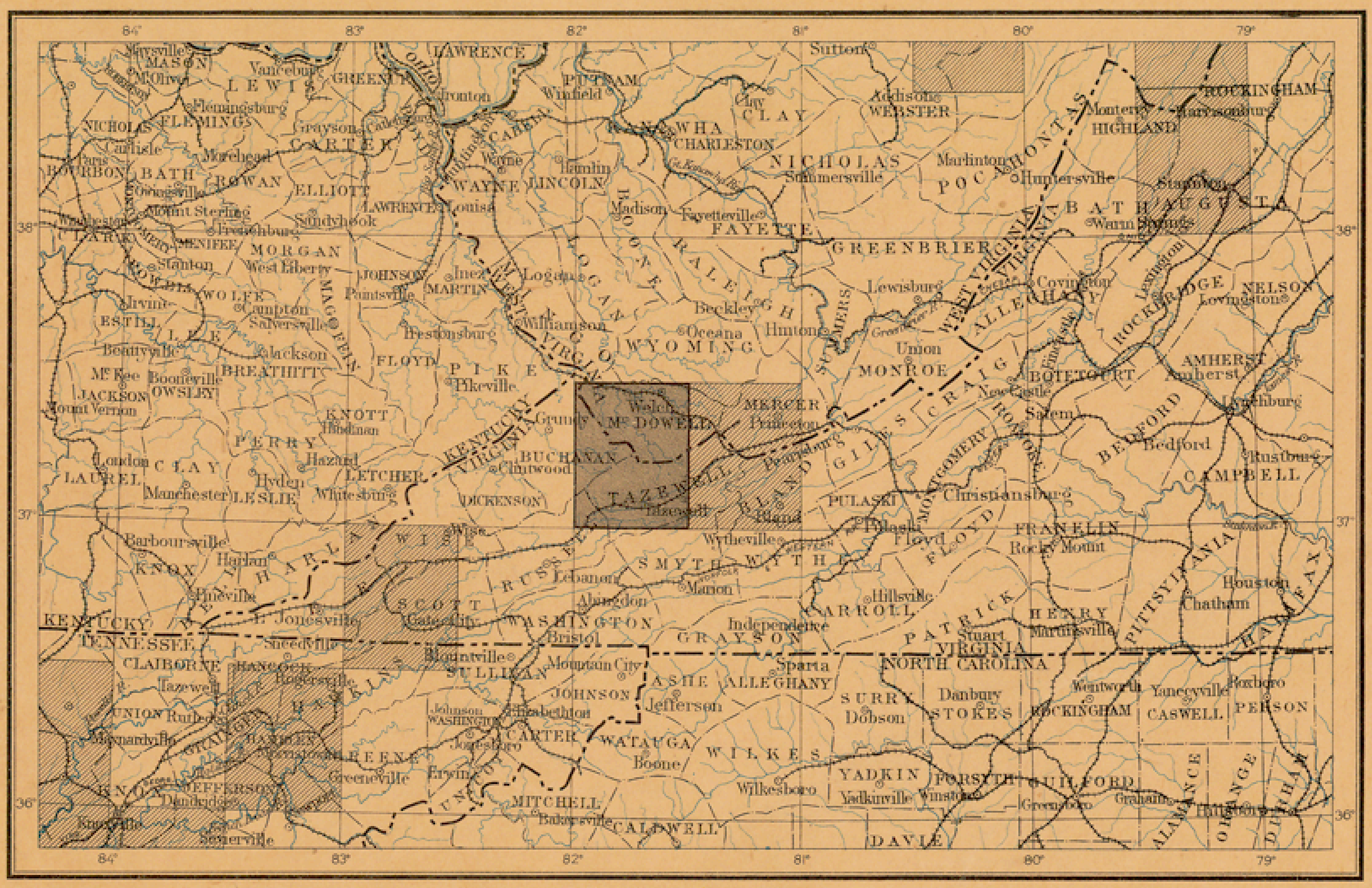
UNITED STATES GEOLOGICAL SURVE

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

TAZEWELL FOLIO
VIRGINIA - WEST VIRGINIA

INDEX MAP



SCALE: 40 MILES=1 INCH

▩ AREA OF THE TAZEWELL FOLIO

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DESCRIPTION
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FOLIO 44 LIBRARY EDITION TAZEWELL

WASHINGTON, D. C.
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BAILEY WILLIS, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER
1897

EXPLANATION.

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

THE TOPOGRAPHIC MAP.

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

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

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

Fig 1.—Ideal sketch and corresponding contour map.

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

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

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

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

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

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

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

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

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

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

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

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

THE GEOLOGIC MAP.

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

KINDS OF ROCKS.

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

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

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

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

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

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

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

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

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

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

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quarzite, 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

DESCRIPTION OF THE TAZEWELL QUADRANGLE.

GEOGRAPHY.

Extent of the quadrangle.

General relations.—The Tazewell quadrangle has an area of 950.4 square miles, extending from latitude 37° on the south to 37° 30′ on the north, and from longitude 81° 30′ on the east to 82° on the west. It is named from Tazewell, Virginia, the most important town within its borders. The quadrangle is divided between the States of Virginia and West Virginia, including portions of Tazewell, Smythe, Russell, and Buchanan counties in the former and portions of McDowell and Wyoming counties in the latter. The adjacent quadrangles are Oceana (on the north), Raleigh, Pocahontas (on the east), Wytheville, Abingdon (on the south), Bristol, Grundy (on the west), and Warfield.

Relation of the quadrangle to Appalachian province.

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

Subdivisions of the Appalachian province.—This 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.

Central division—the Appalachian Valley.

The central division is the Appalachian Valley. It is the best defined and most uniform of the three. It varies in width from 40 to 125 miles, and is sharply outlined on the southeast by the Appalachian Mountains and on the northwest by the Cumberland Plateau and the Allegheny Mountains. Its rocks are almost wholly sedimentary and in large measure calcareous. The originally horizontal strata have been thrust into great folds which in many places have been compressed to such an extent that the strata forming the folds have been broken and crowded forward out of their normal positions. That portion of the Appalachian Valley which lies within the States of Pennsylvania and Virginia may be subdivided into two areas differing materially in topographic features. The eastern area consists of a broad valley which in the former State is known as the Cumberland or Lebanon Valley and in the latter as the Shenandoah Valley. In the western area the rocks lie in broad, open folds, and the outcrops of the hard beds on the sides of these folds give rise to long, generally straight ridges, which are separated by narrow valleys formed on the outcrops of the softer rocks. Farther south the rocks have been closely folded and very much broken, and consequently the surface of the entire Appalachian Valley has been worn down to an undulating lowland which, in Georgia and Alabama, is known as the Coosa Valley and farther north as the Valley of East Tennessee.

Eastern division—the Appalachian Mountains.

The eastern division of the province embraces the Appalachian Mountains, a system which is made up of many individual ranges bearing various local names, and which extends from southern New York to central Alabama. Some of its prominent parts are South Mountain of Pennsylvania, Blue Ridge of Maryland and Virginia, Great Smoky Mountains of Tennessee and North Carolina, and 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.

Western division: its extent and geologic structure.

The western division of the Appalachian province embraces the Cumberland Plateau, the Allegheny Mountains, and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but may be regarded as coinciding with the Mississippi River as far up as Cairo, and thence extending northeastward across the States of Illinois and Indiana. Its eastern boundary is sharply defined in the north by the Allegheny front, in the south by the Cumberland escarpment.

This division is separated by the Cincinnati arch into two structural basins, one lying along the eastern and one along the western margin of the field. The one lying on the western side has but a limited extent in the region outlined above, and is generally known as the coal basin of western Kentucky. The eastern basin is more extensive, comprising the great Appalachian coal field, which extends from the southern line of New York to central Alabama, where it passes beneath the later sediments that have been deposited along the Gulf coast.

The rocks comprising the lower portion of the series exposed in this division of the province are prevailingly calcareous and outcrop in a broad belt upon the crest and flanks of the Cincinnati arch. The rocks forming the upper portion of the series are generally sandy and are found only in the two coal basins.

The topography of this division is varied, its character depending in a large measure upon the nature of the rocks forming the surface. Whether the coal-bearing rocks formerly extended from basin to basin, completely capping the Cincinnati arch, is at present an unsettled question, but it seems altogether probable that at no very remote period the surface sloped gently from the summit of the Cumberland Plateau and the hilltops of the West Virginia coal field to the highlands of the western basin, and that recent erosion has cut from that plateau the low plains of central Tennessee and Kentucky.

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

Altitudes of the Appalachian Mountains.

The Appalachian Mountains rise gradually from less than 1000 feet in Alabama to more than 6600 feet in western North Carolina. From this culminating point they descend to 3000 feet in southern Virginia, rise to 4000 feet in central Virginia, and again descend to 2000 feet on the Maryland–Pennsylvania line.

Altitudes of the Appalachian Valley.

The Appalachian Valley shows a gradual increase in altitude from 500 feet or less in Alabama to 900 feet in the vicinity of Chattanooga, 2000 feet at the Tennessee–Virginia line, and 2500 or 2700 feet at its highest point, on the divide between the New and Tennessee rivers. From this point it descends to 2200 feet in the valley of New River, 1500 to 1000 feet in the James River basin, and 1000 to 500 feet on the Potomac and Susquehanna rivers. 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 2000 feet.

Altitudes of the plateau region.

The surface of the western division rises from an altitude of 400 or 500 feet along the Mississippi River to 2000 or 4000 feet along the eastern front of the Cumberland Plateau and the Allegheny Mountains. This slope is not regular, but, in a general way, is made up of three terraces rising from the river to the eastern margin of this geologic division. The lowest terrace forms the valley of the Mississippi River and its larger tributaries, and it also appears in the central basin of Tennessee. The second terrace forms the "Highland Rim" of Tennessee and the upland plain of Kentucky; its general altitude is about 1000 feet. The third terrace is formed by the even top of the Cumberland table-land, and farther north by hilltops which presumably mark the position of a deeply dissected plateau that was formerly continuous with the Cumberland table-land to the south. The altitude of this highest terrace varies from 500 feet at the southern edge of the province to 1500 feet in northern Alabama, 2000 feet in central Tennessee, and 2000 to 4000 feet in Kentucky, West Virginia, and Pennsylvania.

Direction of drainage.

Drainage of the Appalachian province.—The western division of the province, with the exception of small areas in Pennsylvania and Alabama, is drained by streams flowing westward to the Ohio River. The Appalachian Mountain division is drained eastward into the Atlantic Ocean, except the southern part, where the surplus waters of the region west of the Blue Ridge are carried to the Ohio River by the Kanawha and Tennessee rivers, and to the Gulf by the Alabama River.

Arrangement of streams.

The positions of the streams in the Appalachian Valley are mainly dependent upon the geologic structure. In a general way they flow in courses which, for long distances, are parallel to the mountains on either side, following 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 part of the province these transverse rivers are the Delaware, Susquehanna, Potomac, James, and Roanoke, each of which flows eastward to the sea. In the central part of the province the longitudinal streams form the New (or Kanawha) River which flows westward in a deep, narrow gorge through the Cumberland Plateau into the Ohio River. From New River to northern Georgia the valley is drained by tributaries of the Tennessee River, which also crosses the Cumberland Plateau in its course to the Ohio. In Georgia and Alabama the streams flow directly to the Gulf of Mexico.

Conditions governing erosion: rock character and geologic structure.

Topography of the Appalachian province.—The different divisions of the province vary much in their topography, as do also different parts of the same division. This variation is due to the fact that in parts of the province certain conditions of erosion have had the controlling influence in shaping the results, whereas in other parts other conditions have predominated, and the surface features are modified accordingly. Thus, in the Appalachian Valley rock character and geologic structure are the conditions which chiefly govern erosion; in the Appalachian Mountains structure plays only a secondary part, and in many localities the rocks are so nearly homogeneous that rock character has had but little effect on the topography of the region; in the western division the geologic structure is so simple that it has had only a small effect in the erosion of the region, and consequently the surface features are largely due to the character of the underlying rock.

Cycles of degradation.

Throughout the entire province the surface forms are largely controlled by the altitude of land, which varies in relation to sea level as the surface is worn down by erosion or is uplifted by movements of the earth's crust. When the land is high the streams descend rapidly to the sea, corrading narrow gorges nearly to the base-level of erosion. By lateral corrasion these narrow gorges are gradually widened, and the sides are reduced from precipitous cliffs to gentle slopes. The divides between adjacent streams are, little by little, worn away, and the surface becomes a peneplain gradually approaching base-level. With reference to the development of the stream, such a period has been termed a cycle, and we may equally well apply that term to the degradation which occurs during the same period. At the beginning degradation is active, like the stream in its youth; it grows more feeble as the stream loses power; and finally it becomes sluggish and inactive, suggesting the decrepitude of old age.

Interrupted cycles.

But the process of degradation is carried to completion only in case there is a constant relation of land and sea, a condition which seldom prevails for any great length of time. Usually the cycle of degradation is interrupted by crustal movements which change the relative altitude of land and sea. When erosion is thus interrupted in any stage of its development, some of the characteristic topographic forms remain among features of later development, and they constitute a record of the conditions to which they belonged.

Peneplains in the Appalachians.

In the Appalachian province there are traces of peneplains at various altitudes which, if correctly interpreted, prove that at several periods in the past the cycle of degradation was nearly complete. The most pronounced degradation probably occurred in the Cretaceous period and resulted in the wearing down of most of the surface of the province nearly to base-level. In late Eocene or early Neocene time probably occurred another period of degradation which was a partial cycle, since it resulted only in the reduction of areas of soft rock or those in especially favorable localities. Doubtless many other partial cycles of degradation have marked the geologic history of this region, but they have been so short that they have produced no extensive or well-defined results. Each of the larger periods of quiescence noted above was terminated by crustal movements which elevated the formerly low-lying plain into tablelands and plateaus. Recent erosion has cut these elevated plains into a variety of forms, the topography of a particular area depending upon its location with reference to the main drainage lines of the province and upon the rock character and geologic structure composing it. Thus the hard, level beds of rock in the Cumberland Plateau were very effective in resisting the corrasion of the streams, and consequently when this area was elevated it became a plateau with an extremely regular surface. In the Appalachian Valley a similar plateau was doubtless formed, but erosion has been so active along the soft rocks that great valleys are excavated, leaving the hard rocks in ridges, the summits of which generally represent the surface of the former plain.

The movements which elevated these peneplains were very irregular, producing warped surfaces which now stand at different altitudes in different portions of the province.

Characteristic surface features.

Topography of the Tazewell quadrangle.—This territory lies mainly in the western division of the province, but the southern extremity includes a portion of the Appalachian Valley. The line separating these main divisions passes through Horsepen Cove, Richlands, and Doran. South of this line the forms of relief consist of long, straight ridges and narrow, intermediate valleys all trending N. 60° E. In the coal field north of the fault line the topographic forms are extremely irregular, the direction and continuity of the ridges having been determined apparently by the accidents of erosion on nearly horizontal rocks.

Regularity of hill tops indicative of a peneplain.

Careful study of the topographic sheet reveals the fact that there is a certain element of regularity in the topography of both the coal field and the Appalachian Valley. This element of concordance is the general elevation of the surface as marked by the tops of hills. In passing through the region, the traveler is generally confined to the valleys, and consequently he sees but an endless succession of irregular knobs and ridges with no apparent system or general altitude. Let him ascend an eminence, such as Bear Wallow, and he will then perceive a plain below him, once doubtless continuous across the valley of Dry Fork, but now deeply trenched by every branch of that stream. When the contoured sheet is consulted, it is found that this regularity of summits is not confined to any one area, but is characteristic of most of the territory within the coal field. It is also noticeable that this surface varies in altitude from 1800 feet in the northwestern corner of the quadrangle to 2000 feet near Iaeger; 2300 feet at Bradshaw and Welch; 2400 feet at McNiel Store, Barrenshe Creek, and Kimball; 2500 feet on Sandy Ridge and on the lower course of Long Branch; and 2600 feet at Big Creek and Squirejim. From this line it does not appear to rise much, but passes into the valley region at about the same altitude. It then gradually descends to 2500 feet at Coombs Point and Snapp, and probably 2400 feet near Honaker.

This regular surface has the appearance of a peneplain, above which stand the valley ridges, portions of Sandy Ridge, and Bear Wallow, and in which the present streams have cut narrow valleys, in some cases 1000 feet in depth. The most noticeable feature of this surface is that it extends over the hard sandstones of the coal field as well as over the soft limestones and shales of the Appalachian Valley; rock character seems to have entered but slightly into the determination of the extent of this peneplain.

The ridges which stand above this old plain show a slight correspondence in altitude which, taken in connection with the height of the ridges in the surrounding area, makes it seem probable

High summits possibly indicate older peneplain.

that their crests mark the surface of a still older peneplain, which has been so long exposed to the action of erosion that but few scattered remnants are left to mark its once even surface. Being older than the extended peneplain just described, it has been affected by a greater number of crustal movements, and is consequently deformed to a greater extent than the newer plain.

The surface of the upper peneplain is possibly represented by the extreme summit of Hensley Knob, north of Tug River, and by Bear Wallow at an elevation of 3100 feet, Stony Ridge at 3400 feet, and Paint Lick, Deskins, and House and Barn mountains at an elevation of 3500 feet. South of this line its position is uncertain; the mountains vary in altitude from 3100 to 4500 feet, but it is probable that neither of these extremes represent the altitude of the peneplain. The highest summits are generally due to the attitude of the hard sandstones which form the ridges, and they were probably hills at the time the older peneplain was produced.

The peneplains which appear to be represented by the regular hill-tops of the Tazewell quadrangle are of wide extent, having been recognized over most of the western division of this province.

Drainage of the Tazewell quadrangle.—This territory is entirely within the watershed of the Ohio River, but its drainage is divided among three large tributaries of that stream.

Tennessee River system.

That portion of the quadrangle which lies within the Appalachian Valley belongs mainly to the Tennessee system. Its largest stream is Clinch River, which rises about 6 miles east of Tazewell and flows southwest in a somewhat irregular course, leaving this quadrangle near its southwest corner. South of Clinch Mountain the drainage belongs to Holston River, another branch of the Tennessee.

Big Sandy River system.

With one exception, the streams which drain the coal field unite in the Big Sandy River, and thus reach the Ohio by a direct northwestern course. The principal one of these streams is Tug Fork, which crosses the northern portion of this quadrangle and which receives the waters of Elkhorn Creek, Clear Fork, Dry Fork, Panther Creek, and Knox Creek. Levisa Fork of Big Sandy has its source at the Gap of Sandy and receives Dismal and Slate creeks from the east. The small area north of Indian Ridge is drained by Indian Creek, a tributary of Guyandot River.

Big Sandy River encroaching on Clinch River.

Probable cause of encroachment on Clinch River.

The encroachment of the streams belonging to the Big Sandy system upon that of Clinch River is the most remarkable feature of the topography of this quadrangle. The former has apparently robbed the latter of much of its northern drainage, and at present is rapidly encroaching upon the main branch of Clinch River itself. At Gap Store, in Baptist Valley, the head of Dry Fork is flowing at an altitude of 2000 feet, whereas, about a mile toward the southeast, Clinch River has an elevation of 2300 feet. When it is considered that Clinch River carries a much greater volume of water than Dry Fork, and that the course of the former is directly down the Appalachian Valley to the southwest, along greatly disturbed calcareous rocks, the encroachment will seem to be phenomenal. Under the conditions which appear to prevail at present, Clinch River certainly has a decided advantage over Dry Fork and would tend rather to rob it than to suffer at its hands, therefore we are forced to look for some other explanation than the geographical distribution of hard and soft rocks, or geologic structure. A comparison of the altitudes of the lower peneplain at many points shows that there is a low arch crossing the quadrangle in nearly an east-west direction, which would account for the peculiar relationship between these streams. An arch in this peneplain means a comparatively recent uplift along its axis, and since this axis crosses Clinch River below the point mentioned, it would act as a barrier in preventing the development of the stream above that point. The effect on Dry Fork would be to stimulate its head branches, and consequently their cutting power would be increased, whereas the power of Clinch River would be greatly diminished. This movement would explain the present attitude of the two streams, and if the uplift still continues it will be only a question of time when Clinch River will be captured at this point and transferred to the Big Sandy system.

GEOLOGY.

STRATIGRAPHY.

Origin of the rocks.

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

Conditions of deposition.

These rocks afford a record of almost uninterrupted sedimentation from early Cambrian to late Carboniferous time. Not only do they furnish a record of the conditions under which they were deposited, but they also record the conditions of the land from which they were derived during the same period. In the ocean the waves alone are sufficient to sort very coarse material; hence conglomerates are always indicative of shore conditions; they also usually denote steep slopes and rapid erosion on the adjacent land surface; but before solidification takes place the level of the land may be so changed that the pebbles and bowlders are once more exposed to the action of the waves and are worked over again and redeposited, although at the same time the surface of the land may be near base-level. Consequently, when such beds are used in interpreting the physiographic history of the adjacent land area, the evidence should be supplemented by that drawn from other sources before it is regarded as conclusive. Sands may be transported by oceanic currents to great distances, but their ultimate source must have been a land surface having a considerable diversity of altitude and streams of sufficient power to transport the sand to the sea. As the waste of the land is carried into the sea it is assorted by the waves and currents, the fine mud being carried out into comparatively still water before it gradually settles to the bottom, where, in the course of time, it is solidified into shale. As the surface of the land is reduced toward base-level, the waste transported by the streams becomes finer and finer until the deposits in the sea, even near shore, consist entirely of fine mud, which in time is hardened into shale. Thus shale may represent rapid erosion on the surface of the land and deposition at some distance from the shore, or it may represent base-leveling and close proximity to the coast. In a similar manner it seems possible that limestones may be deposited near shore during the ultimate stage of a period of base-leveling, although under ordinary conditions of erosion they are formed only at considerable depths and at sufficient distances from the shore to be beyond the limit of the transportation of sand and mud. Coal is formed from deposits of peat or from buried vegetation; consequently coal seams indicate the presence of extended swamps of either fresh or brackish water, in which a luxuriant vegetation flourished from time to time, but which was frequently buried by great washes of sand and mud.

The sea in which the Paleozoic sediments were laid down covered most of the Appalachian province and the Mississippi basin. The exact position of its eastern shore-line is not known, but it probably migrated westward at intervals throughout Paleozoic time, as the folding of the rocks lifted them above sea level.

Since the character of the sediment is, to a certain extent, indicative of the attitude and configuration of the land, the history of the continental area from which were derived the sediments now forming the rocks of the Tazewell quadrangle should be found recorded in them. At present our knowledge will permit only the broadest generalizations.

Geologic history of the Appalachian province.

The oldest known rocks of this quadrangle were deposited in a trough or broad strait which was bounded on the east by the continental area then existing to the eastward of what is now the Smoky Mountains and the Blue Ridge, and on the west by a land barrier which was probably located somewhere in the western division of the Appalachian province, and which separated this trough from the great interior sea. Into this trough was swept the waste of the continental area to the east which, hardened into sandstones and shales, is now known as the rocks of lower Cambrian age. The land forming the barrier west of the Appalachian Valley sank beneath the sea, and the coarse sediments of the preceding epoch gave place to an enormous and widespread limestone deposit which marks the close of Cambrian and the beginning of Silurian time. This limestone presumably covers most, if not all, of the western division of the province and extends eastward to the base of the Appalachian Mountains. From the proximity of this outcrop to the supposed shore-line of that period it seems probable that the land area to the east was practically at base-level and that no coarse sediments were delivered to the Appalachian sea from that quarter. In early Silurian time this land area was elevated and such great quantities of sand and mud were swept into the sea that the formation of limestone was interrupted near shore, but farther out it continued to form for some time. Finally, however, the sea became too muddy for the formation of limestome, except in central Kentucky and Tennessee, and the entire Appalachian Valley was covered with a thick deposit of shale. The land continued to rise and the shore-line migrated northwestward, but the extent of this movement has not been definitely determined. In the Appalachian Valley this shore-line is marked by a deposit of clean beach sand, but the absence of rocks of this age over the southern point of the Cincinnati arch seems to indicate that the sea margin did not migrate indefinitely westward, but was interrupted by a land area in central Kentucky and Tennessee.

During Devonian time the Tazewell quadrangle was doubtless covered by the sea which extended over most of the Appalachian province. In the earlier stage of this period the land to the east of the Paleozoic sea was probably near base-level, but in the closing stage the land in the northeastern part of the United States was greatly elevated and from this were swept immense quantities of sandy waste which even extended as far south as Tazewell.

The beginning of Carboniferous time is marked by marine conditions, but with many fluctuations of level which resulted in a rapid alternation of strata of very diverse characters. The Pottsville series of the Carboniferous consists of sandstones and shales which were deposited in a long, narrow trough of fresh or brackish water that extended northeast and southwest along the eastern margin of the coal field. This deepened as time went on, and the sediments stretched farther and farther northwest, until, toward the end of the period, the formations may have extended across the Cincinnati arch. The evidence regarding the eastern margin of this trough is not conclusive, but it seems probable that it did not reach far beyond the present outcrop of the rocks belonging to the Pottsville series. Finally the basin was elevated above water level, and the coal field was added to the eastern continental area of North America.

CAMBRIAN STRATA.

Character of the Russell formation.

Russell formation.—The lowest rocks known in this field contain the Olenellus fauna and are consequently of Lower Cambrian age. They consist of alternating shales, thin sandstones, and impure limestones. Owing to the position of this formation along the great fault lines, and to the complex folding which it has undergone, it is impossible to determine its full thickness, but there can not be less than 600 feet of strata exposed in this quadrangle. The formation is named from Russell County, Virginia, in which it is present with its characteristic fauna.

Distribution of the Russell formation.

It is exposed in one line of outcrop which passes north of Baptist Valley and through Cedar Bluff, Sword Creek, and Honaker. Along most of this line only the upper or more calcareous portion is exposed, and consequently it has no marked effect on the topography; toward the western edge of the territory, however, it becomes more sandy and forms rows of sharp, conical hills.

Honaker limestone.—Overlying the Russell formation, along the northern face of Kent Ridge, is the Honaker limestone, so-called from the town of Honaker, in Russell County. This limestone varies in character from blue, flaggy to dark, impure limestone and massive gray dolomite. It ranges in thickness from 900 to 1000 feet.

Honaker limestone changes toward the west.

West of the Tazewell quadrangle this formation is subdivided by a small band of calcareous shale (Rogersville shale) into two distinct limestones, the upper of which has been named the Marysville and the lower the Rutledge limestone. In passing eastward the Rogersville shale becomes more and more calcareous, until, on the western edge of this quadrangle, the three blend into a single limestone formation with about the same thickness as the aggregate farther west.

Changes in Nolichucky shale.

Nolichucky shale.—Above the Honaker limestone occurs a bed of calcareous shale which varies in thickness from a knife edge to 225 feet. It outcrops on the northern face of Kent Ridge in a narrow band which practically disappears at the eastern edge of the quadrangle. It thins eastward like the Rogersville shale, and finally merges into the limestones above and below, forming a great mass which, in the Pocahontas quadrangle, has been called the Shenandoah limestone. This shale is named from Nolichucky River in East Tennessee.

CAMBRO-SILURIAN STRATA.

Age and character of the Knox dolomite.

Knox dolomite.—This is the greatest limestone formation known in the province. It was early named by Safford from Knox County, Tennessee, and as its outcrop has been traced continuously from the type locality, the same name is appropriate for this region. The formation is generally unfossiliferous, so its exact age can not be determined, but the occurrence of Silurian fossils in the upper portion shows that a part at least belongs to that period; as to the remaining portion the evidence is negative, but seems to favor Cambrian; therefore, as the formation is a lithologic unit, it is provisionally classed as of Cambro-Silurian age. It is generally a gray, cherty magnesian limestone or dolomite, with a thickness of about 2400 feet. East of Tazewell the Knox dolomite unites with the Honaker limestone, forming a mass of great thickness which was called by Rogers No. II, or the Valley limestone, but which has since received the name Shenandoah limestone.

Distribution of the Knox dolomite.

The Knox dolomite appears at the surface in four belts. North of Honaker a small outcrop extends from the western edge of the quadrangle to Stone Mountain. Near the crossing of Clinch River the formation is faulted off, but it is again seen toward Cedar Bluff in a narrow line of outcrop, and it appears and disappears along this fault line until it passes off the quadrangle to the east. The most prominent line of outcrop of the Knox is on Kent Ridge, which crosses the quadrangle from northeast to southwest. The next two belts unite near the center of the region, forming an irregular area of dolomite, whose outcrop in general corresponds to the position of two arches, one passing through Tazewell, Liberty Hill, and Paint Lick, and the other through Thompson Valley and Snapp.

Over much of this quadrangle the upper limit of the Knox is characterized by a thin bed of red, earthy limestone, in certain localities closely approaching shale and in others carrying pebbles of chert in an earthy limestone matrix.

SILURIAN STRATA.

Extent of the Chickamauga limestone.

Chickamauga limestone.—Above the Knox is a series of blue, flaggy limestones which are probably equivalent to the base of Rogers's No. III, and are named from Chickamauga Creek, Georgia. Throughout the Tazewell quadrangle this limestone maintains a constant thickness of from 900 to 1000 feet, but southeastward across the Appalachian Valley it thins to only a few feet, and possibly dies out altogether. This southeastward change in the character of the sediments indicates the existence of a shore-line in that direction during the closing stages of that period of limestone deposition. From this shore came sand and mud which were sorted and separately deposited according to the laws of sedimentation, the coarse material near shore and the fine farther out in the depths of the ocean.

Moccasin limestone.—Between the pure limestone of the northwest and the shales of the southeast is an intermediate deposit of red, earthy limestone, which occurs typically on Moccasin Creek, Scott County, Virginia. Along Clinch Mountain it attains a maximum thickness of 400 feet and is mapped separately; but in the vicinity of Stone Mountain, on the margin of the coal field, it can not be separated from the adjoining formations. In the latter locality it is usually represented by beds of mottled, shaly limestone, so interbedded with the blue limestone below and the shale above that they are inseparable as a distinct formation.

Transition phase between limestone on the west and shale on the east.

Sevier shale.—This shale increases greatly in thickness from northwest to southeast across the Appalachian Valley, but the lateral extent of the outcrop in the Tazewell quadrangle is so small that the change in thickness is not noticeable. In House and Barn, Paint Lick, Deskins and Clinch mountains, and in Morris Knob the thickness possibly varies from 1200 to 1400 feet. In Stone Mountain it is very much thinner, but whether this is due to an actual decrease in thickness toward the northwest or to a thinning produced by intense folding and faulting is uncertain. The formation changes gradually from calcareous shale at the base to sandy shale at the top, and is named from Sevier County, Tennessee. The Sevier shale, Moccasin limestone, and Chicamauga limestone were collectively referred by Rogers to No. III in his Virginia series of rocks.

Character and distribution of the Sevier shale.

Bays sandstone.—This formation attains a thickness of from 300 to 400 feet and is named from the Bays Mountains in northern Tennessee. It consists of red, sandy shale at the base, which passes by insensible gradations into red sandstone at the top of the formation. It outcrops near the summits of all of the valley ridges, but it is usually concealed by the débris that falls from the formation above.

Character of the Bays sandstone.

Clinch sandstone.—All of the more prominent valley ridges owe their existence to this plate of heavy sandstone, which has preserved their summits at or near the general level of the Cretaceous peneplain, while the areas immediately adjacent have been worn down to form the present valleys. It is a massive, coarse, white sandstone varying in thickness from 200 to 250 feet, and is named from Clinch Mountain, the most prominent of the valley ridges in southern Virginia and northern Tennessee. The Bays and Clinch sandstones were called by Rogers the Red and White Medina, or No. IV. The Clinch forms the summits of House and Barn, Deskins, Paint Lick, and Clinch mountains, Morris Knob, and the peak south of Tazewell.

Important ridge-making formation.

Rockwood formation.—Above the Clinch sandstone occurs a heterogeneous mass of shales and ferruginous sandstones from 300 to 400 feet in thickness. This is one of the principal iron-bearing formations of the province, but in the Tazewell quadrangle there are no known ore bodies that are thick enough to work. The most conspicuous member is a coarse, white sandstone which occurs at the extreme top and serves to separate this formation from the one immediately overlying it. This formation represents a part of Rogers's No. V, and takes its name from Rockwood, Roane County, Tennessee, where it has furnished ore for commercial use for twenty-five years.

An iron-bearing formation.

SILURO-DEVONIAN STRATA.

Giles formation.—In the Pocahontas quadrangle the beds above the Rockwood formation consist of shaly limestone, massive limestone, chert, and coarse, yellow sandstone. The geographical distribution of these beds is uncertain; they are generally so covered on their outcrop that their presence over the entire quadrangle is a matter of some doubt. It was deemed inadvisable to show them individually in the Pocahontas folio, consequently they were grouped under one formation and named from Giles County, Virginia.

Transition beds between Silurian and Devonian.

The upper portion was called by Rogers No. VII, or Oriskany sandstone, and the lower, or limestone portion was called No. VI, or Lower Helderberg. The former is undoubtedly of Devonian age, and the latter is probably Silurian; but it seems better to group them together as one formation than to make possible misstatements regarding their areal distribution.

In the Tazewell quadrangle the formation is poorly exposed, except along the southern slope of Clinch Mountain. Here it apparently preserves the same characteristics as in the Pocahontas quadrangle, and hence the same classification is made. In the vicinity of Stone Mountain there are a few isolated outcrops of this formation, but the beds are so crushed and fractured that they are almost unrecognizable.

DEVONIAN STRATA.

Romney shale.—The basal portion of the great mass of Devonian sediments is composed of black, carbonaceous shale, from 300 to 500 feet in thickness, which is named from the town of Romney, West Virginia. The change from this formation to the green, sandy shale above takes place gradually through interbedding, and is shown on the map by the merging of patterns. The Romney shale shows in but two places in the Tazewell quadrangle: one along Laurel Creek, on the southern side of Clinch Mountain, and the other on the northern side of Stone Mountain.

Character and distribution of the Romney shale.

Kimberling shale.—The green, sandy shale and sandstone which lies above the Romney is present in its full thickness only south of Clinch Mountain, where it measures about 3000 feet. In the syncline north of Baptist Valley it shows in two lines of outcrop, but on neither side is the full measure present. This formation varies in character from a fine, green shale at the base to a thin-bedded sandstone near the top, with sometimes thin beds of coarse conglomerate.

The Kimberling and Romney shales, as a whole, represent No. VIII in Rogers's classification, but their exact equivalents in the New York series have not yet been determined.

The great increase in thickness of the Devonian shales, in passing from south to north, is one of the most striking features in the stratigraphy of the Appalachian province. Thus the entire shale series is probably wanting southeast of a line passing through Rome, Georgia, and Gadsden, Alabama; at this line the shale comes in as a thin wedge which increases northward to 25 feet in thickness at Chattanooga, 800 feet at the southwestern end of Clinch Mountain, 1800 feet on the Virginia–Tennessee State line, 2000 feet at Little Moccasin Gap, 3000 feet on the eastern edge of the Tazewell quadrangle, and 4000 or 5000 feet on New River.

Change in character and thickness of Devonian shales along the valley.

CARBONIFEROUS STRATA.

In the Tazewell quadrangle the strata belonging to this period are of much more importance than the strata of any other geologic period because they contain coal, which is the most valuable mineral product that has so far been found in the territory.

The original classification of Rogers, together with the present subdivisions, are presented in descending order in the following table:

No. XIII.	Lower Coal group...	Tellowa formation. Sequoyah formation.
No. XII.	Great Conglomerate.	Dotson sandstone. Bearwallow conglomerate. Dismal formation. (Dismal conglomerate-lentil.) Raleigh sandstone. Welch formation. Pocahontas formation.
No. XI.	Greenbrier shale.....	Bluestone formation. Princeton conglomerate. Hinton formation. Bluefield shale.
	Greenbrier limestone	Greenbrier limestone.
No. X.	...Montgomery grits.....	Price sandstone.

Price sandstone.—This formation overlies and is closely associated in character with the upper, sandy portion of the Devonian shales. Between Tazewell and New River the formation is of considerable thickness and consists of sandstones, shales, and some coal seams, but it diminishes rapidly in thickness westward and changes in character so that it is an inconspicuous formation on the Tazewell quadrangle. It probably does not exceed 200 feet in thickness in its outcrop south of Clinch Mountain, but toward the northwest, where its horizon is exposed, there is no trace of the formation. There is no visible unconformity at this point, and it is uncertain whether the formation is merged with the strata above or is altogether wanting. This formation appears to have been deposited along the margin of a shallow sea which received coarse material from a land area that lay to the southeast; and since these deposits do not appear beyond the line of the Norfolk and Western Railroad it is possible that the shore of the early Carboniferous sea was along that line, passing near the towns of Radford, Wytheville, and Marion.

Coal-bearing formation.

In the New River region the Price sandstone is overlain by a considerable body of bright-red shale which also thins westward and does not appear on the Tazewell quadrangle.

Greenbrier limestone.—The Greenbrier limestone outcrops only on the border of the coal field, where it overlies the Devonian shales with no apparent evidence of unconformity. The limestone is generally dark blue and cherty at its base, graduating upward into thin beds of a light-blue color, and finally becoming decidedly shaly at its upper limit. It enters the Tazewell quadrangle from the east in two lines of outcrop which unite on Indian Creek and extend as a single trough as far as Doran. A second narrow syncline of this limestone shows north of the other outcrop, but it is small and contains only the basal portion of the formation. The full thickness of the limestone is present only along a portion of this line, hence it is difficult to determine the extreme variation in thickness. It probably ranges from 900 to 1000 feet.

Character and thickness of Carboniferous limestone.

Bluefield shale.—Between the top of the limestone and the base of a heavy bed of sandstone which is mainly instrumental in preserving Stony Ridge at its present altitude, is a body of shale ranging in thickness from 1150 to 1250 feet. It is very calcareous at its base and is with difficulty distinguishable from the limestone which underlies it. The calcareous shale passes upward into clay shale, which in turn gives place to sandy shale with thin beds of sandstone. This formation shows only in the trough east of Baptist Valley post-office.

Hinton formation.—This is a heterogeneous formation composed of almost every kind of sedimentary rock and about 1200 feet in thickness. It is a portion of a great mass of similar rocks which extends from the top of the Bluefield shale to the base of the coal-bearing formations, and is usually referred to as the "Red shales," because of its prevailing constituent. The Hinton formation consists of the lower portion of this aggregate, extending upward from the base of the sandstone previously described to a heavy plate of conglomerate or sandstone which is classed as a separate formation.

Lower portion of the Red shale series.

Princeton conglomerate.—On the Pocahontas quadrangle this a is coarsely conglomeratic and very prominent formation. Toward the west it becomes finer, showing on the Tazewell quadrangle only as a coarse sandstone. It is about 40 feet in thickness and outcrops in two lines which unite near the eastern edge of the area; beyond this point it is not known as a separate formation.

Bluestone formation.—This constitutes the upper portion of the "Red shales." It is about 800 feet in thickness and consists of shales, sandstones, and impure limestones. It shows in the Stony Ridge syncline south of Horsepen Cove, and in some of the valleys of the coal field.

Upper portion of the Red shale series.

Unclassified measures.—On the map there is a line of outcrop of the red shales just south of the fault which forms the southern border of the coal field. These are highly contorted, and since they are faulted on both sides it is almost impossible to classify them. They belong to the two preceding shale formations, probably including portions of both; but their equivalence is so uncertain that they can not be ascribed to either, and consequently they are mapped as unclassified rocks of the Red shale series.

COAL-BEARING STRATA.

The upper limit of the Red shales marks an abrupt transition from rocks that are prevailingly calcareous to those in which calcareous matter is almost wholly wanting. Conditions appear to have changed from open sea to fresh or brackish water lagoons where, from time to time, immense coal swamps flourished, which were subsequently buried by quantities of sand and mud that were swept into the basin from the surrounding land areas. Such sediments accumulated in the Tazewell quadrangle to the depth of several thousand feet, forming the coal-bearing series of the region.

Unclassified measures.—At intervals along the margin of the coal field these formations were upturned by the force which crumpled the strata of the Appalachian Valley. In this mass individual formations are not distinguishable, consequently on the map it is represented as the unclassified rocks of the Pottsville series.

Pocahontas formation.—This is the lowest division of the coal-bearing rocks, extending from the top of the Bluestone formation to the roof of the Pocahontas coal. In this interval of 360 feet there are sandstones, shales, and a few coal seams, but those coals which occur below the Pocahontas seam are thin and of not much consequence. The formation shows slightly in outcrop in the valley of Elkhorn Creek and in most of the valleys east of Bear Wallow and Indian Creek.

The famous Pocahontas coal seam.

Welch formation.—Above the Pocahontas coal for a distance of 700 feet there is no bed which can with certainty be identified throughout this area, hence the whole is mapped as one formation and named from the county seat of McDowell County, West Virginia. In the description of Pocahontas quadrangle this is subdivided at the horizon of the Quinnimont coal into two formations; but it is doubtful if this coal can be recognized in the Tazewell quadrangle, consequently the line of division has been dropped. The Welch formation includes many beds of sandstone which form conspicuous cliffs along Tug River above Welch, but in other localities they are not prominent. The formation includes many important coal seams in various parts of the area, but the absence of recognizable beds in the formation renders the correlation of such seams a difficult matter. Its outcrop is limited mainly to the eastern part of the area.

Raleigh sandstone.—In the eastern half of this quadrangle the most prominent formation is the Raleigh sandstone. It is coarse, sometimes conglomeratic, heavy bedded, and about 100 feet in thickness. On Tug River it makes an imposing series of cliffs from the tunnel below Davy to Welch; on Spice Creek it extends from Roderfield to Indian Gap; on Clear Fork, throughout its entire length; and on Dry Fork, from near the mouth of Crane Creek to the mouth of Jacob Fork. In the western half of the quadrangle it loses its massive character and becomes only shaly sandstone but still retains about its original thickness. This sandstone is named from Raleigh County, West Virginia, where it is the most striking feature of the great gorge of New River.

Prominent cliff-making sandstone.

Dismal formation.—Above the Raleigh sandstone is a mass of coal-bearing rocks about 490 feet in thickness which resembles very closely the Welch formation. The chief difference is that the coal seams are neither so numerous nor so valuable. In the western portion of the quadrangle a heavy lentil of conglomerate appears in the middle of this formation, serving to distinguish it still further from the Welch. The formation as well as the lentil of conglomerate is named from Dismal Creek, which drains a large area in the western part of the field.

Dismal conglomerate-lentil.—This lentil of conglomerate is well developed in the basin of Dismal Creek and south of Sandy Ridge. It is here a coarse conglomerate, varying in thickness from 100 to 120 feet. Toward the east and north it loses its character and can be traced only a short distance.

Bearwallow conglomerate.—Above the Dismal formation is a sandstone or conglomerate about 60 feet in thickness, which is named from the high ridge west of Dry Fork. Over most of the area it is a coarse conglomerate which attains its greatest development along Tug River from Nigger Branch to Short Pole Branch, but in some localities the pebbles are absent and it is only a coarse sandstone.

Dotson sandstone.—Above the Bearwallow conglomerate occurs about 60 feet of shale surmounted by 120 feet of coarse but thin-bedded sandstone. This sandstone forms the Roughs on Tug River below the mouth of Bull Creek, and it is therefore named from the town of Dotson, which is located at that place. Although fossil plants have not yet been found near the top of this sandstone, they have been collected from both above and below

Supposed top of Pottsville series.

it. According to the determination of Mr. David White the fossils found below belong to the Pottsville series, and those found above to the Lower Coal Measures; therefore it seems altogether probable that the top of this formation agrees with the top of the series at Pottsville, Pennsylvania, notwithstanding the fact that in the Tazewell quadrangle the series is much thicker than in the type locality.

Sequoyah formation.—This consists of sandstones and shales overlying the Dotson sandstone and extending upward in the series to the top of a heavy sandstone 450 feet above the base of the formation. In this interval there are some coal seams, but they have not been thoroughly prospected and their number and value are not well known.

Tellowa formation.—All of the rocks of the Tazewell area that overlie the Sequoyah formation are included in the Tellowa, which is similar in composition to the underlying formation, except that it carries some larger coal seams. It has only a limited outcrop in this area and consequently is of no great economic value.

Rocks higher in the Carboniferous series were undoubtedly deposited over this region, but erosion has been so extensive that they are now gone, and no indications remain of the amount of the material removed.

STRUCTURE.

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

Anticlines, synclines, and faults.

Structure of the Appalachian province.—Each subdivision of the province is characterized by a distinctive type of structure. In the plateau region and westward the rocks are generally horizontal and retain their original composition. In the valley the rocks have been steeply tilted, bent into folds, broken by faults, and to some extent altered into slates. In the mountain district faults and folds are important features of the structure, but the form of the rocks has been changed to a greater extent by cleavage and by the growth of new minerals.

Types of structure.

In the valley region the folds and faults are parallel to the old shore line along the Blue Ridge, extending in a northeast and southwest direction for very great distances. Some of these faults have been traced 300 miles, and some folds even farther. Many folds maintain a uniform size for great distances, bringing to the surface a single formation in a narrow line of outcrop on the axis of the anticline, and another formation in a similar narrow outcrop in the bottom of the syncline. The folds are also approximately equal to one another in height, so that many parallel folds bring to the surface the same formations. The rocks dip at all angles, and frequently the sides of the folds are compressed until they are parallel. Where the folds have been overturned, it is always toward the northwest, producing southeastern dips on both limbs of the fold. In the southern portion of the Appalachian Valley, where this type of structure prevails, scarcely a bed can be found which dips toward the northwest. Out of the overturned folds the faults were developed, and with few exceptions the fault planes dip toward the southeast and are parallel to the bedding planes. Along these planes of fracture the rocks moved to varying distances, sometimes as great as 6 or 8 miles.

The parallel folds of the Valley.

There is a progressive increase in degree of deformation from northeast to southwest, resulting in different types of structure in different localities. In southern New York the strata are but slightly disturbed by a few inconspicuous folds, except in a narrow belt along the southeastern margin of this division, where the rocks are sharply folded and faulted to a considerable extent. In Pennsylvania many new folds are developed farther west, and all are of increased magnitude, but the folds are open, and, as a rule, the dips are gentle, except along the southeastern margin, where the same structure prevails that is found in New York. This type of structure holds throughout Virginia, except that in the southern portion many of the folds are broken by great overthrust faults. In Tennessee open folds are the exception and faults are the rule. The Appalachian Valley is here composed of a succession of blocks, tilted toward the southeast and separated from one another by fault planes which dip to the southeast at the same angle that the strata dip. In Alabama the faults are fewer in number, but their horizontal displacement is much greater, and the folds are somewhat more open.

In the Appalachian Mountains the same structure is found which marks the Great Valley, such as the eastward dips, the close folds, the thrust faults, etc.; but the force of compression has resulted mainly in the development of cleavage structure in the rocks.

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

Structure is due to horizontal compression.

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

Structure of the Tazewell quadrangle.—Since the Tazewell quadrangle includes parts of two of the great subdivisions of the Appalachian province, the area may be divided into two districts which differ radically in their geologic structure. In the district which lies south of a line through Richlands and Shrader the strata are bent into great anticlines and synclines. Along the northern margin of this district the thrust has been so severe that the folds have broken, producing great thrust faults which have complicated to a great extent the otherwise simple folding. North of the line above mentioned the rocks are nearly horizontal and show but little effect of the force which folded and crushed the strata of the Appalachian Valley.

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

Underground relations of the strata.

Faults are represented on the map by a heavy solid line where their presence is well determined, and by a broken line where their existence is hypothetical. In the sections faults are represented by lines whose inclination shows the probable dip of the fault plane, the arrows indicating the direction in which the strata have moved on its opposite sides.

These sections delineate the structure better than any verbal description, but a few words of explanation will be added. From the southern edge of the quadrangle to a line passing through Baptist Valley, Cedar Bluff, and Honaker the folds are all of the open type, and no faulting is found. The mountains are almost all synclinal in structure and the valleys are eroded on the anticlines.

North of this belt of open folding is a compound fault, which, at intervals, is represented by a single break; but it is more often divided into two faults separated by a narrow belt of Knox dolomite. This remnant probably represents a syncline which, in the great crushing, has been almost obliterated.

The Baptist Valley fault.

The structure immediately north of this fault can be fully understood only by a study of the region to the eastward. On the farther edge of the Pocahontas quadrangle, the strata north of the Baptist Valley fault are unbroken and nearly horizontal. The strata on the southern side of this belt are slightly upturned, and, in the process of folding, the hard beds have apparently broken, allowing the softer strata to flow in and replace the broken members. This small fault cuts out the lower portion of the Greenbrier limestone and all of the other formations to and including the top of the Devonian shales. Westward, the folding is more pronounced; a decided anticline is developed in Abbs Valley and a syncline in the valley of Mud Fork. Still farther westward the anticline develops into a fault, which passes through Shrader and Richlands. A few of the formations are wanting in the upturned edge of the syncline which lies north of the broken anticline; they are supposed to have been broken in the process of folding and to have been replaced by the lower rocks.

In passing westward across the Tazewell quadrangle the syncline lifts, and at Doran nothing but Devonian shale shows in outcrop across the trough. West of Clinch River and at the extreme point of the fold a portion of the southern limb, which shows at no other point except south of Graham, has been preserved and thrust toward the northwest into the center of the basin. The preservation of the overturned limb of the syncline after the northwestern limb is obliterated is anomalous in Appalachian structure.

The Appalachian coal field is in the form of a great trough in which the strata dip gently from the sides toward the center. Since the Tazewell quadrangle includes a portion of the southeastern margin of this trough, the rocks comprising its coal field are generally supposed to have a regular, northwesterly dip. Close examination, however, shows that such is not the case; that the dips, though generally toward the northwest, are exceedingly irregular; and that the inequalities bear but little relation to the general structure of the province. This great irregularity, which may have resulted partly from inequalities of the ocean floor upon which the beds were deposited, but which is more probably due to the compression that folded the rocks of the Appalachian Valley, has made it very difficult to trace coal seams from place to place, and has caused innumerable errors in their correlation.

The Appalachian coal field.

Structure contours.—The determination of the exact "lay" of the coal seams is of so much importance to both prospector and operator that an effort has been made to bring out the structure more fully than it is possible to show it on the structure sections. Since the different beds of coal, shale, and sandstone appear to be parallel, the determination of the "lay" of any one bed will be approximately correct for any other, except that the absolute elevation will be different. The Raleigh sandstone is selected as the most prominent stratum, and on its upper surface points of equal elevation are connected by lines, and since these contour lines are horizontal they indicate the irregularities of the surface on which they are drawn. Over most of the quadrangle the Raleigh sandstone shows at the surface, and consequently its elevation is easily determined; but in that part of the region from which it has been eroded its former position had to be calculated from the rocks which appear at the surface. If the relation of a coal seam to the top of this sandstone is known at any point, its horizon can be determined at any other point by measuring up or down from the contour the required distance.

The "lay" of the Raleigh sandstone.

From these contours, which are shown on the economic sheet, it is apparent that the structure is very irregular, and that most of the irregularities show no connection with the folds of the Appalachian Valley. Near the southern margin of the field, however, there is a well developed anticline that is parallel to the valley structures. This fold begins near Pocahontas and reaches its greatest development on the eastern edge of the Tazewell quadrangle. From this point it gradually descends westward and disappears north of Honaker.

The value of such contours depends almost wholly upon the accuracy with which they are located. In the present case it was impossible to use the spirit level for this work, hence they were determined by the aneroid barometer, and are only approximately correct. The aneroid work is based on railroad surveys along Tug and Clinch rivers and a connecting line along Dry Fork.

MINERAL RESOURCES.

That portion of the Tazewell quadrangle which lies within the Appalachian Valley is but scantily supplied with minerals of value.

Barite.—So far as known, barite is the most abundant mineral. It occurs in the upper portion of the Knox dolomite, and in its geographical distribution is limited mainly to the southern slope of Kent Ridge. The most productive locality so far discovered is on the banks of Clinch River 3 miles below Gardner. It is here dug from the residual limestone clay and hauled to Gardner, where it is washed and ground ready for the market. At present the work at this mine is suspended.

Iron ore.—But little iron ore is known in the Tazewell quadrangle. The Rockwood, which is the great iron-bearing formation of the Appalachians, carries in this area nothing but ferruginous sandstones, which are too siliceous to be considered as ore. On Short Mountain, however, the Rockwood shales contain some red hematite, which appears to be of excellent quality and which may extend in places into this territory, but at present no such deposits are known.

COAL.

By far the most important mineral resource is bituminous coal. Seams of coal are found in all of the measures above the Bluestone formation, except those which are composed entirely of sandstone, and since these formations are found only in the northern portion of the quadrangle the coal seams show in outcrop only in the region north of the fault line which passes through Shrader, Richlands, and Doran. Of course there are many of these seams which are too thin or too much broken up by partings to be of value, but there are a number which are of sufficient thickness and of the requisite quality for profitable mining.

Coal in the Pocahontas formation.—The lowest seam known in the Tazewell quadrangle occurs on Vall Creek near its mouth. The seam is not entirely exposed, but it shows a thickness of 2 feet 8 inches. It is about 150 feet above the top of the red shales. Sixty feet below the Pocahontas seam (No. III) there is a coal seam which ranges from 2 feet 6 inches to 3 feet 8 inches in thickness. This seam shows along Tug River from the eastern end of the quadrangle to Tug River post-office, where it passes below water level, and also on Adkins Branch with a bed-section as shown in fig. 1.

At present the most important seam is No. III, or Pocahontas, so named by the original discoverers from its position in the series of coal seams at the point of discovery, and also from the place of its first development. This seam has been traced over much of the territory along the eastern side of the quadrangle by the Flat Top Coal Land Association. Unfortunately, all of these prospect holes had fallen shut at the time of the present work, and but few measurements of the seam were obtained.

The Pocahontas coal seam.

There are two mines in operation on this seam.

Both are located on Elkhorn Creek, near Vivian, at which point the seam varies in thickness from 5 feet 8 inches to 6 feet 3 inches. It passes below water level at Kimball, but reappears at railroad grade in the bend of the creek above the mouth of Upper Belcher Creek. At Helena it has been reached by the drill at 198 feet below railroad grade, where it has a thickness of 5 feet 4 inches and a bed-section as shown in fig. 2.

On Tug River this seam has been opened at a number of points, but at the time of examination the slipping in of the earth from above had closed all but one. The Flat Top Coal Land Association give the following measurements of the seam at various points. They are evidently total thicknesses of the seam, including all partings. At the mouth of Harmon Branch the thickness of the seam is 8 feet; one mile below, 8 feet 7 inches; at Tug River post-office, 9 feet; and at each of four openings on Sand Lick Creek, 8 feet. The opening at Tug River post-office is still accessible, showing a total thickness of 8 feet 9 inches with a bed-section as shown in fig. 3.

On Long Branch, near the point at which the seam passes beneath water level, the Flat Top Company reports this seam as 10 feet 11 inches in thickness. On Big Creek it is opened in the vicinity of Squirejim, where it shows a thickness of 4 feet 6 inches (fig. 4). On Jacob Fork the Pocahontas seam shows at water level about one and one-quarter miles above the mouth of Big Creek. The full thickness is not shown at this point, but the water has washed out a block of coal which measures 5 feet by 6 feet by 18 inches, hence the seam must be of considerable thickness. Southward from this point the seam rises rapidly, reaching an altitude of 180 feet above water level at the mouth of Cucumber Creek, where it shows a thickness of 6 feet 3 inches and the bed-section shown in fig. 5.

On Dry Fork, about 1½ miles below the mouth of Keewee Creek, the Pocahontas seam rises above water level. The total thickness at this opening is 3 feet 8 inches, but it is so much cut up by partings, as shown in fig. 6, that it is of not much value. A sample from the upper portion of the seam gave analysis No. 1 in the table of analyses. Its heavy percentage of ash is doubtless due to the many thin partings which occur throughout this portion of the seam. Near the mouth of Vall Creek its thickness increases to 4 feet 7 inches, but it still contains a shale parting near the center of the seam (fig. 7).

On Beach Creek, nearly opposite Sayersville, a large seam has been opened, which is probably the Pocahontas coal. It is 6 feet 3 inches in thickness without a parting (fig. 8). The coal at this opening is hard and splinty, differing very much in appearance from that at any other opening on this seam. The upper half of this seam is badly weathered at this opening, unfitting it for chemical analysis, but probably it was originally of about the same quality as the lower half, a sample of which yielded analysis No. 2. Still farther up Beach Creek, on a branch which enters from the north, a coal has been opened which is supposed to be the Pocahontas, though it may belong to a higher horizon. It has a total thickness of 4 feet 9 inches, but it is broken by a thick shale parting which is shown in the section, fig. 9. A sample from the upper bench yielded analysis No. 3.

West of this point the Pocahontas seam is below water level, unless, perhaps, it is exposed in the upturned rocks along the edge of the basin. Even if this seam should be found in the upturned strata it is doubtful if it would pay to work, for the rocks are badly crushed, rendering mining dangerous and expensive. Since the top of the Pocahontas formation is drawn at the top of the coal seam of the same name, the line of division on the general geologic map represents the outcrop of the Pocahontas coal. In the region covered by the surveys of the Flat Top Company, the positions of these openings were determined by transit and level; in the territory west of that covered by these surveys the elevations were all determined by the aneroid barometer, based on a railroad survey along Dry Fork.

The Horsepen group of seams.

Coals in the Welch formation.—This formation carries a greater number of workable coals than any other in the Tazewell area. At Horsepen several large seams occur which range in position from 250 to 440 feet above the Pocahontas seam. On paleobotanic grounds these seams, covering an interval of 290 feet, have been grouped and named from the type locality, Horsepen group. Most of the large seams in the quadrangle fall within the limits of this group.

The Lower Horsepen seam.

The lowest seam of the Horsepen group is about 150 feet above the base of the formation or the Pocahontas seam. It is exposed back of the schoolhouse at Horsepen, where it shows a total thickness of 4 feet 9 inches, but it is much broken by shale partings, as shown in fig. 10. A sample taken from this opening, exclusive of the shale partings, yielded analysis No. 4, but the coal was considerably weathered and the analysis is hardly a fair representation of the quality of the coal. This seam has been opened above Richlands, on Big Creek, where perhaps it is better developed than at any other point within the quadrangle, but even here it proved to be extremely variable and rather expensive to mine. Its bed-section at an old opening below the mine is shown in fig. 11. About a mile above the mine the lower parting of clay has disappeared, leaving a much more attractive seam, as is shown in fig. 12. A sample from the lower bench at this point yielded analysis No. 5. West of Big Creek the downward pitch of the anticline carries this seam below water level. This seam is not known to attain a workable thickness north of the territory just described.

One of the best seams in the region is 120 feet above the Lower Horsepen seam, or 270 feet above the Pocahontas coal. It is well shown in the region about Peeryville and War Creek, and the seam will hereafter be referred to as the War Creek coal. This seam is not known with certainty south of War Creek. It may possibly be present on Indian Creek, but if so it has lost much of its thickness and is broken up by a thick shale parting. On War Creek and Dry Fork it has been opened in seven or eight places. Throughout the area prospected it holds a constant thickness of from 4 feet 4 inches to 5 feet. Two measurements of the seam on War Creek gave the sections shown in figs. 13 and 14. Fig. 13 is from an opening on the left side of the creek about one-half mile above its mouth, and a slightly weathered sample from this opening gave analysis No. 6. Fig. 14 represents the seam as shown in an opening on the right bank of the creek near its mouth, and a slightly weathered sample from this place yielded analysis No. 7. This seam passes beneath water level at Peeryville, where it has been quarried from the bed of the river for many years.

The Middle Horsepen seam.

The Middle Horsepen coal occurs 239 feet above Lower Horsepen seam and 110 feet above the War Creek seam. At Horsepen the seam shows 4 feet of clear coal (fig. 15), and a fair sample from this opening yielded analysis No. 8. This seam is probably present on Indian Creek, but its exact equivalent is still a matter of some doubt. A mine has been opened near the upturned measures on the right hand side of the creek, and is being worked to supply the local demand. The bed-section of the seam at this mine is shown in fig. 16, and the analysis of a sample which includes the two lower benches of the coal at the mine is given in No. 9. This seam presumably shows 2½ miles above Harman, on the eastern fork of the creek, about 130 feet above water level at the forks of the creek. It is here badly broken up by shale partings as shown by the diagram in fig. 17.

On Big Creek above Richlands this seam has been opened directly over the opening on the Lower Horsepen seam, but it proved to be too thin to work profitably, and the mine was abandoned after an entry had been driven 1200 feet. The bed-section at the end of this entry is shown in fig. 18, and a sample from the same place gave analysis No. 10. This seam is doubtless exposed in some of the stream valleys west of Big Creek, but it passes below water level before it reaches Coal Creek.

The Middle Horsepen seam is not known in the northern portion of the Tazewell quadrangle; it may may be present, but if so, it is probably too thin to attract attention.

The Upper Horsepen seam.

In the type locality at Horsepen there is a heavy seam 60 feet above the last described coal, which is called the Upper Horsepen seam; it has a thickness of 8 feet and a bed-section represented in fig. 19. The analysis of a sample from this opening is shown in No. 11 of the table of analyses. This seam, with a thickness of 9 feet and the bed-section shown in fig. 20, has been opened at Smith Store, 4 miles east of Horsepen, where it has been mistaken for the Pocahontas seam.

On Indian Creek this seam makes a fair showing and has been opened in a number of places. On the eastern fork it shows directly above the opening on the Middle Horsepen seam. It varies in thickness from 4 to 6 feet (fig. 21), and in this locality has a heavy sandstone roof. A sample from this opening gave analysis No. 12.

This seam appears to extend over a considerable portion of the Tazewell quadrangle, but it grows thinner toward the north. At Peeryville it is only about 2 feet in thickness, and at Welch, where it has been opened to supply the town, it is but 20½ inches in thickness. This mine has been abandoned and another seam higher in the series supplies the local market. A sample from the lower seam gave analysis No. 13.

About 100 feet above the Upper Horsepen seam, or 250 feet below the top of the Raleigh sandstone, is another coal which seems to be limited to the central portion of the quadrangle. On Indian Creek, 2 miles south of Bear Wallow, this seam shows 2 feet of clear coal. On the trail which crosses from Big Creek to Barrenshe Creek it shows also, but its full thickness could not be determined. At Peeryville it is exposed directly above the town, but at the point opened the seam is very irregular, and it is impossible to form an estimate of its value.

There are probably two coals above the last-mentioned seam, but their occurrence is uncertain and little can be said respecting their thickness or extent.

Coals in the Dismal formation.—Closely overlying the Raleigh sandstone is a coal horizon which appears to be present over most of the Tazewell quadrangle. It is probable that it is not one continuous seam, but a general coal horizon in which the seams vary slightly in their stratigraphic position.

At Welch this seam rests directly upon the sandstone. It has been opened here for local use, but it is a poor seam. Its bed-section is shown in fig. 22 and its analysis, exclusive of the shale partings, is given in No. 14 of the table of analyses.

At Indian Gap it shows a thickness of nearly 4 feet, but the opening was in such a condition that a detailed measurement could not be made.

On Spice Creek numerous openings have been made on this seam, but in all cases the abundance of partings has been a source of great disappointment to those interested in its development. An opening at the mouth of Little Day Camp Branch, 180 feet above Spice Creek, shows a total thickness of 4 feet 5 inches with a bed-section as shown in fig. 23. On Shabby Room Branch, a mile from Spice Creek, this seam has been opened, but it is still broken by partings as shown in fig. 24. On Spice Laurel Branch, 1¼ miles above its mouth, this seam has been thoroughly prospected, but the partings are even worse than in the surrounding region. Its bed-section at this point is shown in fig. 25.

The Dismal Creek seam.

This coal horizon reaches its greatest development on Dismal Creek, but since the shale partings are also thicker and more numerous, the seam is in reality but slightly improved. The seam is spoken of in this region as ranging from 10 to 14 feet in thickness, and much is expected from its development. The character of the seam shows that such hopes can not be realized, and great disappointment is in store for those who are anticipating large fortunes from its commercial development. On the extreme head of Dismal Creek, within a mile of the triangulation station on Bear Wallow, this seam is exposed in the bed of the creek with a thickness of 4 feet 6 inches and a bed-section as shown in fig. 26. A sample taken at this point, including everything except 6 inches of the upper portion of the seam, which was badly weathered, when analyzed gave the result shown in No. 15 of the table.

About 5 miles above McNiel Store this seam shows its greatest development (figs. 27 and 28). On Lick Branch, about 3 miles above McNiel Store, it shows a decided thinning of the shale partings, and is represented by the bed-section in fig. 29. Fig. 30 represents the seam as it shows at McNiel Store, but the bottom bench is full of bony streaks, which give the heavy percentage of ash in analysis No. 16. This seam also shows along Levisa Fork in the vicinity of Shack Mills, but no measurements nor samples of the entire seam could be obtained.

South of Sandy Ridge this seam shows in a number of places. It is opened on Coal Creek, a mile above the railroad, but the mine has been abandoned, as the seam was found to be too thin to mine profitably. Its bed-section at this point is shown in fig. 31, and its analysis in No. 17 of the table. A sample from an opening one-half mile farther up the creek gave analysis No. 18.

On Big Town Hill Creek, near its mouth, this seam has been opened and its bed-section at this point is shown in fig. 32. It has also been opened in two places near the sharp bend in Middle Creek, and its bed-section at the opening beneath the road is given in fig. 33. On Laurel Creek it varies in thickness from 4 to 5 feet, and it has been mined in a small way to supply the local trade for a number of years. This seam is probably present in all the stream valleys west of Doran, but its exact position and thickness are unknown.

Toward the southern margin of the field, the Dismal conglomerate is somewhat broken and complex. It is as coarsely conglomeratic as at any other point in the field, but it seems to split, and a coal seam appears in its lower portion. On the ridge between Big Town Hill and Mud Lick creeks this seam has been opened, showing a thickness of 3 feet 5 inches and a bed-section as given in fig. 34. On the ridge between Indian and Middle creeks it shows a thickness of 4 feet (fig. 35). In each case it has a coarse sandstone roof and consequently is somewhat variable in thickness.

At present only one coal seam of importance is known in the Dismal formation above the conglomerate. This has been opened at Bradshaw (fig. 36), but since the conglomerate is wanting at this point, their exact relation is difficult to determine; the conglomerate appears, however, to be represented by a sandstone which occurs 10 or 15 feet beneath the seam.

Coals in the Dotson sandstone.—Although this is classed as a sandstone formation, it is such only in its upper part; the lower portion, about 60 feet in thickness, consists mainly of shales and contains at least one coal seam. This was seen at the head of Adley Branch, below Peeryville, where it is 2 feet 5 inches in thickness. A sample from this opening gave analysis No. 19. A seam at about this horizon is reported on the lower portion of Dismal Creek as 7 feet in thickness, but it was not seen.

Coals in the Sequoyah formation.—There are several seams in this formation, but none are known to be of great commercial value. A seam about 175 feet above the Dotson sandstone was seen at a number of places. On State Line Ridge, near the head of Mill Branch, it has the section shown in fig. 37. On the same ridge it shows at the point where the road from Bradshaw passes down into the valley of Slate Creek. At this point it has the bed-section shown in fig. 38. It also shows in the road on the summit between Bull Creek and Guess Fork of Knox Creek. A coal which is supposed to be the same as the ones just mentioned can be seen in natural outcrop on the hill back of Iaeger, 600 feet above railroad grade, but it has not been prospected and but little is known regarding its thickness or quality.

About 250 feet above the Dotson sandstone is a coal which was seen at only one place in this quadrangle. It shows on Adkin Branch, opposite the mouth of Horse Creek, about 530 feet above the railroad, with the section represented in fig. 39.

Coals in the Tellowa formation.—By far the most important coal seam in these upper measures is one which barely enters this quadrangle, but which is prominent lower down Tug River. It occurs about 600 feet above the Dotson sandstone with a section as shown in fig. 40. A sample from a mine on Long Pole Creek furnished analysis No. 20.

SOILS.

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

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

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

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

Soils derived from limestones.—As a rule, these are the best soils of the region. Ranking highest as a producer of rich soils is the Chickamauga limestone, which has made Tazewell County famous as a blue-grass region.

Second in importance as a soil producer is the Greenbrier limestone, but in this territory its outcrop is so restricted that it becomes of minor importance.

Portions of the Knox dolomite yield a very good soil, but its outcrop is so generally covered by the chert which weathers out of the limestone that its value is greatly impaired.

Baptist Valley and the region about Honaker are noted for the good quality of their soil, which is the product of the Honaker limestone.

From an agricultural standpoint, the coal field is the poorest region within the limits of the Tazewell area. On the hills the soils are all derived from the underlying shales and sandstones, and are consequently thin and poor. Even the meager flood-plains which occasionally border the streams are but little better than the soil of the upland, for they are composed almost entirely of sand derived from the disintegration of the sandstones and sandy shales which compose the great bulk of the rocks of the coal field.

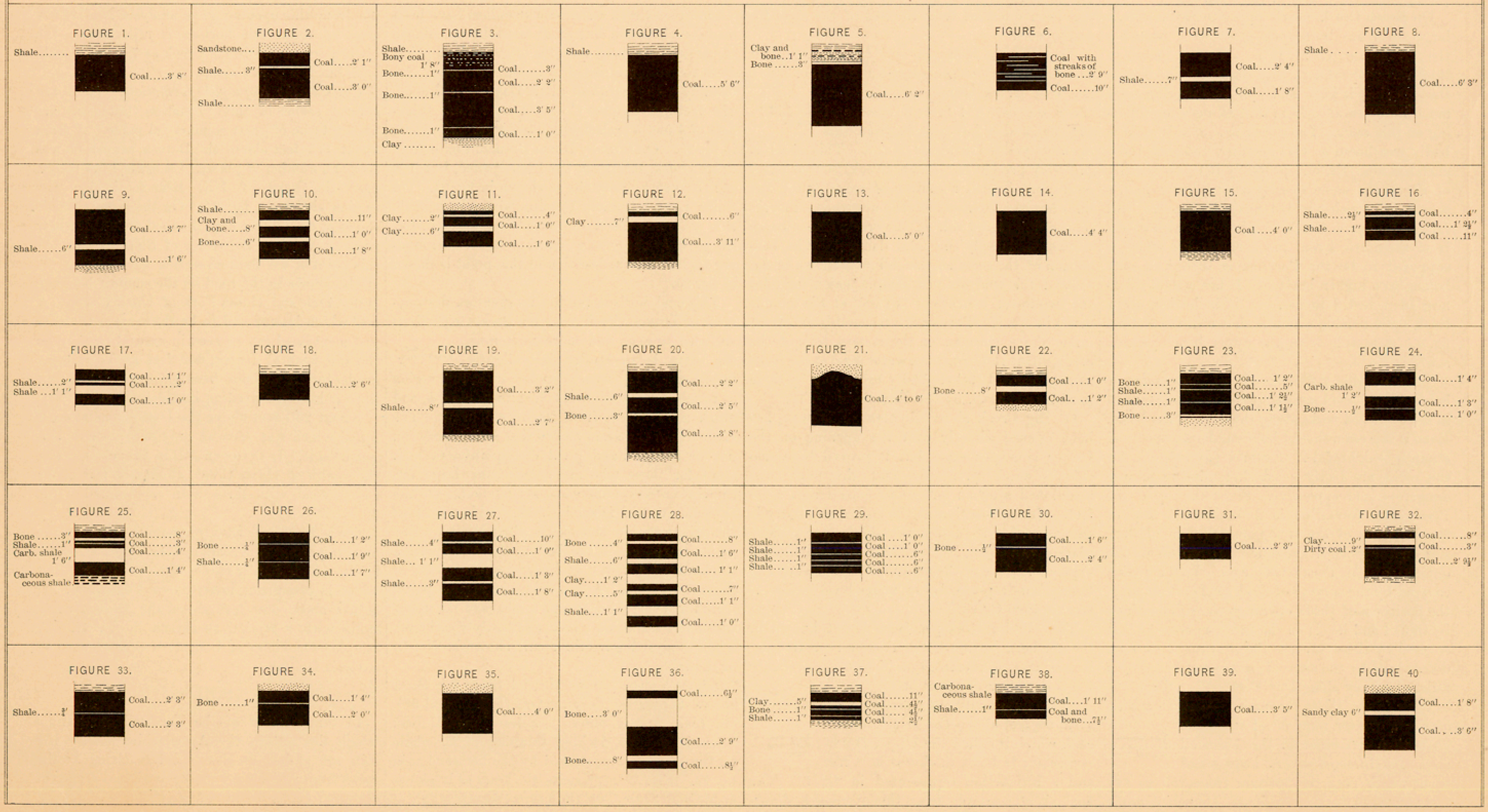
MARIUS R. CAMPBELL,
Geologist.

June, 1898.

Table of analyses of coals from the Tazewell area.

No.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.	Total.	Appearance of Coke.	Quality of Coke.
1	0.29	16.00	70.99	12.72	0.62	Trace.	100.62	Sooty.	Partly dense, coherent.
2	0.62	22.36	70.35	6.67	0.91	do.	100.91	do.	Dense, coherent.
3	0.42	27.19	59.88	12.51	1.30	do.	101.30	Brilliant.	Coherent.
4	0.39	25.29	64.24	10.08	1.17	do.	101.17	do.	do.
5	0.66	25.91	64.23	9.20	1.19	do.	101.19	do.	do.
6	8.42	32.86	48.83	9.89	0.51	do.	100.51	Sooty.	Non-coherent.
7	5.89	22.55	60.72	10.84	0.55	do.	100.55	do.	Coherent.
8	0.15	25.61	68.54	5.70	0.94	do.	100.93	Brilliant.	do.
9	0.58	29.68	61.75	7.99	0.79	do.	100.79	do.	do.
10	0.38	28.80	65.40	5.42	0.57	do.	100 57	do.	do.
11	2.24	24.65	63.77	9.34	0.65	Trace.	100.55	Semi-brilliant.	Dense, mostly coherent.
12	0.52	22.88	65.24	11.36	0.73	do.	100.73	Sooty.	Mostly dense, coherent.
13	2.46	18.45	62.93	16.16	0.54	do.	100.54	do.	Non-coherent.
14	0.21	19.32	70.42	10.05	0.72	do.	100.72	Brilliant.	Coherent.
15	0.50	22.09	71.78	5.63	0.62	do.	100.62	do.	do.
16	1.83	18.80	54.54	24.83	0.54	do.	100.54	Sooty.	Partly coherent.
17	0.66	30.08	55.90	13.36	0.74	do.	100.74	Brilliant.	do.
18	0.77	33.31	59.22	6.70	0.65	do.	100.65	do.	Coherent.
19	0.14	24.20	71.63	4.03	0.85	do.	100.85	do.	do.
20	0.57	30.79	66.52	2.12	0.68	do.	100.68	Part brilliant, part earthy.	Dense, coherent.

SECTIONS OF COAL SEAMS EXPOSED IN THE TAZEWELL AREA.
SCALE: 10 FEET — 1 INCH.



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

TOPOGRA[illegible]

VIRGINIA–WEST VIRGINIA
TAZEWELL SHEET

Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer in charge.
Triangulation by J.H. Gore.
Topography by Hersey Munroe.
Surveyed in 1893.

Contour Interval 100 feet.
Datum is mean Sea level.
Edition of Jan. 1897.

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

AREAL GEOLOGY

VIRGINIA–WEST VIRGINIA
TAZEWELL SHEET

LEGEND
(continued)

- V
  - Sr Rockwood formation *(sandy shale and ferruginous sandstone)*
- IV
  - Scl Clinch sandstone *(coarse white sandstone)*
  - Sb Bays sandstone *(red sandstone and sandy shale)*
- III
  - Ssv Sevier shale *(sandy shale and calcareous shale)*
  - Smc Moccasin limestone *(red earthy limestone)*
  - Sc Chickamauga limestone *(blue flaggy limestone)*

SILURIAN

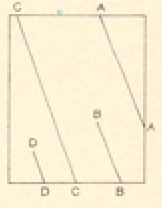
Subdivisions of the Shenandoah limestone

- CSk Knox dolomite *(gray magnesian limestone; contains barite locally in its upper portion)*
- Cn Nolichucky shale *(blue calcareous shale)*
- Chk Honaker limestone *(dark siliceous limestone)*
- Crl Russell formation *(variegated shale and impure limestone)*

CAMBRIAN

Faults ——— - - -

Sections



Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer in charge.
Triangulation by J.H. Gore.
Topography by Hersey Munroe.
Surveyed in 1893.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour Interval 100 feet.

Datum is mean Sea level.

Edition of Nov. 1897.

Geology by Marius R. Campbell.
Assisted by W.C. Mendenhall.
Surveyed in 1894.

LEGEND

SEDIMENTARY ROCKS

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

- XIII
  - Ct Tellowa formation *(sandstone, shale, and coal)*
  - Csq Sequoyah formation *(sandstone, shale, and coal)*
- XII
  - Cdt Dotson sandstone *(coarse sandstone with shale at the base)*
  - Cbr Bearwallow conglomerate *(coarse conglomerate or sandstone)*
  - Cd Dismal formation *(sandstone, shale, and coal)*
  - Cdc Dismal conglomerate-lentil *(coarse conglomerate, occurring in the western portion of the area)*
  - Cr Raleigh sandstone *(coarse sandstone, sometimes conglomeratic)*
  - Cwl Welch formation *(sandstone, shale, and coal)*
  - Cph Pocahontas formation *(sandstone, shale, and coal; Pocahontas coal at the top of the formation)*
  - Cx Formations included in No. XII *(crushed and indistinguishable along the fault)*
- XI
  - Cbl Bluestone formation *(red and green shale and sandstone, and impure limestone)*
  - Cpr Princeton conglomerate *(fine conglomerate)*
  - Chn Hinton formation *(red and green shale and sandstone, and impure limestone)*
  - Cy Formations included in No. XI above the Bluefield shale *(crushed and indistinguishable along the fault)*
  - Cbf Bluefield shale *(sandy shale at top grading into calcareous shale and impure limestone at the base)*
  - Cgr Greenbrier limestone *(blue limestone)*
- X
  - Cpc Price sandstone *(sandstone and shale)*

CARBONIFEROUS

- IX
  - Dk Kimberling shale *(green sandy shale)*
- VIII
  - Dr Romney shale *(black carbonaceous shale)*

DEVONIAN

- VII VI
  - SDg Giles formation *(calcareous sandstone and cherty limestone)*

TRANSITIONAL

Legend is continued on the left margin.

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

ECONOMIC GEOLOGY

VIRGINIA–WEST VIRGINIA
TAZEWELL SHEET

LEGEND

SEDIMENTARY ROCKS

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

CARBONIFEROUS

XIII
- Ct — Tellowa formation *(sandstone, shale, and coal)*
- Csq — Sequoyah formation *(sandstone, shale, and coal)*

XII
- Cdt — Dotson sandstone *(coarse sandstone with shale at the base)*
- Cbr — Bearwallow conglomerate *(coarse conglomerate or sandstone)*
- Cd — Dismal formation *(sandstone, shale, and coal)*
- Cdc — Dismal conglomerate-lentil *(coarse conglomerate, occurring in the western portion of the area)*
- Cr — Raleigh sandstone *(coarse sandstone, sometimes conglomeratic)*
- Cwl — Welch formation *(sandstone, shale, and coal)*
- Cph — Pocahontas formation *(sandstone, shale, and coal; Pocahontas coal at the top of the formation)*
- Cx — Formations included in No. XII *(crushed and indistinguishable along the fault)*

XI
- Cbl — Bluestone formation *(red and green shale and sandstone, and impure limestone)*
- Cpr — Princeton conglomerate *(fine conglomerate)*
- Chn — Hinton formation *(red and green shale and sandstone, and impure limestone)*
- Cy — Formations included in No. XI above the Bluefield shale *(crushed and indistinguishable along the fault)*
- Cbf — Bluefield shale *(sandy shale at top graduating into calcareous shale and impure limestone at the base)*
- Cgr — Greenbrier limestone *(blue limestone)*

X
- Cpc — Price sandstone *(sandstone and shale)*

DEVONIAN

IX
- Dk — Kimberling shale *(green sandy shale)*

VIII
- Dr — Romney shale *(black carbonaceous shale)*

TRANSITIONAL

VII VI
- SDg — Giles formation *(calcareous sandstone and cherty limestone)*

Legend is continued on the left margin.

LEGEND
(continued)

SILURIAN

V
- Sr — Rockwood formation *(sandy shale and ferruginous sandstone)*

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

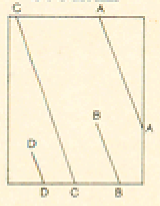
III
- Ssv — Sevier shale *(sandy shale and calcareous shale)*
- Smc — Moccasin limestone *(red earthy limestone)*
- Sc — Chickamanga limestone *(blue flaggy limestone)*

CAMBRIAN

Subdivisions of the Shenandoah limestone
- CSk — Knox dolomite *(gray magnesian limestone; contains barite locally in its upper portion)*
- Cn — Nolichucky shale *(blue calcareous shale)*
- Chk — Honaker limestone *(dark siliceous limestone)*
- Crl — Russell formation *(variegated shale and impure limestone)*

Faults

Sections



⚒ Mines
× Coal prospects

Known productive formations
- Ct — *Tellowa formation (contains workable coal seams)*
- Csq — *Sequoyah formation (contains workable coal seams)*
- Cdt — *Dotson formation (contains a few thin coal seams)*
- Cd — *Dismal formation (contains several workable coal seams)*
- Cw — *Welch formation (contains many important coal seams)*
- Cph — *Pocahontas formation (Pocahontas coal at the top; small seams in the lower portion)*
- ▨ *Barite*

Light-gray contour lines and figures show the lay of the top of the Raleigh sandstone, and indicate its elevation above sea where it now exists and in its former extension where it has been eroded. The contour interval is 100 feet.

All elevations were determined by aneroid barometer from points on the railroad surveys along Clinch River, Tug Fork, and a connecting line along Dry Fork.

Henry Gannett, Chief Topographer.
Gilbert Thompson, Chief Geographer in charge.
Triangulation by J.H. Gore.
Topography by Hersey Munroe.
Surveyed in 1893.

Scale $\frac{1}{125000}$
1 ½ 0 1 2 3 4 5 Miles
1 ½ 0 1 2 3 4 5 Kilometers

Contour Interval 100 feet.
Datum is mean Sea level.

Edition of Nov. 1897.

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Surveyed in 1894.

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

STRUCTURE SECTIONS

VIRGINIA–WEST VIRGINIA
TAZEWELL SHEET

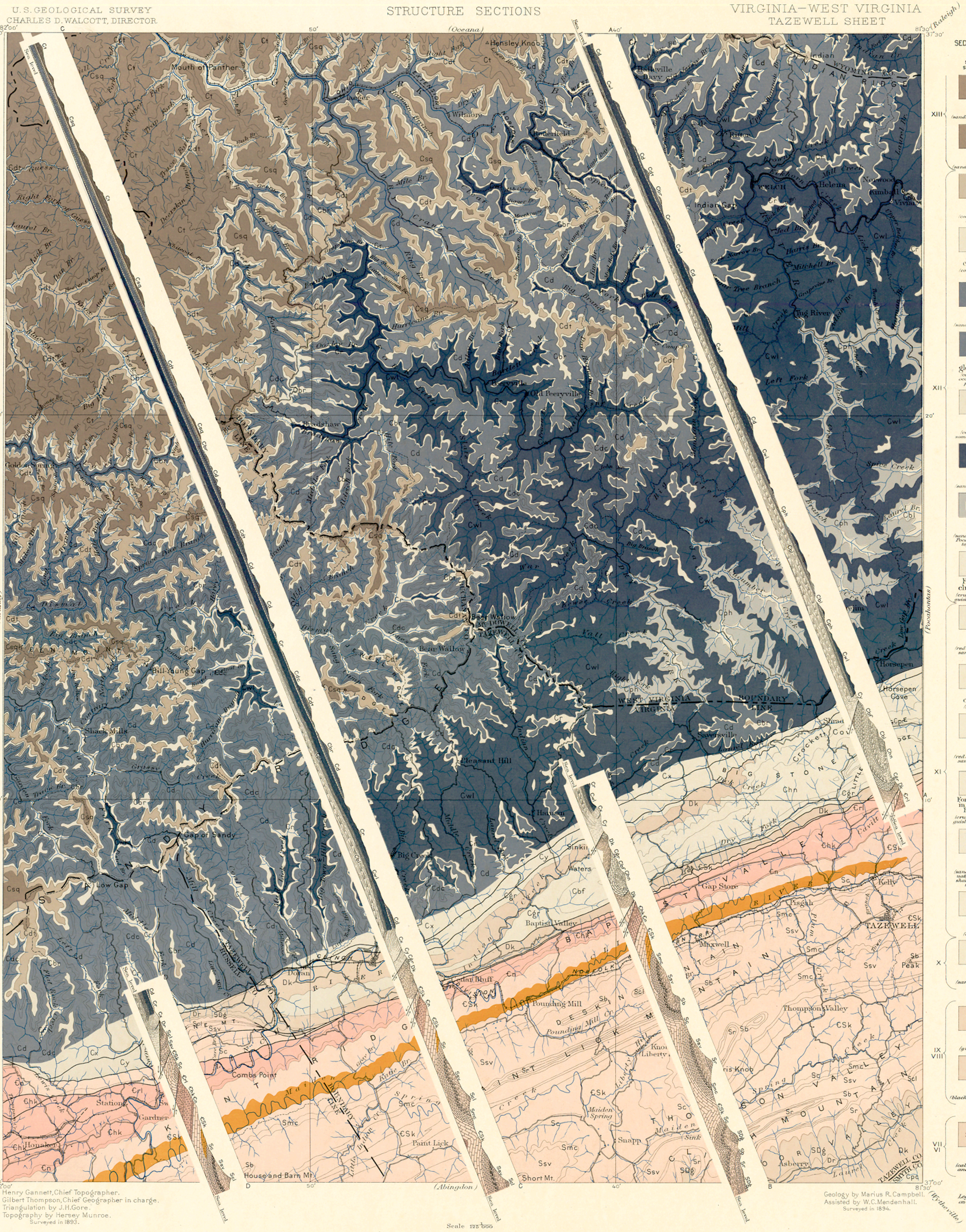
LEGEND
(continued)

	SHEET SYMBOL	SECTION SYMBOL		
V	Sr	Sr	Rockwood formation *(sandy shale and ferruginous sandstone)*	SILURIAN
IV	Scl	Scl	Clinch sandstone *(coarse white sandstone)*	
	Sb	Sb	Bays sandstone *(red sandstone and sandy shale)*	
III	Ssv	Ssv	Sevier shale *(sandy shale and calcareous shale)*	
	Smc	Smc	Moccasin limestone *(red earthy limestone)*	
	Sc	Sc	Chickamauga limestone *(blue flaggy limestone)*	
Subdivisions of the Shenandoah limestone	€Sk	€Sk	Knox dolomite *(gray magnesian limestone; contains barite locally in its upper portion)*	CAMBRIAN
	€n	€n	Nolichucky shale *(blue calcareous shale)*	
	€hk	€hk	Honaker limestone *(dark siliceous limestone)*	
	€rl	€rl	Russell formation *(variegated shale and impure limestone)*	

Faults

Known productive formations

Ct	*Tellowa formation (contains workable coal seams)*
Csq	*Sequoyah formation (contains workable coal seams)*
Cdt	*Dotson formation (contains a few thin coal seams)*
Cd	*Dismal formation (contains several workable coal seams)*
Cwl	*Welch formation (contains many important coal seams)*
Cph	*Pocahontas formation (Pocahontas coal at the top; small seams in the lower portion)*
🟧	*Barite*



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Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Edition of Nov. 1897.

LEGEND

SEDIMENTARY ROCKS

	SHEET SYMBOL	SECTION SYMBOL		
XIII	Ct	Ct	Tellowa formation *(sandstone, shale, and coal)*	CARBONIFEROUS
	Csq	Csq	Sequoyah formation *(sandstone, shale, and coal)*	
XII	Cdt	Cdt	Dotson sandstone *(coarse sandstone with shale at the base)*	
	Cbr	Cbr	Bearwallow conglomerate *(coarse conglomerate or sandstone)*	
	Cd	Cd	Dismal formation *(sandstone, shale, and coal)*	
	Cdc	Cdc	Dismal conglomerate-lentil *(coarse conglomerate, occurring in the western portion of the area)*	
	Cr	Cr	Raleigh sandstone *(coarse sandstone, sometimes conglomeratic)*	
	Cwl	Cwl	Welch formation *(sandstone, shale, and coal)*	
	Cph	Cph	Pocahontas formation *(sandstone, shale, and coal; Pocahontas coal at the top of the formation)*	
	Cx	Cx	Formations included in No. XII *(crushed and indistinguishable along the fault)*	
XI	Cbl	Cbl	Bluestone formation *(red and green shale and sandstone, and impure limestone)*	
	Cpr	Cpr	Princeton conglomerate *(fine conglomerate)*	
	Chn	Chn	Hinton formation *(red and green shale and sandstone and impure limestone)*	
	Cy	Cy	Formations included in No. XI above the Bluefield shale *(crushed and indistinguishable along the fault)*	
	Cbf	Cbf	Bluefield shale *(sandy shale at top graduating into calcareous shale and impure limestone at the base)*	
	Cgr	Cgr	Greenbrier limestone *(blue limestone)*	
X	Cpc		Price sandstone *(sandstone and shale)*	
IX VIII	Dk	Dk	Kimberling shale *(green sandy shale)*	DEVONIAN
	Dr	Dr	Romney shale *(black carbonaceous shale)*	
VII VI	SDg	SDg	Giles formation *(calcareous sandstone and cherty limestone)*	TRANSITIONAL

Legend is continued on the left margin.

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

COLUMNAR SECTION

VIRGINIA–WEST VIRGINIA
TAZEWELL SHEET

GENERALIZED SECTION FOR THE TAZEWELL SHEET.

SCALE: 1000 FEET = 1 INCH.

Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
CARBONIFEROUS	Tellowa formation.	Ct		500	Interbedded sandstone and shale with one large and several small coal seams.	Steep slopes and narrow valleys. Poor soil.
	Sequoyah formation.	Csq		450	Heavy sandstone. Sandstone and shale with a few seams of coal of moderate thickness.	
	Dotson sandstone.	Cdt		180	Coarse sandstone with sandy shale at the base.	Cliffs on exposed points.
	Bearwallow conglomerate.	Cbr		60	Coarse conglomerate or heavy sandstone.	
	Dismal formation. (Dismal conglomerate-lentil.)	Cd (Cdc)		490 (0–120)	Sandstone and shale with several important coal seams. Coarse conglomerate near the center of the formation in the western portion of the area.	Steep slopes and narrow valleys. Cliffs where conglomerate occurs.
	Raleigh sandstone.	Cr		100	Massive sandstone, sometimes conglomeratic.	Prominent cliffs in the center of the area.
	Welch formation.	Cwl		700	Sandstone and shale with many seams of workable coal.	Steep slopes. Poor soil.
	Pocahontas formation.	Cph		360	Pocahontas seam of coal at the top. Sandstone and shale with thin seams of coal.	
	Bluestone formation.	Cbl		700–800	Red and green shale and sandstone with impure limestone; very irregular in their stratigraphic distribution.	Irregular slopes, depending upon the character of the rocks. Soil good where calcareous beds prevail.
	Princeton conglomerate.	Cpr		20–40	Coarse sandstone.	Ledges along ridge summits.
	Hinton formation.	Chn		1150–1250	Variegated shale, red and green sandstone, and impure limestone; prevailing color red. Heavy sandstone.	Irregular slopes, depending upon the character of the rocks. Soil good where calcareous beds prevail. Sharp ridges.
	Bluefield shale.	Cbf		1150–1250	Sandy shale and thin sandstone. Argillaceous shale, grading downward into calcareous shale and impure limestone.	Steep slopes. Undulating valley lands. Good soil, formed by the decay of the limestone and calcareous shale.
	Greenbrier limestone.	Cgr		900–1000	Blue limestone, thin-bedded toward the top, becoming heavier and cherty toward the base.	Coves and gentle slopes. Soil good in places; the most noted localities are Horsepen and Crockett coves.
	Price sandstone.	Cpc		0–200	Sandstone and shale.	Steep slopes.
DEVONIAN	Kimberling shale.	Dk		2000?–3000	Green sandy shale and thin sandstone, containing locally beds of conglomerate. Sandy shale and thin sandstone. Green shale, grading into the formation below.	Steep ridges. Soil very poor. Gentle slopes.
	Romney shale.	Dr		300–500	Black carbonaceous shale.	Valleys. Soil poor.
SILURIAN	Giles formation.	SDg		100–200	Calcareous sandstone at the top, cherty limestone below, and shaly limestone at the base.	Gentle, southern slopes of Clinch Mountain.
	Rockwood formation.	Sr		300–400	Heavy sandstone at the top. Sandy shale and ferruginous sandstone.	Steep, southern slopes of Clinch Mountain.
	Clinch sandstone.	Scl		200–250	Coarse white sandstone.	Mountainous ridges.
	Bays sandstone.	Sb		300–420	Red sandstone. Red sandy shale.	Very steep slopes.
	Sevier shale.	Ssv		1200–1400	Yellow sandy shale. Calcareous shale with beds of impure limestone.	Steep slopes. Generally good soil, but slopes too steep to be farmed well. Gentle slopes.
	Moccasin limestone.	Smc		0–400	Red earthy limestone.	Gentle slopes. Good soil.
	Chickamauga limestone.	Sc		900–1000	Blue flaggy limestone. Heavy blue limestone containing black chert near the base.	Valleys. Best farming lands in the area.
—?— CAMBRIAN	Knox dolomite.	€Sk		2400	Red earthy limestone sometimes conglomeratic. Gray magnesian limestone with cherty horizons; the upper portion carries barite along Kent Ridge.	Chert ridges. Good soil where not cherty.
	Nolichucky shale.	€n		0–175	Blue calcareous shale.	Northern slopes of chert ridges.
	Honaker limestone.	€hk		900–1000	Dark siliceous limestone.	Rolling valley lands. Good soil.
	Russell formation.	€rl		600+	Variegated shale with beds of sandstone and impure limestone.	Sharp hills.

MARIUS R. CAMPBELL
Geologist.

forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

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

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

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

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

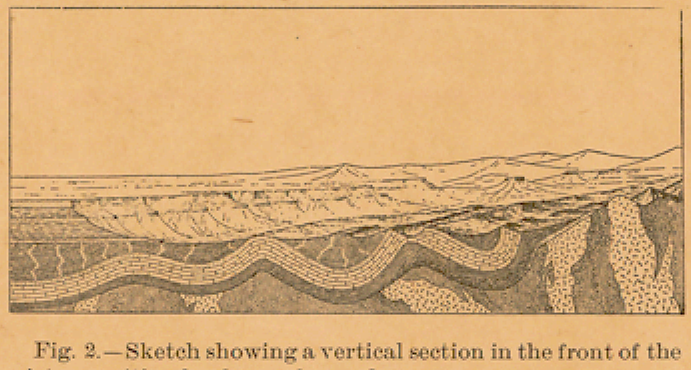

Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

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

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

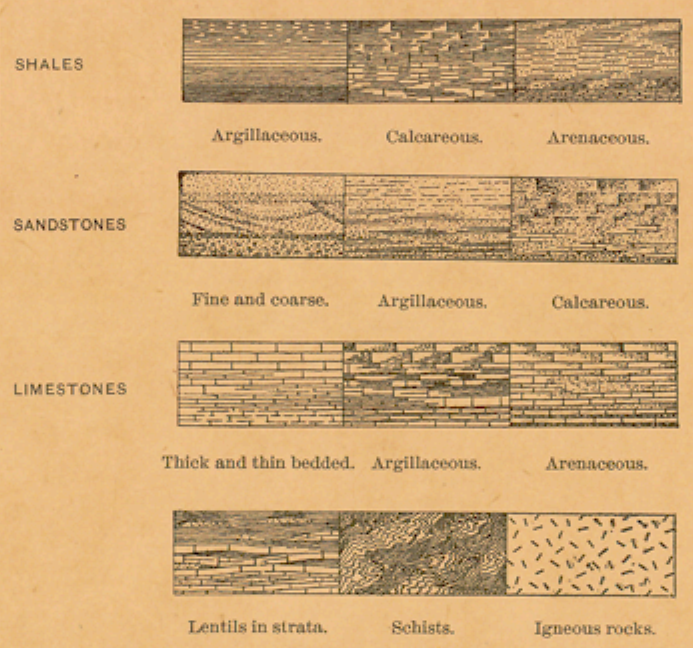

Fig. 3.—Symbols used to represent different kinds of rock.

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

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

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred.

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

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

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

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

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

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

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

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

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

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

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

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

CHARLES D. WALCOTT,
Director.

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