dolomite.—This formation consists of massively bedded and somewhat crystalline, gray, magnesian limestone. Its base is not exposed in this district, but the formation is probably over 3,000 feet thick. Its lower portion is probably of Cambrian age, but since it is almost entirely devoid of fossils and is homogeneous throughout, the line between the Cambrian and Silurian is very indefinite. This limestone, more properly called dolomite, contains a large amount of silica in the form of nodules or layers of chert or flint. That part of the rock which consists of the carbonates of lime and magnesia is dissolved upon weathering, leaving behind the chert, usually imbedded in red clay. This residual material covers the surface to great depths, and the dolomite itself is seldom seen except in the channels of the larger streams.

The Knox dolomite comes to the surface only in a belt about two miles wide through the center of Sequatchie Valley. Its outcrops, except near the rivers, are marked by the characteristic low, rounded, chert hills, which rise from 100 to 300 feet above the Tennessee River.

Chickamauga limestone.—The next higher formation, the Chickamauga limestone, occupies a narrow belt on each side of the Knox dolomite, the three belts together forming the greater part of the Sequatchie Valley. The formation is mainly a blue, thin-bedded, flaggy limestone, with some earthy, mottled beds and some which are slightly shaly. It is from 1,100 to 1,300 feet in thickness. The limestone contains many fossils, the most abundant being brachiopods and corals.

The formation takes its name from the valley of Chickamauga Creek, shown on the Chattanooga and Ringgold atlas sheets, where it is typically developed.

Rockwood formation.—The last-described formation passes without abrupt transition into this higher division of the Silurian strata. The base of the Rockwood consists of calcareous shales together with thin beds of hard, blue limestone. The upper portion is made up of green clay-shales, quite calcareous where they are unweathered, with a few beds of limestone. The formation is from 165 to 360 feet thick, and its outcrop forms a narrow band along the eastern side and about the head of Sequatchie Valley. The corresponding outcrop, which would normally occur along the western side of the valley, is absent by reason of the fault on that side of the Sequatchie anticline. The formation is of great economic importance on account of the red fossil iron ore which it usually contains. This will be described under the head of Mineral Resources. The formation is named from Rockwood, Tennessee, in the Kingston district.

DEVONIAN ROCKS.

Chattanooga black shale.—Overlying the Rockwood formation is a thin stratum of shale which appears to represent the whole of the deposition that took place in this region during the Devonian period. Typical exposures of this shale appear in the north end of Cameron Hill, within the city limits of Chattanooga, from which locality it takes its name.

The Chattanooga black shale has a remarkably uniform character wherever seen within the limits of the atlas sheet and for a long distance on either side north and south. It varies in thickness from 12 to 25 feet. The upper portion of the shale, 3 or 4 feet thick, is usually dark-gray in color, and often carries a layer of round phosphatic concretions about an inch in diameter. The remainder of the formation is jet-black, from an abundance of carbonaceous matter, and when freshly broken it emits a strong odor like that of petroleum.

This shale, on account of its distinctive and striking appearance, has attracted much attention from miners, and has been prospected in many places for coal and various ores, especially silver and copper. Such exploitation, however, has always been attended by failure. Although it contains a large proportion of carbonaceous matter, which burns when it is placed in a hot fire, the amount is not sufficient to constitute a fuel, and no true coal is ever found associated with the shale. Small concretions of iron pyrites, which it often carries, have given rise to the commonly accepted but wholly erroneous belief that the shale contains valuable ores.

In some portions of middle Tennessee, southwest of Nashville, the Chattanooga black shale is of commercial importance, since valuable beds of phosphate there occur associated with it. The conditions favorable for the accumulation of this lime phosphate in thick beds appear to have been quite local, and although, as already stated, the formation generally carries phosphatic nodules, no bed of sufficient thickness to be commercially valuable is found in the area covered by this sheet.

CARBONIFEROUS ROCKS.

Fort Payne chert.—This formation consists of about 150 feet of very siliceous limestone. At the base, resting on the Chattanooga black shale, are usually heavy beds of chert with only a small amount of limestone or greenish shale. The proportion of lime increases toward the top of the formation and, gradually replacing the chert, it passes, without abrupt transition, into the Bangor limestone above. The chert of this formation is readily distinguished from that of the Knox dolomite by the great number of fossils which it contains. It is often made up of a mass of crinoid stems imbedded in a siliceous cement. On weathering the cement remains as a porous chert filled with fossil impressions. In some cases the fossils alone are silicified, so that they remain in the soil after the solution of the calcareous portion of the rock. The formation occurs in a narrow strip along the eastern side of Sequatchie Valley, and frequently forms, with the underlying Chattanooga and Rockwood formations, a narrow ridge or line of knobs parallel with the plateau escarpment. On the western side of Sequatchie Valley it appears north of Tollett Mill, and for a short distance between Cold Spring and Pikeville, but elsewhere it is concealed by the Sequatchie fault, as are also the underlying Chattanooga and Rockwood shales. The chert is also exposed in two narrow strips in the southeast corner of the district, parallel with the eastern escarpment of the Walden Plateau. The name of the formation is taken from Fort Payne, Alabama.

Bangor limestone.—The Bangor limestone consists of 850 or 900 feet of limestone which everywhere forms the lower slopes of the escarpment, the floors of all the coves, and the inner portion of the highland rim. In general it is a massive, blue, crinoidal limestone, although it presents many local variations from this type. Nodules of chert are more or less abundant throughout the formation, though not evenly distributed. Along the western escarpment beds of white, porous chert are somewhat abundant in the limestone, though they are usually found imbedded in deep, red clay. In some cases, particularly along the western side of the Sequatchie Valley south of Pikeville, the limestone contains a very large proportion of argillaceous matter, so that when the calcareous portion of the rock has been removed by solution it appears as a fine, clayey shale, usually gray or green, but sometimes red and purple. It seems that the conditions under which the limestone formed were not everywhere the same, and some localities were furnished with a larger supply of muddy sediment than others near by.

In the northern half of the tract a bed of hard, brown sandstone, 15 to 20 feet in thickness, occurs in the limestone about 280 feet below its top. This sandstone bed is seen in the coves of Crab Orchard Mountains (in the upper part of the Sequatchie Valley) and along the western escarpment. It protects, in some measure, the underlying limestone, so that in many places it forms the surface of a terrace for a part of the way down the side of the escarpment. It also caps most of the outlying limestone hills west of the escarpment, which accounts for their level summits.

Lookout sandstone.—The calcareous shales at the top of the Bangor limestone indicate a change in the conditions of sedimentation, shoaling water, and an increase in quantity of sediment. During the deposition of the succeeding formation the sea bottom was lifted, so that the water became shallow over a wide area, while an abundant supply of mud and sand was washed in from the adjoining land. These conditions were unfavorable for the animals whose remains are so abundant in the preceding formation, and instead of limestone a great mass of shale and sandstone was deposited. The surface also stood above sea-level at various times, long enough at least for the growth of the luxuriant vegetation which formed the coal beds.

The Lookout sandstone includes from 90 to 650 feet of conglomerate, sandstone, sandy and clayey shale, and coal. Its upper limit, which is fixed somewhat arbitrarily, is taken at the top of a heavy bed of conglomerate usually forming the main cliff in the plateau of escarpments. Frequently a hard, cross-bedded sandstone below the conglomerate, and separated from it by an interval of sandy shale, makes a second cliff, in some places more prominent than that formed by the conglomerate. The formation increases in thickness from about 550 feet on the western side of the Walden Plateau to 650 feet in the Sequatchie Valley, and thence decreases westward to 90 feet at Clifty Creek, near the center of the district. At the latter point it consists of a single member. The shales and sandstones which ordinarily underlie the conglomerate entirely disappear, and the coarse, pebbly conglomerate rests directly on the Bangor limestone. West of this point the underlying shales reappear, and at Bon Air, on the western side of the plateau, they are nearly 100 feet in thickness and contain two beds of coal. It is not definitely determined whether the lower portion of the formation was deposited continuously over the whole region and then removed by erosion before the conglomerate was laid down, or whether it was never deposited in some places. The latter, however, is more probable. It seems that the sediments which make up this formation were deposited upon a somewhat uneven sea bottom, in broad, shallow troughs extending in a northeast-southwest direction. Thus the limestone at Clifty Creek may have been lifted high enough to suffer erosion while the Lookout shale and coal were being deposited in estuaries and swamps on either side.

The Walden sandstone.—Above the Lookout conglomerate is another series of coal, shale, sandstone, and conglomerate similar to the one just described, but somewhat more uniform in its character and presenting less-abrupt changes. The formation is capable of subdivision in most places into four members. At the base are several hundred feet of shales, in some places approaching a fire-clay in appearance and in others passing through micaceous, sandy shale into thin-bedded sandstones. This member is the most important part of the formation, since it contains the principal coal seam of the region. It decreases in thickness toward the west and entirely disappears near the western escarpment, where the next member above it rests directly upon the Lookout conglomerate. Above the lower shale is a variable thickness of coarse, white or yellow sandstone, in some places containing a few conglomerate pebbles. This sandstone forms the surface of the plateau over a considerable portion of the area shown on the sheet. Above this middle sandstone are sandy shales, distinguished from those below by the large amount of iron which they contain, giving them usually a rusty, yellow surface. Finally, at the top of the Walden is a heavy, coarse sandstone, generally conglomeritic. The two upper members of the Walden occur chiefly along the eastern side of the Walden and Cumberland plateaus. They also form the broad, rounded hills which were described as rising above the general level of the plateau.

These two formations, the Lookout and Walden sandstones, constitute the productive coal measures of the region. The position and thickness of the various beds of coal will be described under the head of Mineral Resources.

At the close of the Carboniferous period this region was elevated permanently above sea-level, so that the constructive process of deposition was stopped and the destructive process of erosion was begun.

STRUCTURE.

Definition of terms.—As the materials forming the rocks of this region were deposited upon the sea bottom, they must originally have been in nearly horizontal layers. At present, however, the beds are not usually horizontal, but are inclined at various angles. When any particular bed is followed for a considerable distance, it is often found forming a series of arches and troughs. In describing these folded strata the term *syncline* is applied to the downward-bending troughs and *anticline* to the upward-bending arches.

A synclinal axis is a line running lengthwise of 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. These axes may be horizontal or inclined. Their departure from the horizontal is called the *pitch* of the axis, and is usually but a few degrees. In addition to the folding, and as a result of the continued action of the same forces which produced it, the strata along certain lines have been fractured and the rocks have been thrust in different directions on opposite sides of the fracture; this is termed a *fault*. The rocks are also altered by production of new minerals from the old, or by *metamorphism*.

Structure of the Appalachian province.—These three method of change which the rocks of the province have suffered are grouped very distinctly along the three geographical divisions.

In the plateau region and westward the rocks are but little tilted from their original horizontal positions and are almost entirely unchanged; in the valley the rocks have been steeply tilted, bent into anticlines and synclines, broken by faults, and to some extent altered into slates; in the mountain district faults and folds are prominent, but the rocks have been changed to a greater extent by the minute breaks of cleavage and by the growth of new minerals.

In the valley the folds, and the faults developed from them, are parallel among themselves and to the old land body, extending in a northeast-southwest direction for great distances. Some faults have been traced for 300 miles, and some folds have even greater length. The crests of the anticlines are very uniform in height, so that for long distances they contain the same formations. They are also approximately equal to one another in height, so that many parallel folds bring to the surface the same formations. Most of the rocks dip at angles greater than 10°, and frequently the sides of the folds are compressed till they are parallel. The folding is greater in thin-bedded rocks, such as shale and shaly limestone, because the thin layers were most readily bent, and slipped along their bedding planes. Perhaps the most striking feature of the folds 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.

Out of the close folds the faults were developed, and with extremely few exceptions the fault planes dip toward the southeast. The planes on which the rocks broke and moved are often parallel to the bedding planes, as the rocks slipped on the beds in folding. Along these planes of fracture the rocks moved to distances sometimes as great as 6 or 8 miles. There is a progressive increase in degree of deformation from northeast to southwest, resulting in different types in different places. In northern Pennsylvania, folds are inconspicuous. Passing through Pennsylvania toward Virginia, they rapidly become more numerous and dips grow steeper. In southern Virginia the folds are closely compressed and often closed, while occasional faults appear. Passing through Virginia and into Tennessee, the folds are more and more broken by faults, until, halfway through Tennessee, nearly every fold is broken and the strata form a series of narrow, overlapping blocks, all dipping eastward. This condition holds nearly the same southward into Alabama, but the faults become fewer in number and their horizontal displacement much greater, while the folds are somewhat more open.

In the Appalachian Mountains the structure is the same as that which marks the Great Valley: there are the eastward dips, the close folds, the thrust faults, etc. But in addition to these changes of form, which took place mainly by motion on the bedding planes, there were developed a series of minute breaks across the strata, producing cleavage, or a tendency to split readily along these new planes. These planes dip to the east at from 20° to 90°, usually about 60°. This slaty cleavage was somewhat developed in the valley, but not to such an extent as in the mountains. As the breaks became more frequent and greater, they were accompanied by growth of new minerals out of the fragments of the old. These consisted chiefly of mica and quartz, and were crystallized parallel to the cleavage cracks. The final stage of the process resulted in the squeezing and stretching of hard minerals like quartz, and complete recrystallization of the softer rock particles. All rocks, both those of sedimentary origin and those which were originally crystalline, were subjected to this process, and the final products from the metamorphism of very different rocks are often indistinguishable from one another. Rocks containing the most feldspar were most thoroughly altered, and those with most quartz were least changed. Throughout the entire Appalachian province there is a regular increase of metamorphism toward the southeast, so that a bed quite unaltered at the border of the Great Valley can be traced through greater and greater changes until it has lost every original character.

The structures above described are manifestly due chiefly to horizontal compression, which acted in a northwest-southeast direction, at right angles to the trend of the folds and cleavage planes. The compression apparently began in early Paleozoic time, and probably continued at intervals up to its culmination, shortly after the close of the Carboniferous, when the greater portion of the folding was effected.

In addition to the horizontal force of compression, the province has been subjected to other forces, which have repeatedly elevated and depressed its surface. At least two periods of high land near the sea and two longer periods of low land are indicated by the character of the Paleozoic sediments. And in post-Paleozoic time there have been at least three, and probably more, periods of decided oscillation of the land due to the action of some vertical force. In every case the movements have resulted in warping the surface, and the greatest uplift has occurred nearly along the line of the Great Valley.

Structure sections.—The two 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 strip. The vertical and horizontal scales are the same, so that the elevations represented in the profile are not exaggerated, but show the actual form and slope of the land. These sections represent the structure as it is inferred from the position of the strata observed at the surface. On the scale of the map they can not represent the minute details of structure; they are therefore somewhat generalized from the dips observed near the line of the section in a belt a few miles in width.

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

Structure of the Pikeville district.—The area embraced within the limits of this sheet shows but little diversity in geologic structure. There are no crystalline rocks and no traces of metamorphism. Over the greater portion of the district the strata are nearly horizontal, dipping but a few feet to the mile, so that their inclination can be detected only by determining the altitude of some particular bed at several widely separated points. The southeastern corner of the district belongs to the central division of the Appalachian province, which is characterized by steep, narrow folds.

The Sequatchie anticline is typical of the Appalachian folds. In length it is somewhat greater than the Sequatchie valley, for at its ends the upper rocks have not been removed by erosion, but remain as a high arch. This arch forms the Crab Orchard Mountains, in the Kingston tract. On the southeastern side of the anticline the rocks dip at low angles, from 8° to 12°, while on the northwestern side they are much more steeply inclined, being in some places vertical or overturned. Upon the northwestern side of the anticline the strata are broken by a fault, and older rocks are thrust across the broken edges of the younger. Thus near Pikeville the Bangor limestone west of the fault comes in contact with the Chickamauga limestone, the three intermediate formations which normally occur being entirely concealed.

The structure of the southeastern corner of the tract is somewhat complicated, and can be understood only in connection with the adjacent regions to the east and south. Cranmore Cove is formed on a point of the sharp anticline which separates the narrow Lone Mountain syncline from the broad Walden Plateau syncline. This anticline is complicated by a fault near the center of the cove. The abrupt termination of this anticline and the erosion which has been determined by it produce a sharp angle in the eastern escarpment of the Walden Plateau. To the north of the line of the section B-B the formations have been more closely compressed than to the south, so that for a short distance the beds strike northwest at right angles to the normal direction. This produces an offset in the course of the narrow formations in the valley corresponding to that in the escarpment of the plateau, but in the opposite direction. This offset is accompanied by several small faults, so that part of the formations do not occupy their normal positions with reference to the others. The Walden Plateau is a broad, shallow syncline. Along its eastern side the strata dip steeply westward. In some places they are almost vertical, but within a distance of half a mile or less from the edge they become horizontal, and thence to the western side of the plateau they have a very gentle eastward dip. Thus the axis of the syncline, or the line coinciding with its deepest portion, lies very near its eastern side.

West of Sequatchie Valley and south of Bee Creek the strata are practically horizontal except along the edge of the valley, where they are sharply upturned. As in the Walden Plateau they have a gentle eastward dip, although much less in this case, averaging perhaps 25 or 30 feet to the mile. The structure of the plateau in the northern half of the district is much less simple. An anticlinal axis enters the district near its northeast corner and passes southwestward approximately parallel with the axis of the Sequatchie anticline. Unlike the latter, the steepest dips are upon the eastern side of the axis, and are as high as 15 or 20 degrees in the vicinity of Crossville. This anticline is well marked at Lantana and can be detected at Hale's mill. Although the rocks west of this anticline are in general nearly horizontal, they show a large number of minor folds, in which the shales, and in some cases the massive sandstone beds, have been crushed and highly contorted. This condition will interfere seriously with the economic development of the coal.

MINERAL RESOURCES.

Coal.—The productive coal-bearing formations, consisting of the Lookout and Walden sandstones, occupy the surface of the Cumberland and Walden plateaus. They have an area within the region of the atlas sheet of a little over 600 square miles. Not quite all of this, however, contains workable coal.

The accompanying vertical sections show the position and thickness of the various coal beds. These sections are not generalized, but each represents the actual measurements made at a single locality. It will be seen that the beds vary considerably in number, position, and thickness from one part of the field to another. The datum plane from which their position is measured up or down in the section is the top of the Lookout conglomerate. It is not always possible to determine this point exactly, so that some uncertainty is thus introduced into the correlation of coal beds in the different parts of the field.

The coal beneath the Lookout conglomerate has been worked in a small way at various places in the district, especially at the head of Cranmore Cove and in the vicinity of Pikeville. It is worked on a large scale only at Bon Air, on the western side of the plateau. As already stated, the shales beneath the conglomerate which contain the coal beds are absent along the line passing nearly north and south through the mouth of Clifty Creek. Since the deposits on opposite sides of this line may have been laid down in separate basins, the coal beds which they contain may or may not be of the same age; hence it is unsafe to correlate the Bon Air coal with subconglomerate seams showing in the eastern part of the district. At Bon Air two seams are worked. They are separated by from 5 to 15 feet of fireclay and sandy shale. The workings on the two seams are connected by cross-cuts, and the coal from both is taken out by the same entry. The lower seam rests almost directly upon the limestone, being separated by a few inches or feet of marly shale. The two seams are about the same thickness. They vary from 8 inches to 4 feet, but average about 3 feet. They are non-coking, block coal, excellent for steaming and for domestic fuel. The lower seam contains some sulphur and gives a white ash, while the upper seam is free from sulphur and gives a red ash. The extent of the Bon Air coal is not known, but its eastern limit will probably be found within 3 or 4 miles east of the present workings.

On account of their great variation in thickness it is not probable that the Lookout coals can be profitably worked on a large scale over the greater part of the district. At many points, however, it will continue to supply local demands for domestic fuel.

The most important coal in the region, by reason of its greater thickness and uniformity, is the Sewanee seam, which occurs a short distance above the Lookout conglomerate. Its area in the district is about 500 square miles. As stated above, the shale in which it occurs thins out to the westward and disappears at some point between the center of the district and the western escarpment. The coal is exposed at numerous points along the western side of the Sequatchie Valley, and also west of the center of the plateau, so that the area in which it undoubtedly occurs is tolerably well known. It is absent from a large triangular area west of Crossville, where the anticline above described brings the underlying Lookout to the surface.

At Lantana this coal has been mined for local consumption for many years, but it is impossible to determine the thickness of the bed at this point, by reason of the contortion which it has suffered. Where it is mined the coal lies but a few feet below the surface. The soil is removed and the coal taken out from shallow pits. The seam shows at numerous points in the vicinity of Erasmus. The rocks here have been somewhat contorted, but not so much as at Lantana, and the seam is probably 4 or 5 feet in thickness. Farther south, at Newton and Seals, it is shown at least 4 feet in thickness. It also comes to the surface at Farmingdale, near the head of Glade Creek, and at the head of Rocky River, near Olio. At all of these widely separated points the coal appears to be 4 or 5 feet in thickness, so that there can be but little doubt that the workable seam extends continuously over that part of the plateau indicated on the economic sheet.

Two seams have been worked by the Dayton Coal & Iron Company on the eastern side of the Walden Plateau. The lower of these, called the Nelson seam, is about 60 feet above the top of the conglomerate, and probably corresponds to the Sewanee seam, farther west. It is here about 5 feet thick, although it shows some variation, probably produced largely by the folding which the rocks near the edge of the Walden Ridge syncline have suffered. About 250 feet above the conglomerate is a second seam, called the Richland, which was worked for a number of years by the same company. It averages a little over 2 feet in thickness. Both of these seams give excellent coking coal, and the product of the mines is mostly consumed by the furnaces of Dayton.

Iron ore.—The economic sheet shows a narrow belt along the east side and about the head of Sequatchie Valley, and also east of the Walden Plateau, within which red fossil iron ore may occur. This fossil or "Clinton" ore is associated with strata of the Rockwood formation and is very similar to ore occurring at the same horizon in such widely separated localities as Wisconsin, New York, and Alabama. It is a regularly stratified bed, retaining over considerable areas a constant thickness and definite relations to other strata. Like any other rock layer, however, it is not absolutely constant, so that while the map indicates, within narrow limits, the area within which the ore may occur, careful examination is required to determine whether at any particular locality its quantity and quality are such as to make it commercially valuably. The ore is not mined at any point in this district, but is extensively worked a short distance southward, in the Sequatchie Valley, at Inman. The bed of ore there has a thickness of $5\frac{1}{2}$ feet. It is also worked on the strip which crosses the southeastern corner of the area of the sheet a few miles on either side, but the bed is here probably too thin for profitable working at present.

Stone.—The supply of limestone within the Pikeville district suitable for blast-furnace flux and for lime is abundant and convenient of access. At Dayton, just off the southeast corner of the area, the Bangor limestone is used both for flux and lime. It contains a small percentage of magnesia.

Stone adapted to architectural purposes occurs in nearly every formation in the region mapped. The only quarries of any extent are in the vicinity of Pikeville. Here the Lookout formation is in part made up of thin, evenly bedded sandstone, varying in color from light yellow to pink. This is easily quarried in large, regular slabs from two inches to a foot in thickness. It is excellently adapted for flagging or for the trimmings of brick buildings. A similar sandstone is quarried near Dayton, just beyond the southern edge of the area of the sheet.

The hard, blue Bangor and Chickamauga limestones furnish an abundant supply of macadam material, which would require but little transportation to make excellent roads in all the valley portion of the country shown on the sheet. The residual chert in the Fort Payne and Knox dolomite formations is an excellent road material and might be used to advantage in surfacing macadam roads. Unfortunately these abundant materials are as yet wholly unutilized.

Clays.—The residual deposits resulting from the weathering of the Bangor and Chickamauga limestone are red or blue clays, generally well adapted for making brick. They are utilized for supplying local demands in the vicinity of the larger towns. At some points this clay is suitable for pottery and tiling. Several beds of fireclay which are associated with the coal probably contain material well adapted for making firebrick, but they are as yet wholly undeveloped.

SOILS.

Derivation and distribution.—Throughout the region covered by the Pikeville atlas sheet there is a very close relation between the character of the soils and that of the underlying geologic formations. Except in limited areas along the larger streams and on the steepest slopes, the soils are derived directly from the decay and disintegration of the rocks on which they lie. All sedimentary rocks such as occur in this region are changed by surface waters more or less rapidly, the rapidity depending on the character of the cement which holds their particles together. Siliceous cement is nearly insoluble, and rocks in which it is present, such as quartzite and some sandstones, are extremely durable and produce but a scanty soil. Calcareous cement, on the other hand, is readily dissolved by water containing carbonic acid, and the particles which it held together in the rock crumble down and form a deep soil. If the calcareous cement makes up but a small part of the rock, it is often leached out far below the surface, and the rock retains its form but becomes soft and porous; but if, as in limestone, the calcareous material forms the greater part of the rock, the insoluble portions collect on the surface as a mantle of soil, varying in thickness with the character of the limestone, being generally quite thin where the latter is pure, but often very thick where it contains much insoluble matter.

When derived in this way from the disintegration of the underlying rock, soils are called sedentary. If the rock is a sandstone or sandy shale the soil is sandy, and if it is a clay-shale or limestone the resulting soil is clay. As there are abrupt changes in the character of the rocks, sandstones and shales alternating with limestones, so there are abrupt transitions in the character of the soil, and soils differing widely in composition and agricultural qualities often occur side by side. Knowing the character of the soils derived from the various geological formations, their distribution may be approximately determined from the map showing the areal geology, which thus serves also as a soil map. The only considerable areas in which the boundaries between different varieties of soil do not coincide with the formation boundaries are in the river bottoms and upon the steep slopes, where soils derived from rocks higher up the slope have washed down and mingled with or covered the soil derived from those below. The latter are called overplaced soils, and a special map would be required to show their distribution.

Classification.—The soils of this region may conveniently be classed as (1) sandy soils, derived from the Walden and Lookout sandstones; (2) clay soils, derived from the Bangor and Chickamauga limestones and the Rockwood shale; (3) cherty soils, derived from the Fort Payne chert and the Knox dolomite; (4) alluvial soils, depostied by the larger streams on their flood-plains.

Sandy soils.—The Cumberland Plateau is formed of sandstones and sandy shales, and its soil is a sandy loam. At the surface it is gray, while the subsoil is generally light-yellow, but varies to deep-red. In some places it consists largely of sand, but in others it contains sufficient clay to give the subsoil considerable coherence, so that a cut bank will remain vertical for some years. The depth of soil on the plateau varies from a few inches to ten feet or more, diminishing in proximity to streams, where erosion is most active. A large part of the plateau retains its original forest growth, chiefly of oak, chestnut, and hickory, while pines clothe the steep sides of the stream channels. The practice of burning off the leaves each fall prevents the accumulation of vegetable mold and has delayed a just appreciation of the agricultural possibilities of this region. It has been found well adapted to fruit-raising, particularly for grapes and apples.

Since the sandstones of this region occupy the highest land, the overplaced soils, or those washed down to lower levels, are mostly sandy. They are especially abundant at the foot of the escarpment surrounding the plateaus, where the Bangor limestone and its clay soil are often wholly concealed. The delta deposits formed by streams emerging from gorges cut in the plateaus also give considerable areas of sandy soil, overlying rocks which would themselves produce clay or cherty soils.

Clay soils.—These are derived chiefly from the Bangor and Chickamauga limestones, and their distribution coincides with the outcrops of these formations, as shown on the geologic map. They sometimes have a deep-red color, but where the mantle of residual material covering the rock is thin it is often dark bluish-gray. The rocks generally weather more rapidly where they have a steep dip than where they are nearly horizontal. Hence the soil is deeper and more highly colored on the narrow belt of Chickamauga limestone on the western side of Sequatchie Valley than in the broader belt of the same rocks on the eastern side.

The soil in the many coves which penetrate the Cumberland Plateau is derived chiefly from the Bangor limestone. It is a bluish clay with a slight admixture of sand from the rocks capping the plateau, and is exceptionally fertile. It is especially adapted to clover and grain. Considerable areas of red-clay land occur on the highland rim between the foot of the plateau and the inner edge of the Barrens.

Cherty soils.—A considerable portion of the Sequatchie Valley is underlain by the Knox dolomite. The soil derived from this formation consists of clay in which chert is imbedded. The proportion of chert to clay is variable; in some places only occasional fragments occur, while in others the residual material is made up almost wholly of chert. Where the clay predominates the soil is deep-red, but becomes lighter with the increase in amount of chert, and in extreme cases is light-gray or white. Even when the proportion of chert is very large this is a strong, productive soil, especially adapted to fruit-raising. The soil derived from the Fort Payne chert is similar to that from the Knox dolomite, but the areas of the Fort Payne are much smaller and are usually on steep slopes, so that its soil is relatively unimportant.

Alluvial soils.—The Sequatchie River is bordered by narrow strips of bottom-land covered with a rich alluvial soil derived from the limestones of the valley and the surrounding sandstones. All the other streams in the district are at present cutting their channels deeper, so that they have no flood-plains, and hence deposit no alluvial soils.

CHARLES WILLARD HAYES,
Geologist.

May, 1895.

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

TOPOGRAPHY

TENNESSEE
PIKEVILLE SHEET

Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer.
Triangulation by U.S. Coast and Geodetic Survey.
Control Line and Topography by L. Nell and F. M. Pearson.
Surveyed in 1886 and 1890.

Nell | Pearson

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

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour Interval 100 feet
Datum is mean Sea level

Edition of Oct. 1895.

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

AREAL GEOLOGY

TENNESSEE
PIKEVILLE SHEET

LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

- Cw — Walden sandstone *(contains the Sewanee coal bed)*
- Cl — Lookout sandstone *(contains two or more coal beds locally workable)*
- Cb — Bangor limestone *(blue, crinoidal limestone)*
- Cp — Fort Payne chert *(interbedded chert and calcareous shale)*

DEVONIAN

- Dc — Chattanooga black shale *(carbonaceous and phosphatic)*

SILURIAN

- Sr — Rockwood formation *(contains one or more beds of red fossil iron ore generally workable)*
- Sc — Chickamauga limestone *(blue, flaggy limestone)*
- Sk — Knox dolomite *(massive, gray, magnesian limestone, containing chert)*

SPECIAL SYMBOLS

Faults

Sections

Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer.
Triangulation by U.S. Coast and Geodetic Survey.
Control Line and Topography by L. Nell and F. M. Pearson.
Surveyed in 1886 and 1890.

Nell | Pearson

Scale $\frac{1}{125000}$

Contour Interval 100 feet
Datum is mean Sea level

Edition of Oct. 1895.

Geology by C. Willard Hayes.
Assisted by Alfred H. Brooks and R. E. Dodge.
Surveyed in 1894.

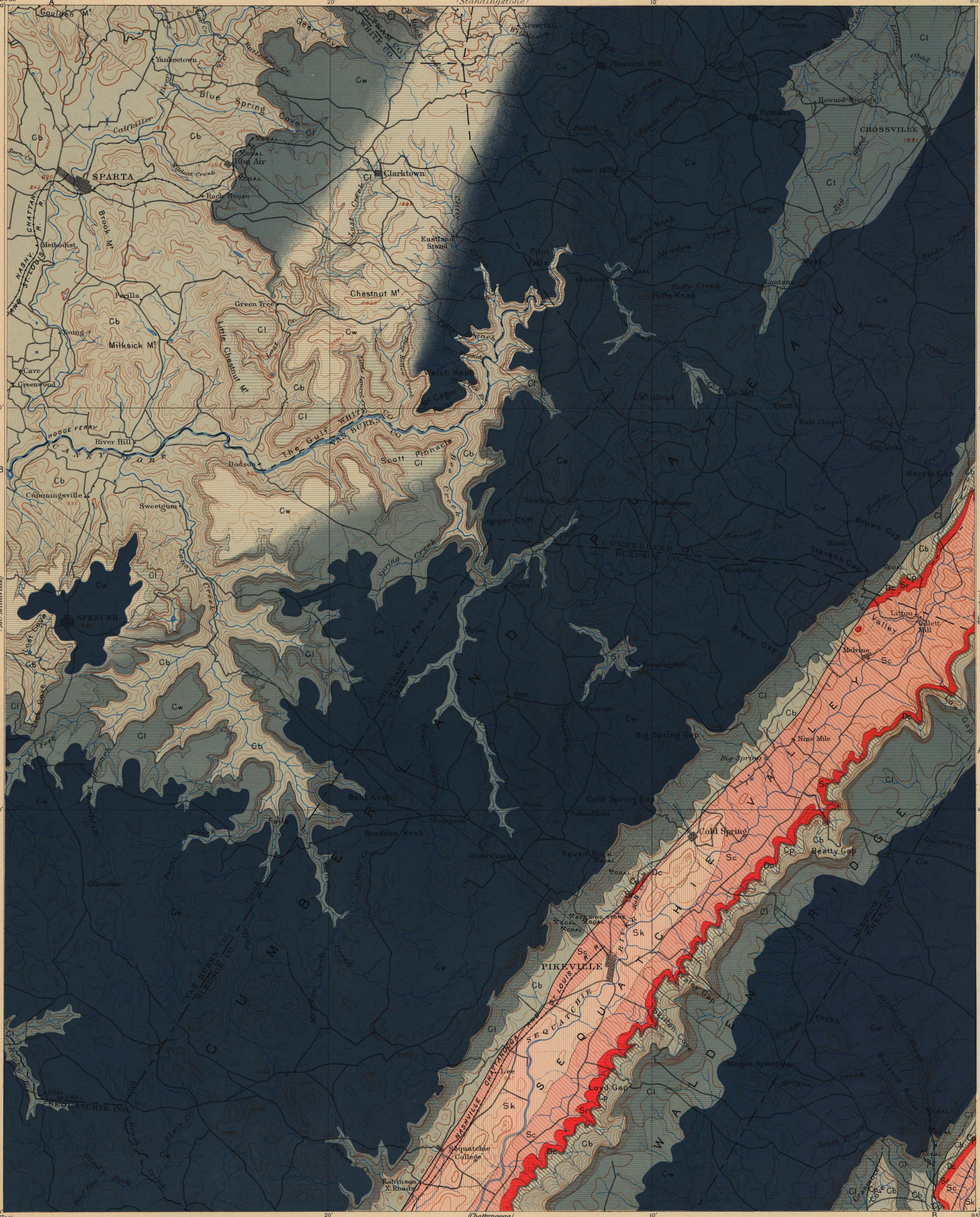
U.S. GEOLOGICAL SURVEY.
CHARLES D. WALCOTT, DIRECTOR.

ECONOMIC GEOLOGY

(Standingstone)

TENNESSEE
PIKEVILLE SHEET

(Wartburg)



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- Sk — Knox dolomite *(massive, gray, magnesian limestone, containing chert)*

Probably productive formations

- *Areas probably containing Sewanee coal*
- *Areas probably containing Bon Air or other sub-conglomerate coal*
- *Areas within which red fossil iron ore may occur*

SPECIAL SYMBOLS

Faults

Sections

⚒ Mines and Quarries

(Sewanee)

Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer.
Triangulation by U.S. Coast and Geodetic Survey.
Control Line and Topography by L. Nell and F. M. Pearson.
Surveyed in 1886 and 1890.

Nell | Pearson

(Chattanooga)

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

Miles: 1 ½ 0 1 2 3 4 5

Kilometers: 1 ½ 0 1 2 3 4 5

Contour Interval 100 feet
Datum is mean Sea level

Edition of Oct. 1895.

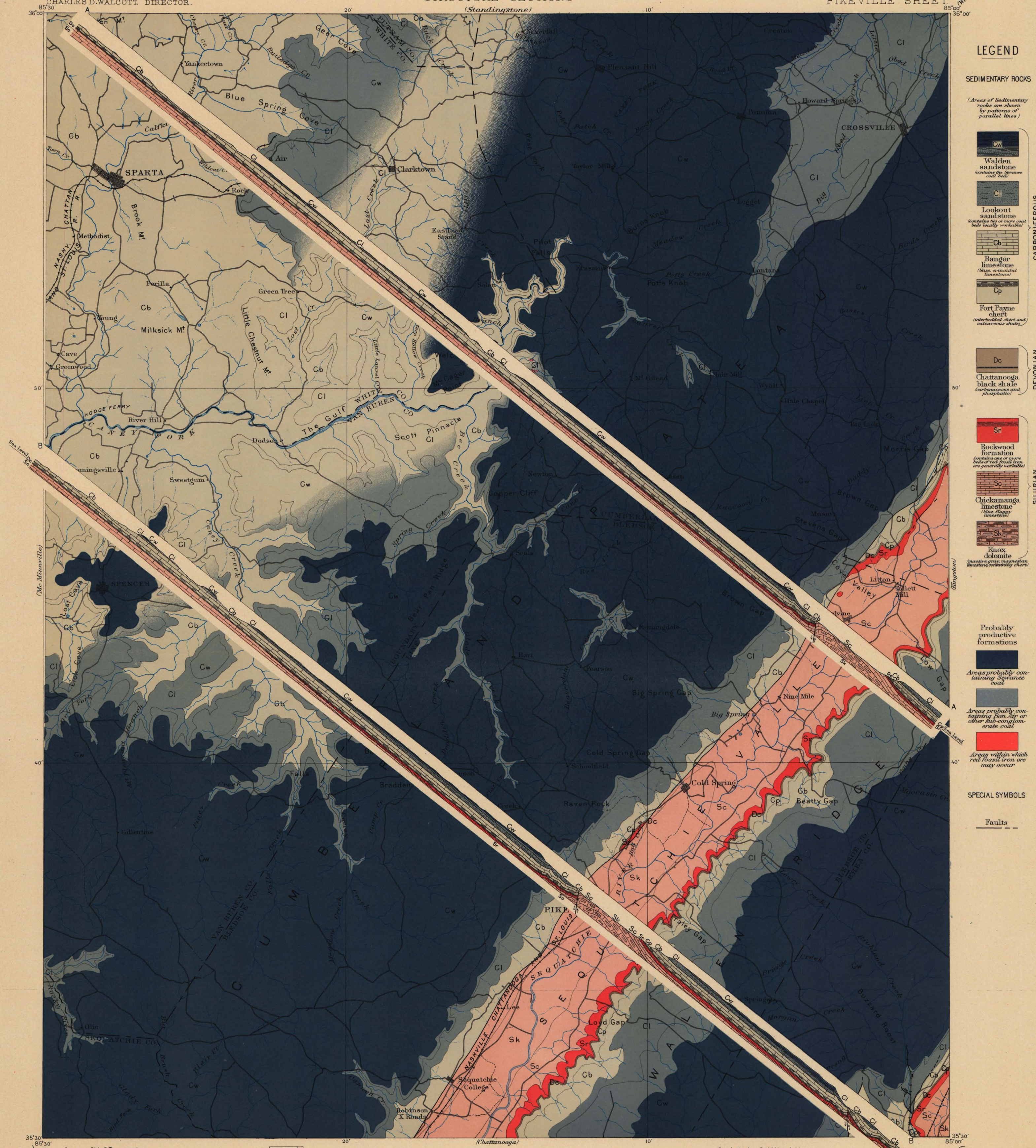
Geology by C. Willard Hayes.
Assisted by Alfred H. Brooks and R. E. Dodge.
Surveyed in 1894.

(Cleveland)

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

STRUCTURE SECTIONS

TENNESSEE
PIKEVILLE SHEET



Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer.
Triangulation by U.S.Coast and Geodetic Survey.
Control Line and Topography by L.Nell and F.M.Pearson.
Surveyed in 1886 and 1890.

Nell | Pearson

Scale 1/125000

Contour Interval 100 feet
Datum is mean Sea level

Edition of Oct. 1895.

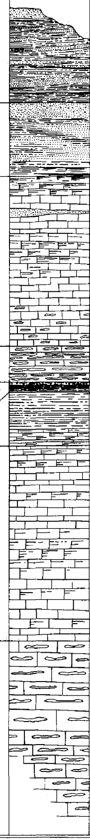
Geology by C.Willard Hayes.
Assisted by Alfred H.Brooks and R.E.Dodge.
Surveyed in 1894.

COLUMNAR SECTION

GENERALIZED SECTION FOR THE PIKEVILLE SHEET.

SCALE: 500 FEET = 1 INCH.

Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soils.
CARBONIFEROUS.	Walden sandstone.	Cw		400–650	Coarse sandstone and sandy shale with beds of coal and fire-clay.	Broad level plateaus intersected by narrow rocky gorges. Gray, yellow, or red sandy loam.
	Lookout sandstone.	Cl		90–650	Conglomerate. Sandstone and shale with beds of coal and fire-clay.	Cliffs and steep upper slopes of plateau escarpments.
	Bangor limestone.	Cb		800–850	Shaly limestone. Blue, crinoidal limestone with a few lenses of coarse sandstone. Blue, crinoidal limestone with nodules of chert.	Steep lower slopes of plateau escarpments. Black or red clay-soil.
	Fort Payne chert.	Cp		150–200	Cherty limestone and heavy beds of chert.	Ridges or knobs at the base of plateau escarpments.
DEVONIAN.	Chattanooga black shale.	Dc		15	Carbonaceous shale.	
SILURIAN.	Rockwood shale.	Sr		165–360	Calcareous shale with thin beds of blue limestone and red fossil iron ore.	Ridges with clay-soil.
	Chickamauga limestone.	Sc		950–1200	Blue, flaggy limestone.	Level valleys. Shallow, residual deposits of red or blue clay; scanty, blue clay-soil where the rocks are nearly horizontal, and deeper, red clay where the beds are steeply inclined.
CAMBRIAN.	Knox dolomite.	Sk		1000+	Magnesian limestone, white, gray, or light-blue, generally granular and massively bedded, containing nodules and beds of chert.	Low ridges and irregular, rounded hills. Deep, residual deposits of red clay and chert; red clay with a few fragments of chert, grading into white or gray soil composed almost entirely of chert.

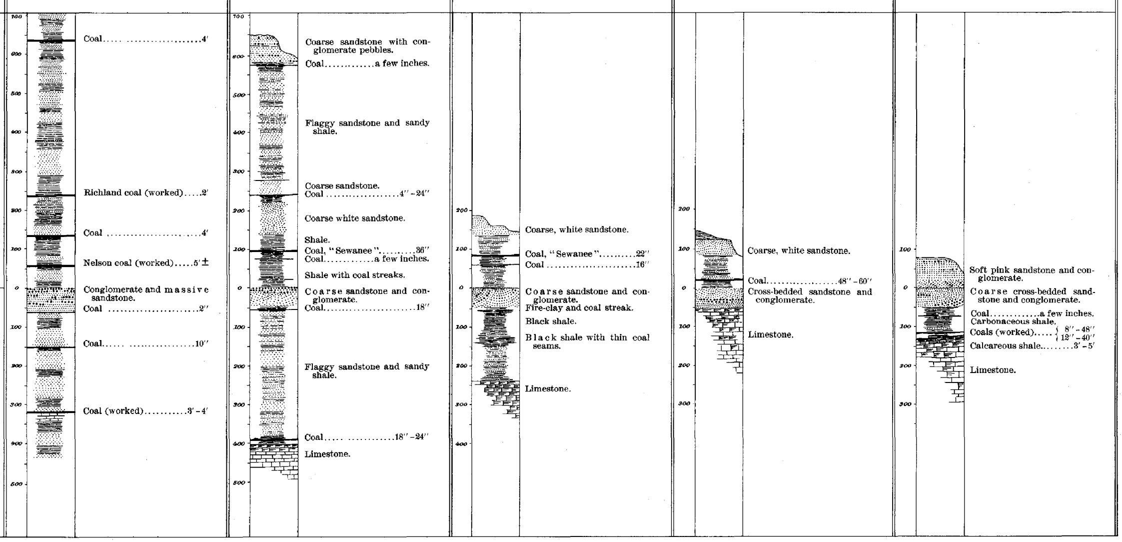


VERTICAL SECTIONS; SHOWING THE POSITION AND THICKNESS OF COAL BEDS.

SCALE: 250 FEET = 1 INCH.

VERTICAL DISTANCES ARE MEASURED FROM THE TOP OF LOOKOUT CONGLOMERATE.

Formation.	Section at the Richland mines, Dayton, Tenn.	Section west of Pikeville; in part from drill records.	Section on Basses Creek 6 miles south of Crossville; from drill records.	Section on Laurel and Clifty Creeks near Erasmus.	Section at the Bon Air mines.
Walden Sandstone. (Cw) Lookout Sandstone. (Cl)					



CHARLES WILLARD HAYES,
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