DE... INTERIOR

UNITED STATE... GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

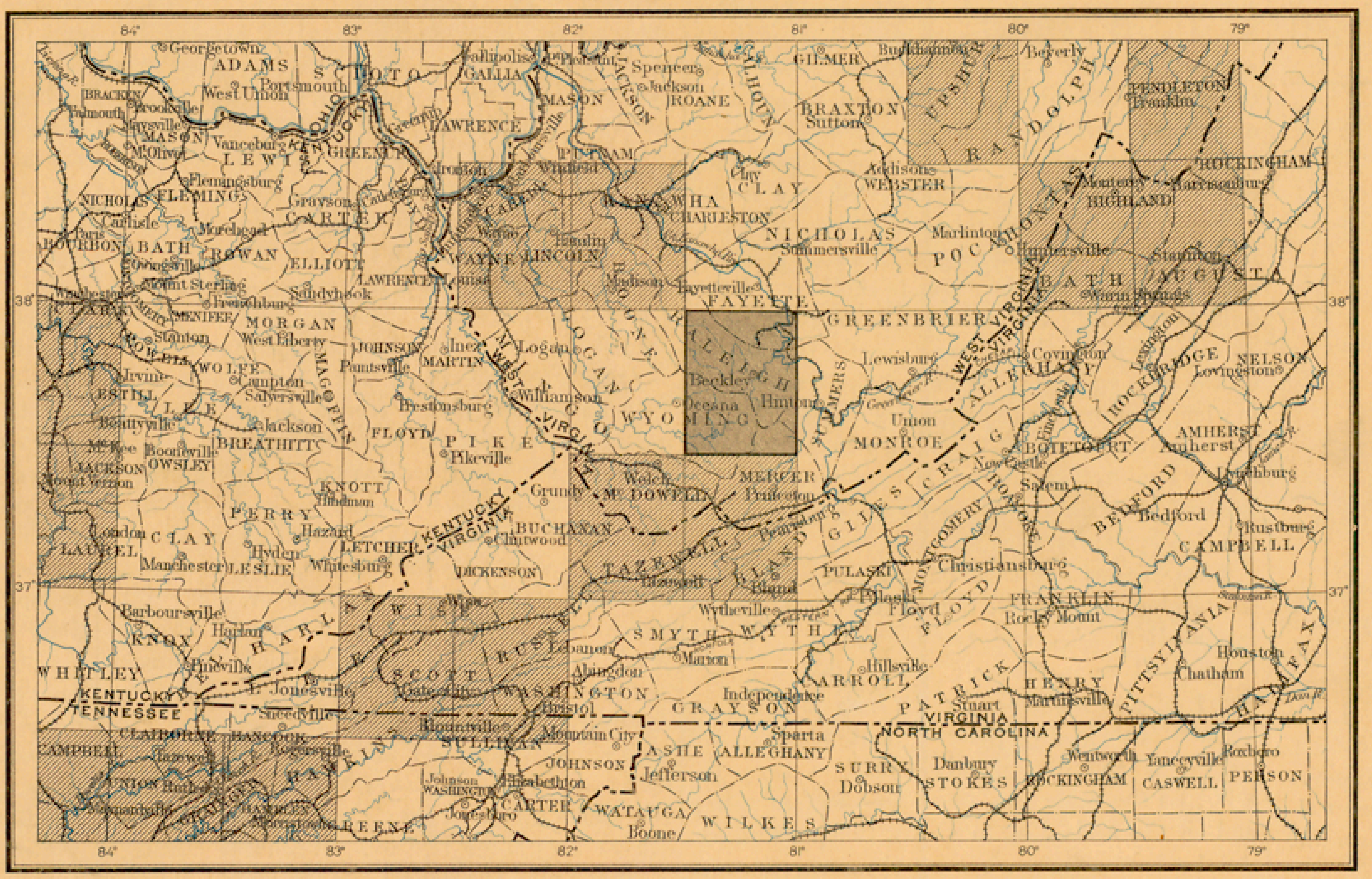
OF THE

UNITED STATES

RALEIGH FOLIO

WEST VIRGINIA

INDEX MAP



SCALE: 40 MILES=1 INCH

AREA OF THE RALEIGH FOLIO

AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION — TOPOGRAPHY — HISTORICAL GEOLOGY — ECONOMIC GEOLOGY — STRUCTURE SECTIONS

COLUMNAR SECTIONS — COAL SECTIONS

FOLIO 77 — LIBRARY EDITION — RALEIGH

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GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER
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EXPLANATION.

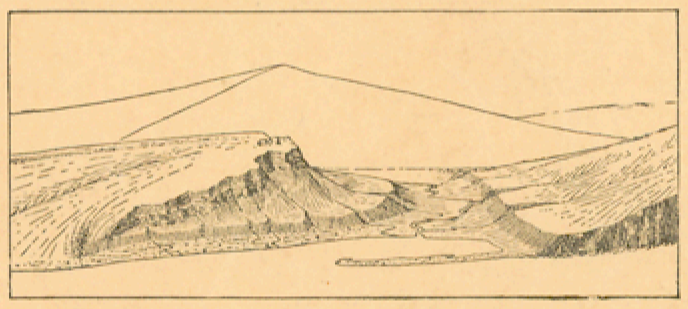
The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small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

THE TOPOGRAPHIC MAP.

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

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

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



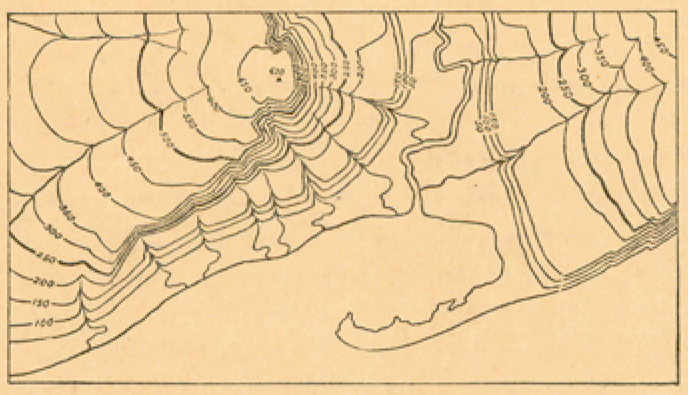


Fig. 1.—Ideal sketch and corresponding contour map.

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

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

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

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

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

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

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

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

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

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

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

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

THE GEOLOGIC MAP.

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

KINDS OF ROCKS.

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

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

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

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

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

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

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

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

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

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

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

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

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus

DESCRIPTION OF THE RALEIGH QUADRANGLE.

By Marius R. Campbell.

GEOGRAPHY.

General relations.—The Raleigh quadrangle embraces an area of 944 square miles, extending from latitude 37° 30′ on the south to 38° on the north, and from longitude 81° on the east to 81° 30′ on the west. The quadrangle is located in the State of West Virginia, and the larger part of its surface is included in the County of Raleigh, from which the quadrangle derives its name. Within its boundaries are also included considerable territory belonging to Fayette and Wyoming counties and small areas of Mercer, Summers, Boone, and Kanawha counties.

Location of quadrangle.

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

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

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

Limits of the Appalachian province.

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

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

Allegheny Plateaus.

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

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

Cincinnati anticline.

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

Divisions of the Allegheny Plateaus.

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

Ridges produced by anticlines.

Anticlinal valleys.

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

Altitude of the mountainous belt.

Escarpment at western margin of coal field.

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

Plain at altitude of 1000 feet.

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

Central Basin a limited plain of about 700 feet elevation.

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

TOPOGRAPHY OF THE RALEIGH QUADRANGLE.

As shown in fig. 1, this quadrangle lies on the southeastern margin of the Appalachian coal basin, and its topography is of the type which characterizes that field, where the strata are composed of alternate beds of hard and soft material lying in a nearly horizontal position.

Drainage.—The larger part of the quadrangle lies in the drainage basin of Kanawha River. This stream, having its source upon the summit of the Blue Ridge in North Carolina, flows northwestward across the Appalachian Valley and the coal field and joins Ohio River at Point Pleasant, West Virginia. Although a single, continuous trunk stream, two names have been applied to it, resulting in some confusion to persons unacquainted with the region. From its source to its junction with Gauley River, a small branch coming in from the northeast and joining it in the quadrangle to the north, the stream is known as New River; below this point it is called Kanawha River, a name appropriate for the whole stream from source to mouth.

New or Kanawha River.

By an extensive system of locks and dams, Kanawha River has been made navigable as far up as the mouth of Armstrong Creek, which enters a few miles below the point where New River becomes the Kanawha. Above Armstrong Creek the grade is greater, and the river is narrow and is beset by falls and almost continuous rapids throughout the coal field.

The New River portion of this trunk stream crosses the northeastern corner of the Raleigh quadrangle in a deep and narrow gorge, through which the water rushes in its hurried descent to the more quiet stretches of Kanawha River. Its principal tributary streams in this quadrangle are as follows: Clear Fork and Marsh Fork of Coal River, draining the extreme northwestern corner and emptying into Kanawha River; Bluestone River, in the southeastern part of the territory; and Paint, Piney, Glade, and Dunloup creeks, in the central part of the quadrangle.

Fig. 1.—Outline map showing the relation of the Raleigh quadrangle to the Appalachian coal field. Coal field is represented by the shaded area.

Most of the small streams in this territory have their sources upon a plateau located near the center of the quadrangle, and flow off in various directions. Upon the plateau the streams are somewhat sluggish and generally occupy broad, open valleys, but farther downstream they cut into this surface, and their lower courses are marked by deep gorges, the streams themselves being swift-flowing mountain torrents. The major streams possess the same characteristics, and hence are useless for purposes of navigation, but they present great possibilities in the way of undeveloped water power. New River in particular is extremely rapid for a stream of its size, and it exhibits unmistakable evidence of the youthfulness of its present valley.

Streams largely in deep gorges.

Relief.—The surface features of any quadrangle are difficult of interpretation if the student is confined to the facts shown in that quadrangle, for many of the conditions which have modified the action of erosion so as to produce the present topography are general in their character and can be understood only through a knowledge of the surface features and the configuration of the drainage lines over a wide extent of territory.

In attempting to read the physiographic history of this quadrangle, it will be necessary first to consider the history of a portion of the same general region in which the topographic forms are well marked and clearly distinguishable one from another. The nearest region to which we can go for reference is central Kentucky, where there is a clean-cut, sharp distinction between the features of the coal field and those of the "Blue-grass" region. These are shown in the Richmond and London folios (Folios Nos. 46 and 47), to which the reader is referred for a more detailed description.

Topographic forms typically developed in Kentucky.

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

Complete and partial cycles of erosion.

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

Ages of the peneplain surfaces.

The Raleigh quadrangle doubtless passed through approximately the same cycle of events as did the region of central Kentucky, but the conditions in West Virginia were not so favorable for the formation and preservation of sharp distinctions between topographic features, hence at first sight it seems impossible to interpret these features in the terms of erosion cycles by which we are accustomed to express the physiographic history of land areas. It is apparent that the criteria for such an interpretation are very different in the Raleigh region from those which are used in central Kentucky.

Dip of rocks to northwest steeper than slope of surface.

The surface of this quadrangle is somewhat diversified, but in a general way it slopes gently toward the northwest; the rocks dip in the same direction, but their average rate of descent is considerably greater than the slope of the surface, hence the older rocks, which are exposed in the southeastern part of the quadrangle, dip below the surface in passing to the northwest and are replaced by younger formations in successive order.

The mountains, plateaus, and valleys of this quadrangle are in a measure due to differences in the character of the various strata appearing at the surface, but taken in a broad way the rocks are fairly homogeneous and not very unequally resistant to the action of erosion.

In rocks having the above-described characteristics and relation to the surface, escarpments are not produced, and features formed at different times and under different conditions of erosion are only moderately differentiated. If, then, the cycles and subcycles of erosion have been the same in West Virginia as in Kentucky, the effects of development should be dissimilar rather than alike in their topographic expression.

The first cycle of erosion recorded in the topography.

The cycle of erosion in which was produced the higher plateau of Kentucky was doubtless of great duration and affected the entire Appalachian province. The coal field appears to have been reduced generally to a gently undulating surface which is now shown in the even hilltops of Kentucky and West Virginia, but in the interior of the latter State, away from the main drainage lines, there are many areas which were not reduced to the common level. Some of these occur in the Raleigh quadrangle, and consequently its surface is more diversified and broken than that of other quadrangles lying farther west.

Since the formation of that surface the region has been greatly elevated with reference to the sea, and erosion has removed most of the direct evidence concerning its former existence, but there is a correspondence in altitude of the higher points of the topography along northeast-southwest lines which makes it seem highly probable that they once formed parts of the even surface of a peneplain that was presumably well developed in the Kanawha Valley.

Altitude of the old peneplain.

In attempting to determine the position of that peneplain the character of the rocks composing it must be taken into consideration. In the soft red shales overlying the Charleston sandstone the peneplain would doubtless be well developed, but, owing to the rapidity with which erosion has operated since its elevation above sea level, only the highest hills possibly represent its surface. According to this criterion the present altitude of that surface at Ohio River is about 1000 feet.

In passing toward the southeast, the Charleston sandstone, which underlies the soft shales just described, rises gradually to the surface of the ancient peneplain. In the vicinity of Charleston, where its upper surface corresponds with that plain, the latter is not only well developed, but it is also well preserved, and it can be distinguished readily in the nearly even summits at an altitude of about 1400 feet. As this stratum continues to rise toward the southeast, it lies more and more above the base-level of that time, and it is probable that its surface was not reduced to the common level. If it had been so reduced, the regular slope would have carried the peneplain to an altitude of about 2300 feet near the northwestern corner of the Raleigh quadrangle.

Near Matville the Charleston sandstone was above the Cretaceous base-level and consequently this formation was completely removed, leaving the softer rocks of the Kanawha formation exposed to the erosive action of the elements. Here the peneplain was doubtless well developed, but the conditions that were favorable to the formation of this surface also accelerated its removal in subsequent periods of rapid erosion. On account of this fact it is difficult to determine its position, but presumably it would be not far from 3200 feet above the level of the sea.

Old peneplain preserved on Flat Top Mountain.

South of Matville the conditions were similar to those along Ohio River, and the summits of the highest hills are probably not far from the position of the peneplain. Accordingly it would now be about 3500 feet above sea level at Flat Top Mountain, which is located on the southeastern margin of the coal field.

The cycle of erosion in which this peneplain was produced was terminated by a movement of elevation which was greatest along the axis of the Appalachian province, and which, from this axial line, diminished at about the same rate toward the northwest and southeast. In Kentucky the uplift was about 500 feet at the present margin of the coal field; in West Virginia it varied from less than 100 feet near Ohio River to nearly 1000 feet in the Raleigh quadrangle.

Under the conditions favoring erosion in Kentucky the great Lexington Plain and the scarp separating it from the higher plateau developed during the next cycle. In West Virginia the same uplift appears to have prevailed, but the time during which erosion was active and undisturbed sufficed only for broadening the valleys of the larger streams, and no feature resembling the Lexington Plain could possibly have been produced in the resistant strata of the Raleigh region. Where the hills were protected by the Charleston sandstone the second period of erosion probably had little effect in reducing the surface, except in that stratum lay above the previously formed peneplain, or well beneath its surface, erosion operated to advantage during this second partial cycle, and broad valleys were formed.

Evidence of a second cycle of erosion.

Near Huntington, on Ohio River, these old valley floors are recognizable at altitudes ranging from 900 to 1000 feet above the level of the sea. In the territory lying between Huntington and the Raleigh quadrangle this feature is poorly developed, because its horizon corresponds with that of the Charleston sandstone, and this formation is too resistant to have been much reduced in the limited interval of time in which the broadened valleys were produced. In the soft shales of the Kanawha formation which outcrop in the Raleigh quadrangle this feature was well developed. In the vicinity of Oak Hill its position corresponds with the top of the Nuttall sandstone and hence it is well preserved; it rises to an altitude of about 2500 feet in the vicinity of Beckley, where again it corresponds with a heavy sandstone (Raleigh) which has preserved its even surface over a wide extent of territory. From Beckley to Flat Top the present surface rises gradually to an altitude of 3200 feet, but this is probably due to an inclined bed of massive sandstone and not to the influence of the base-level of erosion. The area of soft rocks in the southeastern corner of the quadrangle is so limited that the surface features are scarcely intelligible, but an examination of the Pocahontas quadrangle, bordering this on the south, shows a well-developed peneplain at an altitude of about 2700 feet. Therefore the surface which presumably corresponds in age with the Lexington Plain rises from 2000 feet at Oak Hill to 2500 feet at Beckley and 2700 feet in the southeastern corner of the quadrangle. In the vicinity of New River and in the Guyandot basin this feature is generally well developed, but in much of the intervening territory the surface is broken by ridges of various heights, which are the remnants of the higher plateau.

Altitude of the second erosion plain.

The cycle of erosion which resulted in the formation of the broad valleys just described was interrupted by an upward movement of the land. The streams were rejuvenated and they cut deep trenches in the floors of their former valleys. These trenches are the deep V-shaped gorges which are such a familiar feature in the present topography.

Along New and Kanawha rivers no evidence has been observed of any subsequent period of quiescence in the crust of the earth during which the streams had an opportunity to increase materially the width of their channels. The great gorge of New River seems to have been the work of continuous cutting, in which the stream is still actively engaged. The land may be rising even at the present time, but if such is the case the rate of elevation is too slow to be noticed.

Summary of events producing surface features.

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

GEOLOGY.

GENERAL SEDIMENTARY RECORD.

All the consolidated rocks appearing at the surface within the limits of the Raleigh quadrangle are of sedimentary origin — that is, they were deposited by water. They consist of shales, sandstones, and coal beds, having a total average thickness of about 3900 feet. The materials of which they are composed were originally mud, sand, and gravel derived from the waste of the older rocks and from the remains of plants which lived while the strata were being laid down.

Wide distribution of the lower Carboniferous shale.

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

Land area at the close of the lower Carboniferous.

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

Unconformity toward the west of the basin.

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

Close of sedimentation.

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

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

STRATIGRAPHY.

The strata exposed in the Raleigh quadrangle have a thickness of about 3900 feet. The thickness of the formations, their order of succession, and their general characteristics are given on the Columnar Section sheet, but more detailed descriptions of the individual beds and the indications of their probable equivalents in other fields are given in the following paragraphs.

Many formations that are lower in the geologic series than those showing at the surface in this quadrangle are exposed in the upturned strata of the Appalachian Valley southeast of this area. They doubtless underlie this quadrangle, but since no deep drilling has been done here it is impossible definitely to affirm their existence.

CARBONIFEROUS ROCKS.

MISSISSIPPIAN SERIES.

Hinton formation.—Geologically the lowest formation exposed in this quadrangle is that part of the Mississippian series which in the Pocahontas folio was designated the Hinton formation. It was defined as extending downward from the Princeton conglomerate to the base of a heavy sandstone or quartzite that occurs in Stony Ridge in Mercer County. The base of the formation is not shown in this quadrangle. The formation is well exposed in the gorge of New River at Hinton, and it is from this fact that it has been called the Hinton formation. When the formation was first described and named its upper limit was supposed to be well defined and constant, but the survey of the Raleigh quadrangle demonstrated the fact that the Princeton conglomerate is a local development of coarse material. Where the conglomerate is absent the Hinton formation can not be separated definitely from the overlying Bluestone formation. The horizon of the Princeton conglomerate has, however, been traced as accurately as possible and constitutes the boundary between the Hinton and Bluestone formations.

The Hinton formation is composed principally of red and green shales, but includes also many beds of green sandstone and occasionally thin beds of impure limestone or calcareous shale. In the Pocahontas region its thickness varies from 1250 to 1300 feet; at Hinton, on New River, it is approximately 1050 feet, and toward the northwest it presumably continues to decrease in thickness, but there is no evidence to determine this point until we approach the western margin of the coal field, where the entire Mississippian series has shrunk to a thickness of only a few hundred feet. In the Raleigh quadrangle strata belonging to this formation have an exposed thickness of 500 feet, but the base of the formation is not visible and therefore its full thickness is unknown.

Princeton conglomerate.—This formation, named from the county seat of Mercer County, is conspicuous in the river bluffs in the vicinity of Quinnimont and on Bluestone River, but when an attempt is made to follow the outcrop it is found frequently to grow thinner and thinner and finally to disappear from the section. In its best development this formation is a conglomerate which is almost free from bedding planes. Owing to its massive character the conglomerate forms perpendicular cliffs wherever it is exposed on the hillsides, and produces cascades where it crosses the courses of the streams. In the Pocahontas region its thickness averages about 40 feet, but increases toward the northeast until a maximum of 80 feet is attained on New River at the mouth of Meadow Creek. In passing down the river from this point the conglomerate gradually becomes thinner, until it finally disappears east of the margin of the Raleigh quadrangle. Just below the mouth of Glade Creek, however, it reappears, and forms a continuous line of cliffs, with a maximum height of 50 feet, to the lower end of Stretcher Neck, where it again fades out. Below this point it is unknown, but its approximate horizon has been traced down the river until it passes below water level near Stone Cliff. On Bluestone River and along the eastern edge of the quadrangle to Flat Top Mountain it is conspicuous in the topography, but westward it soon disappears and its horizon can be determined only approximately.

Conglomerate in the red and green shale series.

Bluestone formation.—Over most of the Appalachian coal field the differentiation of the Mississippian series of rocks from the coal-bearing series above is an easy matter, for they are separated by a profound time break, which is shown both by the fossils that the two series carry and by the lithologic difference in the rocks composing them. In the Raleigh quadrangle, however, there is no evidence of unconformity, and the red and green shales and sandstones of the Bluestone formation merge almost imperceptibly into the lowest member of the overlying series. The plane of subdivision is usually placed at the highest observed outcrop of red shale, but that is so indefinite that a boundary line can not be drawn, and therefore the patterns are merged on the geologic map.

Absence of unconformity at top of Mississippian series.

The thickness of this formation is variable. Near Bluestone Junction, in the Pocahontas quadrangle, it is 800 feet; in the southern half of the Raleigh quadrangle it varies from 400 to 700 feet; and on the road leading west from the mouth of Piney Creek the formation is only 180 feet thick.

This formation is named from Bluestone River, along which it outcrops in the Pocahontas quadrangle. It is exposed along the southeastern slope of Flat Top Mountain, on Glade Creek, and along New River to a point a little below Stone Cliff, where it passes beneath water level. It rises again in the bend of the river at Fire Creek, but it soon descends, and is not known below East Sewell.

PENNSYLVANIAN SERIES.

The Pottsville is the lowest grand division of the coal-bearing rocks or Pennsylvanian series, and has been variously called The Conglomerate and the Millstone Grit. Along the southeastern margin of the coal field it has a great development in thickness, and it may be divided into several formations. The series is complex, consisting of a number of overlapping lenses of shale, sandstone, and coal. On account of this variability it is difficult to find any stratum which can be easily identified and traced over a territory greater than that of a quadrangle. Most of the formations named and described in this folio are of this local character, and frequently it is necessary to discontinue mapping a formation for the reason that it is no longer recognizable.

Pottsville series or Millstone Grit.

In the Pocahontas folio the strata lying below the base of the Quinnimont formation were divided into two formations, the plane of division occurring at the top of the Pocahontas bed of coal. This horizon was easily determined in the valleys of Elkhorn Creek, Tug Fork, Dry Fork, and Guyandot River, and, owing to the excellence of this coal, its representation on the maps of that region is of the utmost importance. In passing to the northeast from the Guyandot basin, the celebrated Pocahontas bed of coal becomes too thin to mine, and it is difficult, if not impossible, to follow its horizon. Even if it could be followed, a line drawn at this horizon would be of no value, consequently the division has been discontinued in the territory east of the Guyandot basin, and only such subdivisions have been made as are recognizable on the ground.

Pocahontas formation.—This is the lowest division of the Pottsville series. It extends from the uppermost bed of red shale in the Bluestone formation to the roof of the Pocahontas coal bed, from which it takes its name. Its thickness ranges from 325 to 350 feet, but it is difficult to obtain an accurate measure in the Raleigh quadrangle. The formation has a very limited outcrop in this territory. It shows along Guyandot River from the mouth of Long Branch to the mouth of Devil Fork, and along that stream nearly to its source. It also shows at two points on Tommy Creek and at two points on Stone Coal Creek. On the lower course of Pinnacle Creek there is a very small outcrop, and on Gooney Otter Creek the Pocahontas coal rises above water level within $1\frac{1}{2}$ miles of the southern margin of the quadrangle. On the east side of Flat Top Mountain the Pocahontas coal can be traced for a short distance north of the boundary of the quadrangle, but the coal is soon lost, and the Pocahontas formation is no longer identifiable. The rocks composing it can not be distinguished from those of the overlying formation except by the presence of the well-known bed of coal.

Horizon of the Pocahontas coal bed.

Plant remains are relatively abundant in the formation, especially in the roof shales of the Pocahontas coal. This has a well-marked and distinct flora, which may be used to great advantage in determining the identity of isolated exposures of this bed.

Clark formation.—Over the southern half of the Raleigh quadrangle the Quinnimont coal horizon has been well identified by its fossil flora and by a coarse, heavy-bedded sandstone, which closely underlies the coal bed. The floor of this coal has been taken as the top of the Clark formation in the basin of Guyandot River.

Heavy sandstone beneath the Quinnimont coal bed.

This formation varies in thickness from 350 to 375 feet. It is composed of shale, sandstone, and coal beds, and it can not be differentiated from the other formations except by the determination of its upper and lower limits. It is named from Clark Gap in Flat Top Mountain, in the Pocahontas quadrangle, and it outcrops in the valleys of all of the head branches of Guyandot River. Owing to the strong westward dip of the strata, it passes beneath water level within the limits of this quadrangle.

Thurmond formation.—Since the Pocahontas coal is not of sufficient thickness to be recognized in the region east of the Guyandot basin, the division line between the Pocahontas and Clark formation can not be drawn in that region. This necessitates the introduction of a new formation name for the strata lying between the red shales of the Mississippian series and the Quinnimont coal bed. This series of beds is equivalent to the combined Pocahontas and Clark formations, and it is named from the town of Thurmond, on New River, where it is well exposed, and where its upper limit is clearly indicated by the numerous mines on the Quinnimont coal.

In thickness this formation varies from about 725 feet on the southern margin of the quadrangle to 550 feet at Quinnimont and 450 feet at Fire Creek. North of the latter point the base of the formation soon passes below water level, and owing to the disappearance of the Quinnimont coal the top is not definite and it is difficult to identify the formation.

The Thurmond formation is prevailingly sandy, and the beds vary so much in thickness and composition that it is impossible to identify and correlate the various members from place to place. In Flat Top Mountain the sandstone which underlies the Quinnimont coal is so thick and massive that it has controlled the erosion of this region, forming a plateau which has given the name to the mountain. On approaching New River this sandstone sinks below the surface, and another sandstone, which lies considerably higher in the geologic series, becomes the prominent bed. This is called the Raleigh sandstone, and it is one of the most persistent as well as one of the most prominent members of the Pottsville series.

Sandstone forming Flat Top Mountain.

Quinnimont formation.—The strata which lie between the base of the Quinnimont coal bed and the Raleigh sandstone have been grouped into one formation, which has been named from the town of Quinnimont on New River, at which the coal at the base of the formation was first mined. The formation is composed of shale and sandstone, which vary so much from place to place that it is impossible to give a good generalized section. Along New River the base of the formation is well defined by numerous mines on the Quinnimont coal, and its top is almost equally well marked by the line of cliffs which characterize the outcrop of the Raleigh sandstone. The formation varies in thickness from about 180 feet in the vicinity of Thurmond to 225 feet on the southern margin of the quadrangle.

Raleigh sandstone.—This formation has its maximum development in the region between Beckley and Thurmond. It is particularly thick and massive along New River from Glade Creek to McKendree and on Piney Creek from Beckley to its mouth. At the latter locality it attains a thickness of about 150 feet, and in other parts of the quadrangle it varies from 75 to 100 feet in thickness. In a southeasterly direction from the area of maximum development the Raleigh sandstone diminishes somewhat in thickness and loses its hardness and massiveness, but it can be traced with a fair degree of certainty beyond the borders of this quadrangle.

This bed has been described as the highest member of the Pottsville series and as the equivalent of the heavy conglomerate which caps the walls of the gorge at Nuttallburg. This correlation is incorrect, since the Raleigh can be traced down the river, step by step, from Quinnimont to Nuttallburg, where it occurs 375 feet below the massive bed forming the summit of the canyon wall.

Thick sandstone capping bluff at Quinnimont.

Sewell formation.—Upon the completion of the Chesapeake and Ohio Railway in 1873 the development of the coal beds along New River began by the opening of the mine at Quinnimont. The second mine to be developed in this quadrangle was at Sewell, on the coal bed overlying the Raleigh sandstone. This mine has long been worked out and abandoned, but it gave the name Sewell to one of the most important coal beds of the district, and in this folio the name is applied to the formation including the Sewell coal bed, which extends from the Raleigh sandstone to the top of the Pottsville series.

The strata composing this formation are variable, both in stratigraphic occurrence and in geographic distribution. The most important members are local beds of massive sandstone or conglomerate. It is not desirable to map these beds as independent formations, but they will be considered as lentils in the Sewell formation.

In this quadrangle the Sewell formation does not show its full thickness nor all of its members in the canyon of New River, but at Nuttallburg, a few miles down the river, it is present in full force in the immediate walls of the gorge, and from its excellent exposure this will ever be regarded as the type section of this formation.

Along the river from Caperton to Deepwater the uppermost formation is a massive conglomerate which ranges from 150 to 200 feet in thickness. Generally the lower half of this stratum is harder and more massive than the upper half, and it is this part which forms the picturesque cliffs from Nuttallburg to Gauley Bridge. The lentil receives its name from the mining town of Nuttallburg, above which the cliffs of this formation are particularly prominent.

Nuttall sandstone lentil forming cliffs at Nuttallburg.

In passing west from New River the Nuttall sandstone is found to hold its full thickness and composition as far as Oak Hill, but beyond this point it breaks up into several beds separated by intervals of sandy shale. The lowest bed is generally conglomeratic, and this part alone is recognizable west of Oak Hill. The lentil is supposed to include only the recognizable bed, the strata above being grouped with the Sewell formation. To the southwest this conglomerate can be traced as far as Bend Branch, where it disappears, but in a westerly direction it extends nearly to the margin of the quadrangle. It is very heavy on Mossy Creek, and it shows in the valley of Paint Creek from near Roseville to beyond the northern margin of the quadrangle, where it dips more rapidly than the stream falls, and passes below water level. It is also present in the valley of Clear Fork from Clear Creek post-office to Lawson, and on Sycamore Creek for a short distance, but in the latter valley it has lost its massive and conglomeratic character and can be identified with difficulty. Its horizon is above water level in the upper course of Clear Fork, but it is not a massive bed and can not be traced and mapped.

The Nuttall sandstone is truly a lens. It diminishes in thickness in all directions in which it can be traced, and eventually loses its character and becomes unrecognizable. It presents an excellent example of the lenticular character of many of the beds of this series.

North of Oak Hill the Nuttall sandstone forms the top of the Sewell formation, but to the south soft sandy beds come in above, which are included in the Sewell formation. This material, which overlies the Nuttall sandstone, resembles so much that which occurs in the lower part of the Kanawha formation above that it is impossible to draw a definite boundary line between them, but the position of the line along which the geologic patterns meet on the map has been fairly well determined by fossil plants that have been collected from a number of localities in this region.

In the section exposed in the canyon wall at Nuttallburg the interval between the base of the Nuttall sandstone lentil and the top of the Raleigh sandstone, a distance of 375 feet, is composed almost entirely of sandy shale and thin-bedded sandstone. In various parts of the quadrangle beds of sandstone appear in this interval, but as a rule they are local in their development and can not be identified over any considerable extent of territory.

A massive conglomerate of this character appears in the region west of Beckley. It is called the Harvey conglomerate lentil, from a small village of the same name on the headwaters of Marsh Fork of Coal River. This lentil probably lies about 100 feet below the horizon of the base of the Nuttall sandstone. It probably never exceeds 50 feet in thickness, and from that maximum it decreases to a feather edge and disappears. In most cases the change is gradual, but on Marsh Fork just below the mouth of Horse Creek it disappears with great suddenness, in a distance of a few hundred yards passing from a massive conglomerate to thin sandstones which can not be separated from the rocks of the overlying formation.

Harvey conglomerate lentil exposed on Marsh Fork.

The best development of this lentil is on Marsh Fork, but it can be traced eastward to Prosperity, where it is thin and hardly noticeable. From this point southwest it is generally weak, and at the head of Slab Fork of Guyandot River it again disappears. It is not known down the valley of Slab Fork, nor on any of the other streams on the southwestern side of Guyandot Mountain.

The lentils in the Sewell formation show an east-and-west arrangement, which is apparent in the extension of the Nuttall sandstone westward into the valleys of Paint Creek and Clear Fork and in the development of the Harvey conglomerate from Prosperity westward. Below the last-named bed in the vicinity of Pemberton another small conglomerate is found, which develops westward into a bed of sufficient importance to deserve representation on the geologic map. This is particularly heavy along Guyandot River from Pineville to Gilbert, in the Oceana quadrangle, and hence it has been named the Guyandot sandstone lentil.

Guyandot sandstone lentil on Guyandot River.

Where it is thin and conglomeratic it is generally massive, but in its greatest development it is a coarse, heavy-bedded sandstone. In the Raleigh quadrangle it varies in thickness from a feather edge to 100 feet, and apparently it is limited to a narrow belt which trends in an east-west direction. It occurs about 150 feet above the top of the Raleigh sandstone and 80 to 100 feet below the Harvey conglomerate.

In the valley of Marsh Fork the upper limit of the Sewell formation is even more indefinite than farther north. On the evidence of fossil plants it has been placed about 350 feet above the Harvey conglomerate lentil, but the uncertainty is recognized on the map by the omission of the boundary line. The interval between this lentil and the base of the Sewell formation is about 300 feet, and the rocks composing it are shales and soft sandstones.

The total thickness of the Sewell formation, including the three lentils, is about 600 feet on New River at the northern edge of the quadrangle and 700 feet on Marsh Fork and in Guyandot Mountain.

Aside from local variations in thickness of the various members of the Pottsville series, there is a general decrease in thickness from southeast to northwest. By reference to the descriptions of the different formations it will be seen that all, with the exception of the Raleigh sandstone, show a greater thickness in the basin of Guyandot River than they show on the northern margin of the quadrangle. By the addition of the various thicknesses given, it appears that the Pottsville series ranges from 1500 to 1800 feet in thickness in the southern part of the quadrangle and from 1350 to 1500 feet in the northern part.

On account of the strata dipping below water level on New River it is impossible to secure measurements of its total thickness north of East Sewell. On Kanawha River, however, as we learn from deep wells, the thickness of the Pottsville diminishes to about 830 feet at Brownstown, 550 feet at Charleston, 480 feet at Lock No. 6, and 290 feet at Winfield.

Kanawha formation.—In the early comparisons of this field with the type region in Pennsylvania, the Nuttall sandstone was correlated with the Homewood sandstone, and the softer series overlying it were correlated with the Allegheny formation of the type locality. The various coal beds of the Kanawha Valley were recognized as the equivalents of the coals in the Pennsylvania section, with the Stockton or Lewiston coal at the horizon of the Upper Freeport coal, and therefore marking the upper limit of the Lower Productive Measures. Recent study of the fossil plants of this region has shown that the Lewiston coal is not equivalent to the Upper Freeport of Pennsylvania, nor do any of the coal beds lower in the series correspond with the Pennsylvania beds with which they have been correlated. This study has shown conclusively that the nomenclature of the northern end of the field can not be applied to the central region, and that the only system of classification which is applicable is one based upon the local lithologic appearance, without regard to the systems in use in different sections of the field.

On Kanawha River the strata above the Pottsville are naturally divided into three great groups. The lowest group comprises a relatively soft series of rocks, the second a sandy series, and the third a series composed principally of red and green shales. The first group is designated the Kanawha formation, from the river along which it is best exposed. It rests upon the Nuttall sandstone lentil north of Oak Hill, and to the southwest it is separated from the Sewell formation by a plane whose position is largely determined by fossil plants. The upper limit of the Kanawha formation is approximately the base of the sandstone series previously mentioned. In the region lying north of New and Kanawha rivers and east of the city of Charleston, the black flint is regarded as the upper limit of the Kanawha formation, for this stratum occurs near the base of the sandstone and is by far the most important member of the series, serving, as it does, for a datum plane from which to determine the position of all coal beds. In the Raleigh quadrangle this stratum is absent, and the separation of the Kanawha formation from the overlying sandstone can be made only approximately. This fact is indicated on the map by the absence of a definite boundary line.

The Kanawha is the most important coal-bearing formation in the quadrangle. True, the coal beds of the Pottsville series are at present better known, but that is largely due to the fact that the development of mines occurs first along lines of easy transportation. In this case the line that is most available is New River, and the territory which is situated at a distance from this stream and which contains the outcrops of the Kanawha formation has received little attention from coal operators.

The most important coal-bearing formation.

The thickness of this formation is difficult to determine, for over much of this territory neither its upper nor its lower limits are well defined. In passing across the coal field toward the northwest it changes at about the same rate as does the Pottsville series. From an estimated thickness of 1000 feet in the northwestern corner of this quadrangle, it decreases to 700 feet at Brownstown, 600 feet at Charleston, 500 feet at Lock No. 6, 425 feet at Winfield, and, according to Prof. I. C. White, 244 feet on its western line of outcrop at Ironton, Ohio.

Charleston sandstone.—This generally sandy series of rocks, lying between the Kanawha formation below and the red and green shales above, was early correlated with the Mahoning sandstone of Pennsylvania. Like the other correlations based on lithologic resemblances, this does not agree with evidence supplied by fossil plants. According to this evidence the Charleston sandstone is much older than the Mahoning sandstone, therefore the latter name is not accepted and the formation is named from the city of Charleston, West Virginia, at which it is well shown in cliffs along the river bluffs.

At Charleston this formation is about 300 feet in thickness; it increases toward the southeast to about 400 feet at Montgomery, and 600 feet in the northwestern corner of this quadrangle. In the last two localities no red shale appears above the sandstone; consequently it is impossible to determine the full thickness of the formation, but presumably only the soft material above has been removed, leaving the sandstone with its full original thickness.

This formation generally carries conglomerate in some of its horizons, but in the Raleigh quadrangle such beds are rare. The rocks are generally coarse sandstones with only a little interbedded shale, but the sandstones are rarely or never massive. This may be due to their great exposure to weathering on the highest points of the ridges, but it is more probably due to thin bedding in the original rock.

The Charleston sandstone caps the ridge between Clear Fork and Paint Creek as far east as Potato Hill, the divide between Clear and Marsh forks, and Guyandot Mountain, near the western edge of the quadrangle.

Sandstone capping the highest ridges.

The red shales which normally belong above this formation may have been deposited over this quadrangle, but if so they have been completely removed, leaving no rocks younger than the Charleston sandstone. The later geologic history of this region is recorded only in the topographic forms which have been carved from its surface, and has already been set forth.

STRUCTURE.

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

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

The coal basin a folded syncline of deposition.

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

These points are illustrated in the sketch section across the basin as it now stands, shown in fig. 2. The lowest member represented — the Pottsville — thins from 1500 feet on the eastern outcrop to about 250 feet on the western. A similar change is observed in the Kanawha, from 1000 feet on the east to 270 feet on the west; and some change in the same direction is noticeable in the overlying Charleston sandstone.

Thinning of formations toward the west.

The position of the Raleigh quadrangle, as shown by the section, is upon the eastern side of the trough, where the formations attain their maximum thickness. The center of the trough, as indicated by the most recent formation, lies far to the west of the geographic center of the coal field. This is due to the shifting of the areas of deposition westward as time advanced and to the greater thickness of the sediments on the eastern margin of the trough.

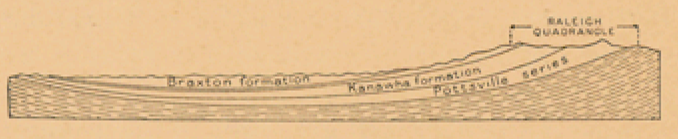


Fig 2.—Sketch section across the Appalachian coal basin in the latitude of Raleigh, West Virginia.

Structure section.—The section on the Structure Section sheet represents the strata as they would appear in the side of a deep trench cut across the quadrangle along the line A–A. The vertical and horizontal scales are the same, hence the actual form and slope of the land are shown in the profile and the actual dips of the strata are shown in the section. There are few, if any, irregularities in the northwestward dip of the rocks in this quadrangle. The average rate at the surface is about 60 feet per mile, but since the formation becomes thinner toward the northwest the dips beneath the surface are much less than those which can be observed.

MINERAL RESOURCES.

COAL.

So far as known, coal is the only mineral resource of this quadrangle. It is found in all of the formations lying above the red and green shales of the Bluestone formation, but some contain a greater number of beds and a larger amount of workable coal than others.

In the following description of the various coal outcrops and workings which were seen or which have been reported on good authority, the quadrangle is divided into nine parts by the 10-minute projection lines, and the divisions are designated by the letters A to I, as indicated in the diagram on Coal Section sheet 1.

Division A.—The formations outcropping in this region are the Charleston sandstone, the Kanawha formation, and that part of the Sewell formation which lies above the Harvey conglomerate lentil. In taking up the different divisions in the order indicated, the highest rocks will of necessity be considered first; therefore, in order to make the treatment uniform, the same order will be followed within each division and the coals will be described in descending order.

The Charleston sandstone in Division A is expanded to nearly double its thickness in the type locality, and with this increase in thickness of the rocky strata there occurs also an increase in thickness and importance of the coal beds which it carries. The formation, however, is restricted in its outcrop to the highest ridges, and consequently the tonnage of coal remaining is relatively small compared with its original extent. Costly plants would be required to develop this coal and bring it within reach of transportation facilities, and this also detracts from its prospective value.

In the absence of the black flint the exact position of the base of the formation can not be determined, and consequently the stratigraphic position of the various coal beds can not be fixed with accuracy.

The black flint marker absent.

The highest coal which has been reported from this area was opened by W. C. Reynolds on the top of the ridge between Clear and Little Marsh forks. The coal is reported to be of good quality and of great thickness, as shown in section 1, and it is unfortunate that so little remains of this important bed. According to Mr. Reynolds this opening is 1800 feet above Clear Fork, but the contoured map shows an altitude of only about 1600 feet, hence there is some uncertainty concerning the position of this bed in the series. In this region the beds have a strong northward dip, which tends to reduce the measure first given and to harmonize the results. The coal bed which Mr. Reynolds opened on the point of the spur just west of Panther Branch (section 6), and which he reports as 450 feet below the bed just described, presumably occurs at the base of the Charleston sandstone. Hence the stratigraphic position of the upper bed is about 450 feet above the base of the formation less the amount of northward dip between the two openings and less also the correction which appears to be necessary from his determination of the height of the mountain as 1800 feet. The amounts of deduction are somewhat arbitrary, but the coal presumably occurs from 300 to 350 feet above the base of the formation. This coal bed is probably present at the head of Drews Creek, but with reduced thickness, as shown in section 84.

A bed of coal, occurring about 200 feet above the base of the formation, outcrops at a number of places on the ridge north of Clear Fork, in the vicinity of Lawson. An old but well-known opening on this bed is situated on the Lawson-Acme road near the summit of the mountain. The coal does not show in full at this opening, but its thickness is reported to be 7 feet (section 2).

Farther eastward along the ridge numerous openings may be seen, but they are now in such condition that it is impossible to examine the coal. At the head of Short Branch of Fifteenmile Fork of Cabin Creek, however, an opening near the summit of the mountain affords a fine exposure of the entire thickness of the bed. At this point it measures a little more than 10 feet (section 3), and the coal is a fine grade of splint from top to bottom. This is presumably the same coal as that reported by Professor White about 310 feet above the Acme coal on Cabin Creek, with a thickness of 5 feet 5 inches.

The next lower coal horizon is equally difficult to locate in the series, but presumably it occurs at the division line between the Charleston sandstone and the Kanawha formation. It is reported by the Stevens Coal Company 150 to 200 feet above the Acme coal on Cabin Creek, and with the thickness shown in section 4. The total thickness at this point is large, but the bed is badly broken by the thick shale parting. Toward the south the shale dies out, but the bed holds a thickness of over 8 feet, as shown by section 5, reported by Mr. Reynolds from an opening at the head of Long Branch of Clear Fork. The general section on Long Branch from Clear Fork to the top of the mountain was carefully leveled by Mr. Reynolds, who reports this opening as 1370 feet above Clear Fork. Section 6 is presumably the same coal. It shows at an opening made by Mr. Reynolds on the south side of Clear Fork and west of Panther Branch.

The correlation of this coal with the beds of the type section on Kanawha River can not be made with certainty, but it seems probable that the horizon just described is not far from the black flint. The bed may be the Lewiston or the No. 5, or it may be a different one, having no representation in the type section.

In descending order, the next coal horizon of importance is that of the Acme coal, so-called from a mine on Tenmile Fork of Cabin Creek, north of this quadrangle. Section 7 represents the coal bed at this mine. The full thickness of the coal is not removed, the lower bench being undisturbed in the process of mining now employed. It is difficult, if not impossible, to correlate definitely these coals with those along Kanawha River. The Acme coal is locally regarded as the Coalburg, but there are some facts which seem to indicate its equivalence with the Winifrede rather than the Coalburg bed. Four miles above Acme and near the northern margin of this quadrangle there is an old coal opening which probably belongs to this horizon. The pit has fallen in, and it is impossible to say much about the character and thickness of the coal, but it appears to range from 5 to 6 feet in thickness.

Acme coal.

This coal bed is not known in the valley of Clear Fork. It seems probable that careful prospecting will reveal its presence, but it may not be thick enough to mine.

The most important coal horizon in this division occurs about 650 feet below the top of the Kanawha formation and 350 feet above the Pottsville series. Presumably this is the same horizon as the Coal Valley or Gas coal of the Upper Kanawha and the Cedar Grove coal farther down the stream.

One of the most remarkable exposures of coal in the Raleigh quadrangle is on Long Branch of Clear Fork, where, within an interval of 250 feet, four coal beds are exposed. According to Mr. Reynolds, who opened these beds, the highest and most important bed is 750 feet above Clear Fork. This bed belongs to the Cedar Grove–Gas coal horizon, and it is one of the largest bodies of coal known in the quadrangle. Section 8 represents this bed as determined by Mr. Reynolds. Sections 9 and 10 were measured during the present survey, the former in 1895 and the latter in 1899.

The Cedar Grove–Gas coal.

North of the divide between Cabin Creek and Clear Fork this coal bed has been opened in a number of places on the headwaters of Fifteenmile Fork, but at no point does it show a thickness so great as on Clear Fork. Section 11 represents this coal at an opening at water level on Long Branch of Cabin Creek, about three-fourths of a mile above its junction with Fifteenmile Fork. Section 12 was measured at an opening on Fifteenmile Fork near the mouth of Short Branch, at an altitude of 90 feet above the level of the stream, and section 13 a little higher up the creek, at the mouth of Gibson Branch, where the coal is about 40 feet above the level of the stream.

On Tenmile Fork of Cabin Creek this bed is exposed along the valley for a considerable distance, and at Acme it has been mined for a number of years. Its thickness in the Keystone mine, as reported by the company, is shown in section 14. This coal bed is also known at several points on the main head branch of Cabin Creek. Section 15, which represents it at one of these exposures, shows that the bed is degenerating in this direction by the introduction of a thick parting of shale near the middle.

Near Lawson on the road to Acme a small coal (section 16) has recently been opened and mined for local use at Lawson. By barometer it is 520 feet above Clear Fork, and it appears to belong to the horizon of the thick coal on Long Branch. It is possible that this is one of the small beds that accompany the large one, but this can be told only by careful prospecting. The latter supposition derives some weight from the fact that the large coal was found by Mr. Reynolds just below Panther Branch, on the south side of the valley, 610 feet above Clear Fork. The thickness of the coal is shown in section 17, and unless this is simply a pocket the section indicates that a large body of coal exists in the valley of Clear Fork and extends through the mountain to Drews Creek, as will be shown under Division D. South of Clear Fork this bed appears to be broken by shale partings, as shown in section 18, which is from an opening on the south side of Squealer Knob and 750 feet by barometer above Horse Creek at the point where the Birch Fork trail leaves the creek.

Large body of coal in Clear Fork Valley.

About 100 feet above the Cedar Grove–Gas coal horizon occurs a small coal which has been noted in several places southwest of Clear Fork. Mr. Reynolds opened it on the spur below Panther Branch 90 feet above the large bed already described. The thickness of the bed at this point is shown in section 19. On Sturgeon Fork of Dry Creek it has a greater thickness, as shown in section 20, but the coal is streaked with impurities and its value is less than that of some thinner beds. The same coal, presumably, was seen on the main head branch of Dry Creek, but its thickness could not be determined. Coal having a thickness of 3 feet is visible, but it is full of impurities and is of little value.

Coals above the Cedar Grove–Gas coal horizon.

On Sturgeon Fork a bed of coal 3 feet thick is reported as occurring 50 or 60 feet below the coal shown in section 20, but the report could not be verified.

Below the Cedar Grove–Gas coal horizon are several medium-sized coal beds, which show in outcrop in a number of places in this quadrangle. It is difficult to arrange these outcrops according to horizons, for they seem to occur irregularly in the interval between the thick coal and the top of the Pottsville series. For this reason their descriptions by horizons will not be attempted, but they will be described by localities.

Coals below the Cedar Grove–Gas coal horizon.

Three of these beds have been opened on the left Fork of Long Branch below the large exposure of the Cedar Grove–Gas coal. The first occurs 50 feet below the large coal, and according to Mr. Reynolds it has a thickness of 30 inches (section 21). About 120 feet below this is another bed, the thickness of which is shown in section 22. The lowest coal of the group is shown in section 23. It is 520 feet above Clear Fork and 65 feet below the coal bed represented in section 22. This bed is probably 100 feet above the Pottsville series, but, owing to the lithologic similarity of the Pottsville series and the Kanawha formation, it is impossible to determine this interval definitely.

On the spur below Panther Branch Mr. Reynolds opened two coal beds of workable thickness below the Cedar Grove–Gas horizon. The uppermost of these beds is 40 feet below the large coal, and it corresponds in position with the coal on Long Branch already described and figured in section 21, but it is nearly twice as thick (section 24) at Panther Branch as it is on Long Branch. The other workable coal in the Panther Branch section is 290 feet below the coal last described and 280 feet above Clear Fork. The thickness of this bed is shown in section 25.

About 100 feet below the Cedar Grove–Gas horizon is a coal bed which has been opened in a number of places, only one of which comes within the limits of this division. Section 26 represents the coal on Moll Kelly Branch, where it has been opened 600 feet above the level of Drews Creek.

A coal bed, or group of small beds, occurs about 150 feet below the Cedar Grove–Gas coal horizon, and of this group there are several exposures in this region. Probably they are best shown at Decota, where two coal beds, within 20 feet of each other, are exposed near water level. The lower bed is shown in section 27 and the upper in section 28. This horizon is represented, west of Lawson, by a coal on the head of Low Gap Branch, which is shown in section 29, and on the head of Hays Creek, in the Oceana quadrangle, by a small coal, which is shown in section 30. In the vicinity of Acme the largest coal bed of this group is exposed near water level. Its thickness is shown in section 31.

In the neighborhood of Lawson the boundary line between the Kanawha and Sewell formations occurs in a group of sandstone beds which form conspicuous cliffs along Coal River and its several tributaries. In this sandy interval, which has a thickness of about 180 feet, there is a small bed of coal that was seen at a number of points in this vicinity. Section 32 is from an opening on Little Marsh Fork about one mile above Big Brushy Fork; section 33 represents this bed as it shows in an opening on Low Gap Branch; and section 34 is from a natural exposure on Birch Fork about 4 miles above its junction with Little Marsh Fork.

That part of the Sewell formation which is exposed in this division carries very few coal beds of commercial importance. There is, however, a coal horizon from 150 to 200 feet below the top of the formation, which merits a brief description; in the Raleigh quadrangle it has only moderate thickness, but farther west it increases to workable proportions. Section 35 represents this bed as it appears on the left fork of Dillon Branch, near Matville, 250 feet above Sand Lick Creek. Section 36 is from an opening on the opposite side of the ridge at the head of Stover Fork. This bed was not observed farther north in the valley of Clear Fork, but it is probably present on Birch Fork (section 37) about 2 miles above its junction with Little Marsh Fork. In passing to the west this coal appears to grow thicker and more promising, as shown in section 38, which is from an opening on a small branch of Hays Creek about a mile from Coal River.

Division B.—Only a few coal outcrops and prospect pits were observed in this division.

The highest coal that was seen outcrops in the gap of the ridge just west of Lick Knob; it shows in the trail which crosses from Whiteoak Creek to Milburn Creek. The thickness of the coal bed is unknown, but, judging from the appearance of the bloom, it is of workable proportions. This coal was not seen south of Lick Knob, but its horizon is present in the high points of the ridge as far south as Potato Hill. The horizon of this coal is not well determined, but it presumably belongs at the top of the Kanawha formation.

Other blooms were observed which indicate that there are coal beds between the top of the Kanawha formation and the Cedar Grove–Gas coal horizon, but at no point could exposures be found by which to determine their thickness and quality.

The Cedar Grove–Gas coal bed, which is so promising in Division A, is present in this region, but the coal is not so thick as it is farther west and north. A coal (section 39) which appears to be at this horizon is mined for local use at Cirtsville. The mine is situated in a ravine about $1\frac{1}{4}$ miles northwest of the village and 840 feet higher than the bed of Paint Creek at the village. Southwest of Cirtsville this coal bed has been opened on the summit of the ridge nearly 150 feet higher than the gap through which the Clear Creek road passes. The bed, which is represented by section 40, is a little thicker than the one represented in section 39, but it lies so high on the ridge that it is expensive to mine.

Coals on Paint Creek.

About 100 feet lower in the series is a coal bed, or group of small beds, which shows at a few places in this district. Section 41 represents this coal at an opening a few miles north of the border of this quadrangle. The opening is high on the northeastern face of Payne Knob, on a small branch which flows into Johnson Fork of Loop Creek. The bed extends eastward, but appears to diminish in thickness in that direction. Section 42 shows the condition of this coal at an old opening on the divide between Whiteoak and Mossy creeks, in the eastern part of the division. The Sewell formation does not show many coal outcrops above drainage level. About 100 feet below the top of the formation is a small coal which outcrops in Whiteoak Creek in the western part of the area, about 2 miles from Clear Fork, and which is represented in section 43.

The famous Sewell coal bed is not commercially developed to any extent in this division. Section 44 represents the reported character of the coal bed at the Sugar Creek mine, which has been in operation for a number of years. Recently the bed has been reached by a slope on Bend Branch, and a mining plant has been established about a half-mile from Dunloup Creek. On this creek near the mouth of Shepherd Spring Branch the Sewell coal has been uncovered at water level, where it shows the thickness indicated in section 45. So far as known, there has been no attempt to trace the coal to the westward in the area in which it is below drainage level. At the present time there is so much of this coal bed showing in natural outcrop near the river that it would not pay to undertake its development under very deep cover, but the time will surely come when there will be a demand for new territory in which to locate mines, and then the valley of Paint Creek will offer an attractive field for coal operators.

Sugar Creek mine.

Division C.—This area includes most of the coal mines that are located in the quadrangle. The development of the coal dates from the opening of the Chesapeake and Ohio Railway in 1873. At first the mines were confined to the main line of the railway, along New River, but with the increased demand for coal has come the development of contiguous territory by the building of branch lines up the principal creeks flowing into the river. Dunloup Creek was the first to be developed, and it has held precedence in the matter of coal production. Laurel Creek was also opened up several years ago by a branch line from Quinnimont, and recently mines have been opened on Arbuckle and Whiteoak creeks, which will add considerable productive territory in the neighborhood of Oak Hill. A branch line has just been completed up Piney Creek to Beckley. This affords an outlet for a promising field in that vicinity, and doubtless the next few years will witness considerable activity in the commercial development of this new field.

The workable coal beds of Division C belong to two well-known horizons, named from the points of original development, Sewell and Quinnimont.

From the characteristics of the coal itself and from its relation to the associated rocks, the Sewell coal bed is the most easily identified and traced of all the coals of the Pottsville series. It occurs from 40 to 90 feet above the Raleigh sandstone, in a generally shaly series which weathers rapidly, leaving the sandstone as a table or terrace around the hills, with the coal

The Sewell coal bed.

outcropping a little distance back from the edge of the terrace. Throughout the New River region from Beckley to Hawks Nest the Sewell coal is everywhere present and of fairly constant thickness.

The Quinnimont coal is present along New River from above Quinnimont to East Sewell. It occurs about 200 feet below the base of the Raleigh sandstone, but it is so variable in thickness that at some localities it is difficult to identify. In the early geologic reports on this region the workings at Quinnimont and Fire Creek were regarded as upon different beds, but now it is known that all of the river mines below the Raleigh sandstone are upon one bed—the Quinnimont coal.

The Quinnimont coal bed.

The Sewell coal was first mined at the town of the same name on the east side of the river, but the sharp southeastward rise of the strata at this point soon carried the coal bed above the upland, and the mine was exhausted in a few years. In an opening made near this mine by J. A. McGuffin the thickness of the bed is reported to be 4 feet 10 inches (section 46), but the average thickness in the mine, as reported by Professor Fontaine, is 3 feet 6 inches (section 47). On the west side of the river, opposite the original workings, the Brooklyn mine is at present operating on this coal, the thickness of which is represented in section 48.

Sewell coal bed along New River.

Down the river this coal bed maintains a regular thickness of about 4 feet for a distance of several miles. Section 49 shows the reported thickness at the Cunard mine opposite Sewell, and section 50 is from the mine on the west side of the river at Caperton, about 2 miles beyond the northern edge of the quadrangle. From this point north the bed decreases in thickness, as shown by section 51, which represents the condition at the mouth of Keeny Creek, section 52 at Nuttallburg, section 53 at Fayette, and section 54 at Gaymont, the most northerly point at which this bed is worked. At Hawks Nest the Sewell coal is present, but its thickness, according to Professor Fontaine, is only 2 feet. Below this point there is no trace of the coal passing below water level, and the presumption is that it dies out before its horizon disappears beneath the waters of New River.

Westward from Sewell this coal bed gradually increases in thickness, as shown by section 55, which represents its condition at the Echo mine above Beury, and by section 56, from the Beechwood mine, which is now connected underground with the Echo mine. On the north side of the river this coal is mined at Concho, where its thickness is shown in section 57. In 1899 a mine was opened on Arbuckle Creek about $2\frac{1}{2}$ miles from New River, and the thickness of the coal at this point is shown in section 58.

On Meadow Fork of Dunloup Creek this coal has been prospected in a number of places, but the prospect pits have generally fallen shut and accurate measurements are impossible. Section 59 is reported from an opening about 2 miles from the main creek and on the road which crosses the hill to Bissell. This coal also had been opened in the high land about Garden Ground Mountain, but at no place could the entire section be seen. It is at least 4 feet in thickness, and the full measure may run to 5 or 6 feet, but these figures are hypothetical and consequently of little value.

On Dunloup Creek the first mine is at Harvey, on Smith Branch north of Redstar. Section 60 shows the reported thickness of the coal at the Harvey mine, and section 61 at the Redstar mine, only a short distance above the Harvey mine. The coal maintains an average thickness of 5 feet as far as Glenjean, as shown by section 62, which is from the Collins mine at the latter place. Section 63 represents the coal at the Dunloup mine, 2 miles above Glenjean, and section 64 at the mine at Turkey Knob. The last section shows about the maximum thickness of the coal in this district. At Macdonald it maintains a good thickness, but carries a small shale parting near the bottom, which detracts somewhat from its value (section 65).

The mines on Dunloup Creek.

This coal has been opened at a number of points on the headwaters of Dunloup Creek, but its thickness in this territory is unknown. Judging, however, from the heavy blooms which occur on the road leading from Prince to Beckley and from the large pit from which coal has been raised on Stanaford Branch, it seems probable that the Sewell coal will be found of workable thickness throughout most of the region between Dunloup and Piney creeks wherever the land is high enough to reach its horizon.

On the east side of New River the coal is not present in this quadrangle above Beechwood, but a short distance farther east its outcrop may be seen along the road leading from Sewell to Crickmer and Quinnimont. It is not so thick in this region as it is west of the river.

The Quinnimont coal is so variable in thickness that it is difficult to show its true value by a series of sections. Section 66 is from the old original mine at Quinnimont, as reported by Prof. I. C. White. The workable coal was exhausted in this mine several years ago and the company has opened new mines up Laurel Creek, beyond the limit of this quadrangle. At Royal, on the south side of the river, a mine has been in operation for a long time, and the coal in this mine is reported to average from 42 to 48 inches (section 67). A mine plant was once established at McKendree, but the coal is so variable in thickness that the mine was soon abandoned. At Slater similar difficulties were encountered and the original mine at the head of the incline was abandoned, but coal is now drawn from a new mine about $1\frac{1}{2}$ miles up Slater Creek. Section 68 was measured some distance within the new mine and may probably be taken as a fair average of the coal bed.

Quinnimont coal bed along New River.

At Alaska the coal has a greater thickness (section 69), but it contains a band of "niggerhead," which is separated from the coal before it is coked or put upon the market. At Beechwood the condition of the coal bed (section 70) is much the same as at Alaska. It varies little at Stone Cliff, as shown by section 71. At Dimmock its general thickness, as shown in section 72, is somewhat greater than at the mines farther up the river, but the variation from mine to mine is no less than frequently occurs within a single mine.

Variable character of some of the coal beds.

On Arbuckle Creek a mine has recently been opened on this coal one-fourth mile from the river. The coal is represented by section 73. Section 74 shows this bed at Concho, where it has been opened about 300 feet below the Sewell coal. The average section for the Rush Run mine is reported by the owner to be over 6 feet (section 75). Similarly the average thickness in the Red Ash mine is given as 5 feet 9 inches (section 76), but the coal lies in "swamps," the extent of which may be seen by comparing the average section with sections 77 and 78, which represent the maximum and minimum measures in the mine. In the Beury mine the coal is reported to vary in thickness from 3 to 10 feet (section 79), the latter being the greatest thickness reported in the New River field. In the Central mine the average thickness is shown in section 80, and in the Fire Creek mine the coal is reported as ranging from 3 to 5 feet (section 81).

Below this point the Quinnimont coal is not mined on New River. Mr. McGuffin reports it 2 feet 6 inches in thickness at Sewell (section 82), but below this point it has not been recognized.

Both the Sewell and the Quinnimont are coking coals, and almost every mine in this district is provided with ovens by which most if not all of its product is converted into coke.

Division D.—The known outcrops of coal in this area are few in number, but the presence in the territory to the west of thick beds of good coal gives some assurance that there are beds in this division which have not been prospected, and consequently are unknown.

The highest known coal bed in this territory is the thickest, but, since it occurs on the summit of the most lofty ridge, it has only a small acreage remaining, and that probably under not sufficient cover to be successfully mined. This bed was opened by Mr. Reynolds on the summit of Cherry Pond Mountain, a short distance southeast of Indian Gap and just beyond the limit of the quadrangle, where it has the unprecedented thickness of over 12 feet of clear coal, as shown in section 83. This coal bed lies apparently about 500 feet above the base of the Charleston sandstone, and is not known to outcrop in this quadrangle.

Twelve-foot coal bed on Cherry Pond Mountain.

The next coal, in descending order, was also opened by Mr. Reynolds on the same ridge, about 530 feet above Indian Gap. This agrees approximately in stratigraphic position with the highest coal observed on Panther Branch, shown in section 1. The character of this bed is shown in section 84, and it will be seen that there is little similarity between it and section 1. Mr. Reynolds regarded the highest coal on Cherry Pond Mountain as equivalent to the uppermost coal in the Panther Branch section, and, judging from the appearance of the coals themselves, this is the most rational correlation, but when the sections are adjusted for dip there seems to be too great a disagreement between their distances above the base of the formation to permit of their being the same bed. As a rule the thick coal beds of the Charleston sandstone are extremely variable, a fact well illustrated by the celebrated North Coalburg bed, and it is not at all improbable that the thick coal of Panther Branch is the same as the bed, 40 inches in thickness, in Indian Gap or that at the head of Drews Creek.

In this division and in the territory immediately adjacent on the west there appears to be an important coal horizon from 450 to 480 feet above the base of the Kanawha formation, or 100 to 130 feet above the Cedar Grove-Gas coal horizon. The latter bed is well represented on Drews Creek just beyond this quadrangle, and 110 feet above it Mr. Reynolds reports a coal bed having the thickness shown in section 85. What appears to be the same coal has been opened in Clear Fork Gap about 30 feet below the summit. Its thickness is shown in section 86.

On Drews Creek just west of the boundary line of the quadrangle is a somewhat famous outcrop of coal which shows a total thickness of more than 14 feet (section 87). This seems to belong to the same horizon as the thick beds on Long Branch and Panther Branch, or the Cedar Grove-Gas coal horizon. From its great total thickness this outcrop has attracted considerable attention, and immense returns are anticipated when mines are developed upon it. Unfortunately, however, the bed is so broken by heavy partings of shale that the available coal is reduced to a thickness of only a few feet, and the bed is no more valuable than many other coal beds of only moderate thickness. No other exposures of this bed were seen in Division D, but it is probable that this coal underlies Guyandot Mountain west of Skin Poplar Gap.

Fourteen-foot coal at the head of Drews Creek.

About 150 feet lower in the series and about 550 feet above the Harvey conglomerate lentil is a coal bed which shows in a number of places west of the boundary line of this quadrangle. Section 88 is from an opening on a branch of Drews Creek below Hazy Gap, and section 89 is from Rich Branch of Pond Fork, $1\frac{1}{2}$ miles southwest of the same gap. This bed is of sufficient thickness to be mined in the region about the head of Pond Fork, and it seems probable that it also occurs in the high land of Division D of the Raleigh quadrangle.

Still another workable coal shows on Drews Creek just west of the boundary line of this quadrangle. Its thickness is shown in section 90, and it occurs about 60 feet above the base of the Kanawha formation.

On Laurel Fork about 2 miles below McGraw is an outcrop of coal in the bed of the creek, which is represented by section 91. This coal lies directly under the Guyandot sandstone lentil, which in this locality has a maximum thickness of about 100 feet. The same coal beds show a mile or two farther down the creek, with the same thickness, as seen in section 92.

This completes the list of workable coal outcrops that were observed in this division of the quadrangle. Other beds doubtless occur, but they were not seen, or the prospect pits had fallen in to such an extent that it was impossible to form an estimate of their thickness and character.

Division E.—The highest coal bed in this territory is from 50 to 75 feet above the Raleigh sandstone, and consequently it belongs to the Sewell coal horizon. This bed may be traced almost continuously from Dunloup Creek to Beckley, but in the latter locality it is difficult to find exposures from which to determine its thickness. Section 93 is from a prospect pit on the south side of Big Whitestick Creek near the road from Beckley to Cole. This coal is reported as showing a thickness of 5 feet at a number of points on Big Whitestick Creek, but the reports were not verified.

It is probable that the Sewell coal, which is so important in the region between Beckley and Oak Hill, fades out beyond Big Whitestick Creek, or at least becomes thin and patchy and consequently of little commercial value. Even in the vicinity of Beckley it seems to show a variability in thickness which is unknown in the type locality about Dunloup Creek.

Sewell coal fades out southwest of Beckley.

The fading of the well-known Sewell coal in the vicinity of Beckley corresponds with the introduction of a coal bed of workable thickness which is unknown in the New River section. This bed occurs immediately below the Raleigh sandstone, and from its great development in this locality it will be called the Beckley coal bed. Locally this coal is regarded as equivalent to the Quinnimont bed of New River, but since the latter lies 200 feet below the Raleigh sandstone, and the former at its base, it is manifestly impossible for the Beckley and Quinnimont to be the same. The detailed evidence for the above conclusion will be presented under Division F.

For most of the details regarding the coal outcrops in the vicinity of Beckley the writer is indebted to the work of John Anderson of Beckley, who prospected the coals very thoroughly a few years ago. Some of the coal sections have been verified by the writer, but many pits had so fallen in that it was impossible to determine the thickness of the coal.

The Beckley coal is well shown at the junction of Cranberry and Little Whitestick creeks, where it has a thickness of 3 feet (section 94). It is exposed here in natural outcrop under a heavy ledge of Raleigh sandstone. The sandstone forms prominent cliffs along both creeks, and it can be traced easily along the Beckley-Prince road to the head of Batoff Creek, where the Raleigh sandstone is present in its best development. The coal was opened by Mr. Anderson in a number of places below the outcrop just described, but since they fall in Division F they will be described later.

The Beckley coal bed.

South of Beckley the coal increases greatly, though irregularly, in thickness, and at its next appearance in this division, on Big Whitestick Creek, it is very promising in both thickness and composition. Six openings in the vicinity of the mouth of Big Whitestick Creek furnished sections 95, 96, 97, 98, 99, and 100. Since the geologic map was printed, the Piney Creek Branch railroad has been extended to Big Whitestick Creek, and a large mine has been opened near the mouth of the creek. Within this mine the coal is reported to be variable, running from 3 feet 10 inches to 10 feet in thickness. It is free from shale partings, and is in every way a most promising bed of coal. It is said to be a fine coking coal, but as yet no effort has been made to produce coke on a commercial scale.

The coal reaches water level at Spangler Factory, but between that point and the mouth of Big Whitestick Creek Mr. Anderson reports three openings on the north side of Piney Creek, with thicknesses shown in sections 101, 102, and 103. On the south side of the creek he reports five openings, which gave sections 104, 105, 106, 107, and 108.

The coal is below the level of Piney Creek from Spangler Factory to Pemberton. At the latter point it appears above water level, and to the south it rises more rapidly than the stream, and reaches the hilltop north of Flat Top Mountain. Section 109 is from a prospect pit at Pemberton. South of this point the bloom of this coal shows in many places at the base of the Raleigh sandstone, but no exposure of the unweathered coal was seen.

West of Spangler Factory and Pemberton the streams have not cut deeply enough to reveal this horizon, but it was presumably found by a diamond drill near Lester at a depth of 280 feet. This well is located about a mile east of Lester, on Shockley Branch, where it

Well section near Lester.

is crossed by the road leading from Lester to Cole, and the well head is about 130 feet below the top of the Harvey conglomerate lentil. The following table, kindly furnished by W. C. Reynolds, who had charge of the drilling, shows in great detail the character and thickness of the rocks:

Record of well boring near Lester.

	Ft.	in.	Ft.	in.
Soil	4			
Hard stone in layers	15			
Shale	5			
Coal { Coal.....1 foot; Slate.....2 inches; Coal.....3 inches }	1	5		
			25	5
Fire clay	0	6		
Dark slate	16	6		
Shale	5	8		
Coal	0	9		
			23	5
Fire clay	1	6		
Sandy shale	19	3		
Sandstone	21	0		
Coal	1	10		
			43	7
Fire clay	2	0		
Sandstone	25	6		
Black slate	52	2		
Sandstone	6	0		
Black slate	10	6		
Sandstone	7	0		
Black shale	3	6		
Black, gritty slate	2	2		
Bituminous shale	1	6		
Light slate	9	0		
Coal and slate	4	6		
			123	10
Light shale	6	6		
Sandstone	6	0		
Coal and slate	2	0		
			14	6
Light shale	12	0		
Hard, micaceous sandstone	22	0		
Dark, gritty shale	6	6		
Coal with two small partings	9	0		
			49	6
Fire clay	1	0		
Very hard sandstone	4	0		

On account of the absence of any distinctive beds in this section it is difficult to correlate the coals with certainty. The coal bed 9 feet in thickness at a distance of 410 feet below the top of the Harvey conglomerate lentil seems to be the Beckley coal, but in the well record there is no trace of heavy sandstone corresponding to the Raleigh sandstone. The Raleigh sandstone, where it is exposed in the region south of Lester, is not prominent, but appears to consist of thin sandstone beds separated by softer members, either shale or soft sandstone. Therefore it seems probable that at Lester it is even more broken up, and is no longer recognizable as a sandstone formation. Provisionally, the large 9-foot coal (section 110) will be classed as Beckley; and the small coal, 22 inches in thickness, which occurs 179 feet above the Beckley and 91 feet below the surface, will be called the Sewell coal.

Coal beds in the well section near Lester.

The Beckley coal shows in natural outcrop on Winding Gulf south of Soak Creek. Its thickness is somewhat reduced in this locality, as shown in section 111, and the amount of impurities is greater, but there are two benches of coal of good thickness and fine quality. The position of this outcrop is evidently below the Raleigh sandstone, but the latter is so poorly developed that it is scarcely recognizable.

The uncertainty of the coal correlations in this locality is increased by the fact that on Piney Creek there is another coal bed about 100 feet below the base of the Raleigh sandstone. Both beds are well shown on a road which crosses Piney Creek about 2 miles above Pemberton. The Beckley coal shows as a large bloom in the road at the base of the heavy Raleigh sandstone, and 100 feet lower there is a large but almost worthless coal (section 112) exposed near the level of the creek.

The lowest coal horizon exposed in this division is that of the Quinnimont coal, which shows on Boyer Fork near its junction with Piney Creek. Section 113 represents the coal bed at this locality.

Division F.—The coal beds exposed in this division lie generally below the Raleigh sandstone. The only exception is the Sewell coal, which shows in a number of places in the northwestern corner of the territory, on the road which leads from Prince to Beckley.

Below the Raleigh sandstone there are two coal beds of workable thickness in this division. The uppermost or Beckley coal lies directly below the Raleigh sandstone, and the Quinnimont coal is from 170 to 200 feet below the same horizon. In local prospecting in this field the two coal beds have been confused and the openings on the Beckley coal are supposed to be on the Quinnimont bed.

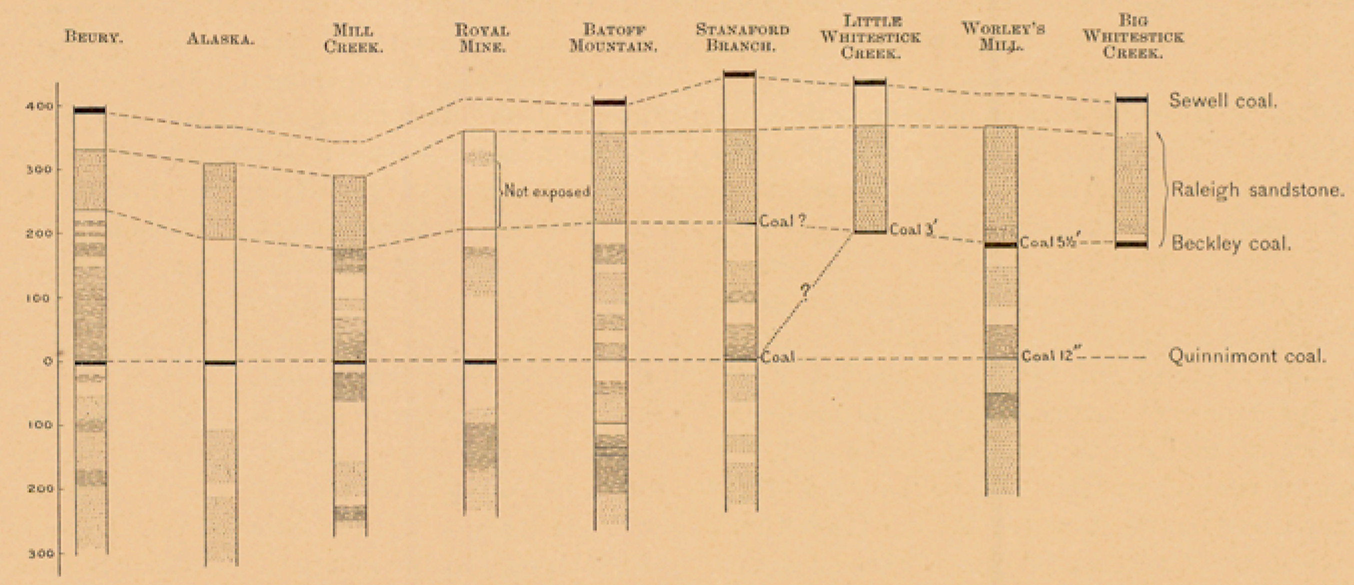


FIG. 3.—Sections showing the relation of the Beckley coal to the other well-known beds of the geologic series.
Scale: 1 inch = 300 feet.

The relationship of these beds is shown in the accompanying illustration (fig. 3), giving a series of sections along New River and Piney Creek to the recent development near the mouth of Big Whitestick Creek.

The first section was measured at Beury, where both the Quinnimont and Sewell coals are well shown and their relationship to the Raleigh sandstone is easily determined. The Sewell coal is 50 or 60 feet above the Raleigh sandstone, and the Quinnimont coal lies about 230 feet below the same prominent stratum. This sandstone is one of the most pronounced geologic features along this portion of New River, and can be traced with absolute certainty up the river to the limits of this quadrangle.

Confusion of Quinnimont and Beckley coal beds.

At Alaska it is very pronounced, and it there holds the same relation to the Quinnimont coal that it does at Beury, except that the interval between them is slightly reduced.

From Alaska to the mouth of Mill Creek the relationship of the beds remains unchanged and the interval between the lower coal and the sandstone holds a constant thickness of about 190 feet. The Sewell coal has been eroded from the hilltops near the river, so it does not appear in the section, but within a distance of 8 or 10 miles on either side it is present in its normal position of from 40 to 70 feet above the Raleigh sandstone.

At the Royal mine the section is almost identical with that at the mouth of Mill Creek, except that the Raleigh sandstone is not so well exposed, but it is doubtless present in its full thickness. The section along the Prince and Beckley turnpike up Batoff Mountain is also essentially the same as the two last described, except that the Quinnimont coal is replaced by carbonaceous shale at this point. A short distance back on the upland the Sewell coal is present in its normal position above the Raleigh sandstone.

The sections along the river have so far shown no trace of workable coals other than the Sewell and Quinnimont beds. If the Beckley coal is present, it is presumably too thin to attract attention or is concealed by the débris which falls from the sandstone cliff above.

Recent mining operations on Piney Creek have thrown considerable light on the geology of this region. The sequence of rocks and coal beds on the lower course of Piney Creek is well illustrated by the section exposed at Stanaford Branch. At this point the Quinnimont coal is found in its normal position, 200 feet below the Raleigh sandstone, and the mass of stiff sandy shale which overlies it is almost identical with that which shows on New River at the same horizon. Above the Raleigh sandstone the Sewell coal occurs in its normal position and with a thickness that promises well for mining operations. At the base of the Raleigh sandstone there is a small, irregular bed of coal, which appears to be the first showing of the Beckley coal.

The Raleigh sandstone is easily traced from Stanaford Branch to the junction of Little Whitestick and Cranberry creeks near Beckley. At this point the Beckley coal is well shown (section 94) directly underlying the Raleigh sandstone. This bed has been correlated with the Quinnimont coal at Stanaford Branch, as indicated by the dotted line in the figure. Such transgressions are possible, but in this case the great regularity of the series, as shown by the various sections, and the short distance in which the change is supposed to occur, make such a transgression extremely improbable.

The next section (section 122), exposed on the road to Worley's mill, seems to settle the question beyond doubt. In this section the Raleigh sandstone is very prominent, forming the uplands between Beckley and Piney Creek. At the base of this sandstone the Beckley coal shows a thickness of 5 feet 6 inches in an opening by the roadside. At a distance of 170 feet below the Beckley coal is the Quinnimont coal, having a thickness of 12 inches, with its customary associations of sandy shale above and sandstone below. The Beckley and Quinnimont coals are also present in their normal relative positions on the head of Fat Creek, near Table Rock, where presumably both are of workable thickness.

Relation of the Beckley and Quinnimont coal beds.

The last section in the figure represents the Beckley and Sewell coals and the Raleigh sandstone on Big Whitestick Creek in the vicinity of the mines which recently have been established at that point.

All the evidence available shows that the Beckley and Quinnimont coals are separate beds, and that their correlation and confusion has been due to an effort to trace the coal beds regardless of the associated rocks.

So far as present knowledge goes the Beckley coal is equal in quality to the Quinnimont coal in its best development on New River, and it is certainly equal to, if not superior to, that bed in economy of operation. It presents a promising field in the vicinity of Beckley, one that will probably soon be an important factor in the coal production of New River Valley.

Comparison of Quinnimont and Beckley coals.

When the geologic map of this folio was prepared it was assumed that all of the coal outcrops described by Mr. Anderson belonged to the Beckley horizon, but a late visit to the field has shown that many of them are at the horizon of the Quinnimont coal. It was impossible to visit all of these old openings, hence it is uncertain how many belong to the Beckley horizon and how many to the Quinnimont horizon. Future prospectors may easily determine each case for themselves by noting the position of the outcrop relative to that of the generally heavy-bedded, white, sugary sandstone of the Raleigh formation.

In division F the most northerly exposure of coal on Piney Creek that was visited is at Stanaford Branch, where the Quinnimont bed has a thickness of 2 feet 6 inches. The thickness of this bed is variable, and since five or six new mines are being opened in this region it is probable that the coal has a greater average thickness than that given. This supposition is strengthened by the fact that at an opening directly opposite Stanaford Branch Mr. Anderson reports this coal as having a thickness of 5 feet 6 inches (section 114).

On the south side of Cranberry Creek are four openings, presumably on the Beckley coal, which, according to the same authority, have the thicknesses shown in sections 115, 116, 117, and 118. On the west side of Piney Creek, between Cranberry Creek and Worley's mill, four openings have been made by Mr. Anderson on the supposed Beckley coal, and its condition at these points is shown in sections 119, 120, 121, and 122. Section 122 is from the opening on the Worley's mill road already described and shown in fig. 3. This is undoubtedly the true Beckley coal, but the roof has so caved that only a part of the coal is visible.

The Beckley coal on Piney Creek.

Six sections (123, 124, 125, 126, 127, and 128) are reported on the same authority from the east side of Piney Creek below Worley's mill. Judging from the altitude of the openings these are presumably on the Beckley coal, but they may belong to a lower horizon.

On the west side of Piney Creek above Worley's mill there is an opening on the Beckley coal which, according to Mr. Anderson, shows the thickness given in section 129. Farther up the creek on the same side there is an old opening which affords a partial view of the coal. The bed appears to have a thickness of about 4 feet 6 inches, but at present only 3 feet of coal is visible.

This coal has been mined in a small way for a number of years by the side of the Princeton-Beckley turnpike north of Piney Creek. Its thickness at this point is shown in section 130. At this locality there is a pronounced roll in the rocks, which causes the two openings here to appear to be on different beds.

East of Beaver Creek there are a number of openings on this coal bed, but they have generally fallen shut and the coal is inaccessible. It is impossible to obtain definite sections, but the coal appears to be of workable thickness.

At an opening on the south side of Piney Creek and a little above the crossing of the Princeton turnpike the Beckley coal, according to Mr. Anderson, has the thickness shown in section 131.

In the valleys of Beaver and Little Beaver creeks this coal also appears to be generally present, but the steady rising of the strata toward the south soon carries its horizon above the tops of the hills in this direction. An opening has been made in the knob above Daniel's store, 3 miles north of Shady Spring, on what appears to be this bed. The opening has a height of 5 feet, but the coal could not be seen.

On the north side of Little Beaver Creek Mr. Anderson reports three openings, which are represented by sections 132, 133, and 134.

In the vicinity of Table Rock the Beckley coal shows in a number of places directly beneath the sandstone, and judging from the size of the bloom it seems probable that the bed is of workable thickness in this region.

About three-quarters of a mile east of Table Rock a bed of cannel coal, represented by section 135, has been mined to some extent for local use. This bed occurs below the Raleigh sandstone, but the exact interval between it and the base of the sandstone is unknown. It is presumably too low in the series to be correlated with the Beckley coal and too high to be correlated with the Quinnimont. It is not a very thick bed of coal, and presumably is not an important factor in the coal resources of this region.

A small bed of coal has been prospected to some extent up the valley of Glade Creek. Two openings on this bed on Cooper Creek are represented by sections 136 and 137. This bed appears to belong about 150 feet below the Quinnimont coal. It is not known on New River, but it is seen on Piney Creek, along the grade of the railroad which has recently been constructed up that creek, where it shows considerable coal, but the bed is so broken by heavy shale partings as to be of little value.

Division G.—The deep valley cut by Guyandot River across this territory has laid bare the rocks from near the horizon of the Harvey conglomerate lentil to below that of the Pocahontas bed of coal, but the homogeneity of the strata renders it somewhat difficult to trace formations and identify horizons. In the Guyandot basin the Raleigh sandstone is the most reliable guide, but there are many other beds of sandstone that are equally thick and coarse, and hence the section along the river can not be depended upon for the determination of structure and stratigraphic succession. On Flat Top Mountain, in the vicinity of Old Bluff, the Raleigh is conglomeratic, but this feature soon disappears in passing westward. The bed descends with considerable regularity to the western margin of the quadrangle, where its base is about 200 feet above water level. In general, along Guyandot River and to the south the Raleigh is heavy and coarse, but in the opposite direction it breaks up into a number of thin beds of sandstone which can be identified with difficulty.

Several beds of coal have been prospected on Rock Castle Creek, which joins Guyandot River at Pineville, a few miles west of the Raleigh quadrangle. On Gulf Branch of this creek is a coal which lies less than 100 feet above the top of the Raleigh sandstone. This is not a very promising coal, as shown in section 138, but it is interesting on account of its being probably the southwestern extension of the Sewell coal. From this point it can be traced to the southwest into McDowell County, where it has wide distribution, although not very great prospective value.

The Beckley coal is presumably of not much consequence in the Guyandot basin. It was seen at one point on Rock Castle Creek, near Pineville, where it shows the thickness given in section 139.

Quinnimont coal in Guyandot Valley.

An exceedingly variable bed of coal has been opened at several places in this quadrangle and in the adjoining territory which appears to occupy the horizon of the Quinnimont coal. A large opening on this coal was seen on Pinnacle Creek, beyond the limits of the quadrangle, but it was impossible to determine the section of the coal at this point. A noted opening occurs on Guyandot River, near the western edge of this quadrangle. This fine exposure of coal is represented in section 140. If the coal is found to hold this thickness over any considerable extent of territory, it would be extremely valuable, but it changes rapidly, as shown by section 141, which is from an opening one mile below Cabin Creek. Here the total thickness is nearly the same as in section 140, but the coal is badly broken up by shale partings.

In descending order, the next coal bed of importance is the celebrated Pocahontas coal, which has been traced throughout most of the Guyandot River basin by the Flat Top Coal Land Association, to which the writer is indebted for much information concerning this coal. Fossil plants were collected from the roof shales of this bed in several places in order to check the identifications of the land company. With one exception, noted later, the determinations were substantiated in every particular.

Pocahontas coal in Guyandot River basin.

The Pocahontas coal bed rises from Guyandot River near the mouth of Long Branch. From section 142, which was measured at this point, it is apparent that this coal in the Guyandot River basin is much thinner than it is in the type locality on Elkhorn Creek.

At the junction of the Saulsville and River roads an opening was made by the Flat Top Association, which, according to their report, shows the thickness given in section 143, but from the detailed sections which have been measured on either side it is apparent that these figures indicate simply the total thickness of the coal bed inclusive of the bone and shale partings.

Section 144 was measured by the writer at an opening below Joe Branch, and its agreement with the section at the mouth of Long Branch and one on Slab Fork, to be described later, affords good evidence that along Guyandot River the coal is generally characterized by the presence of at least one parting of bone or shale.

Section 145 is reported by the Flat Top Association from an opening on Still Run, and section 146 from Barker Creek, where the bed passes below water level. On the same authority section 147 represents the thickness of the coal below the mouth of Slab Fork. Section 148 was measured by the writer on the latter stream near the mouth of Cedar Creek. It shows a close agreement with the reported sections in this vicinity, with the exception of the band of impure coal, which appears to be a constant feature in this region.

On Barker Creek this coal remains below the level of the water from near Guyandot River to within a mile of the southern boundary of the quadrangle, where it reappears. The thickness of the coal at the latter locality, as reported by the Flat Top Association, is shown in section 149, and its thickness at an opening on Jim Branch, as determined by the writer, is shown in section 150. South of this point the coal has been extensively prospected on the headwaters of Pinnacle Creek, and its total thickness is reported to vary from 4 feet 4 inches to 5 feet 4 inches.

Division H.—The Raleigh sandstone caps the highest hills in this part of the quadrangle, hence the coal beds which show in outcrop are those which occur below that stratum.

The Beckley coal does not seem to be present in this division, at least not in workable thickness.

In descending order, the next coal of workable proportions occurs 200 feet below the base of the Raleigh sandstone and consequently at about the horizon of the Quinnimont coal. Section 151 is from an opening on this bed on Boyer Fork of Piney Creek, and section 152 is from Piney Creek above Laurel Creek, on presumably the same bed. This section is reported by Mr. Anderson, who regards the coal as equivalent to the Beckley bed on Big Whitestick Creek. This correlation can not hold, since the coal, as well as the associated sandstones, dips to the north more rapidly than the grade of the creek, and passes below water level south of Pemberton. Section 153 represents this coal bed as it is exposed on Laurel Fork of Stone Coal Creek, within a few miles of the openings just described.

Quinnimont coal present in the southern part of the area.

This coal bed appears to be present over most of this territory where its horizon has not been removed by the erosion forming the deep valleys. Its best development seems to be in the vicinity of Basin Spring, where it attains the thickness shown in section 154. It also has been opened on the head of Barker Creek, but the full thickness of the coal could not be determined. Section 155 represents that part of the coal which is visible in this opening. The bloom of this coal was seen at a number of points, but no other complete section of the coal could be obtained.

A coal bed which seems to deserve attention occurs about 120 feet below the Quinnimont horizon. Section 156 represents this bed at an opening on Milam Fork south of Basin Spring. A partial exposure of this bed occurs on Barker Creek beneath the opening on the Quinnimont coal shown in section 155, but the opening had fallen in and it was impossible to determine the full thickness or the quality of the coal.

About 90 feet below the last-mentioned horizon occurs another coal bed, which at the head of Barker Creek was evidently mistaken by the Flat Top Coal Land Association for the Pocahontas coal, although its position in the series is about 160 feet above that well-known bed. An old opening on this horizon was observed on Guyandot River just below Cabin Creek, but it has fallen shut and no information could be obtained concerning the coal. On the head of Barker Creek it is conspicuous, for it shows in outcrop in the bed of the creek for a long distance. It is evidently a coal bed of considerable importance, since it was mistaken for the Pocahontas coal, but no measurement of its thickness could be obtained.

The Pocahontas coal is exposed in a number of valleys in this division. It shows in natural outcrop at water level on Stone Coal Creek for a distance of 2 or 3 miles, and presumably this fact gave rise to the name of the creek. Its thickness on this creek is represented by section 157, which was measured at an opening at the mouth of Farley Branch. At the junction of Laurel Fork with the main creek there are two exposures of coal, which appear to be upon this bed, but the sharp dip at this point throws some doubt upon the determination. Section 158 shows the thickness of the coal in the larger opening; the other may be on the same bed, or on a small coal which usually underlies the Pocahontas bed a short distance.

The Pocahontas coal shows in outcrop at water level on Tommy Creek from near the mouth of Stone Coal Creek to Meadow's mill, above Bragg Branch. The outcrop is of such a nature that the full thickness of the coal is not exposed at any point. A short distance below Bragg Branch an opening has been made on this bed, which shows 3 feet 6 inches of coal (section 159), and another one near Meadow's mill shows the coal with a slightly increased thickness (section 160). At the latter point the small coal bed which usually accompanies the Pocahontas coal in this region is exposed directly beneath the opening on the principal bed. The lower coal is too thin to be of commercial value, and it is interesting only as affording a means of identifying the Pocahontas bed. The best means of identification is the comparison of fossil plants, which are very abundant in the roof shales of the Pocahontas coal, but this requires a close and detailed acquaintance with fossil plants, which few possess.

Pocahontas bed usually accompanied by a small coal seam.

Below the mouth of Stone Coal Creek the Pocahontas coal dips beneath the level of the stream, but it reappears near the mouth of Devil Fork. In passing up the latter stream, the coal is first exposed at the mouth of Bee Tree Branch, where it has the thickness shown in section 161. This section is reported by the Flat Top Association. It seems probable that it represents the total thickness of the bed, without taking account of the small streak of bony coal which commonly occurs near the top of the bed in this region. Section 162 shows the reported thickness of the coal in an opening located about a mile above the section last described. This section shows practically the same total thickness that is shown in 161, and like that section, it fails to show any impurities in the coal. Section 163 was measured by the writer in an opening near the mouth of Bluff Fork, and it will be noticed that it carries a notable amount of bone or impure coal.

On Gooney Otter Creek the Pocahontas coal rises from water level a short distance below Jim Branch. Its outcrop extends up Noseman Branch nearly to its head, where the coal has the thickness shown in section 164. This section is reported by the Flat Top Association, and it evidently ignores the partings in the coal.

Section 165 is the reported thickness of the coal at an opening on one of the head branches of Rich Creek 1½ miles southwest of Old Bluff. This section shows the beginning of the great increase in thickness which this coal bed undergoes in passing southwest toward the region of its greatest development on Bluestone River and Elkhorn Creek.

Many openings have been made in the territory south of this division, but they show the Pocahontas coal bed in essentially the same condition as it is on the headwaters of Barker Creek.

A small coal bed which appears to belong about 50 feet below the Pocahontas coal was observed in a number of localities in this region, but it is too small to be of much value. Section 166 represents this coal as it shows in the opening at Meadow's mill on Tommy Creek.

Division I.—The rocks exposed in this division lie in the lower part of the coal-bearing series and in the red shales of the Mississippian series. The Raleigh sandstone occurs in a few places in this area, but it seems probable that the Beckley coal, which belongs at the base of this prominent stratum, is either wanting or too thin to attract attention.

The Quinnimont is the highest known coal horizon. It is of workable thickness on Boyer Fork of Piney Creek, in the northwestern corner of this division. It maintains a fair thickness toward the head of the stream, as shown by section 167, which was measured in that locality. The outcrop of this coal was observed in a number of other places, but at no point does it seem to attain great thickness. Its horizon shows in many places north of Flat Top Mountain, but erosion has removed it in many localities, leaving the heavy underlying sandstone at the surface of the plateau.

The Pocahontas coal is known on the headwaters of Camp Creek, on the eastern side of Flat Top Mountain. Section 168 is from an opening 3 miles northeast of Old Bluff, on what is presumably the Pocahontas coal, but the determination is only provisional and can not be relied upon as showing the condition of this famous coal bed in that region. The coal loses its importance in passing to the east, and in the zone of transition it is difficult to determine its value.

Much time and money have been expended in searching for the Pocahontas coal on New River, but without success. Coal beds are generally looked upon as continuous layers of carbonaceous matter that extend indefinitely in all directions. If that assumption is true the Pocahontas coal should be found on New River below the horizon of the Quinnimont coal; but exhaustive search has shown that it is not present in that part of the series. From the study of fossil plants we know that the coal bed which is so prominent in the vicinity of Pocahontas is an insignificant bed on New River—too thin to attract the attention of even the most careful prospector—and, conversely, that the coal beds which are so important in the economic resources of New River are either unimportant or entirely wanting on Guyandot River and Tug Fork.

Limited geographic extent of coal beds.

When it is understood that coal beds are simply the accumulated vegetable matter of old swamps, it will be appreciated better that they have a limited geographic range. The swamp must have had its boundaries, and in approaching these boundaries the coal becomes thinner and thinner until finally, at the outer margin of the swamp, it disappears. An extensive bed of coal means the existence in that far-off time of a large swamp, and, while it is possible that the swamps were larger than any that are known to-day, the probabilities are that the widest swamp extended for a distance of only a few miles, and that there were many swamps of limited area rather than a few swamps covering the whole Appalachian coal field.

In applying this explanation to the Raleigh quadrangle it is to be expected that the Sewell and Quinnimont coals do not extend to any great distance from New River, and that the Beckley coal is developed in a limited region on Piney Creek.

SOILS.

Soil is the residual product of the decay and disintegration of rocks, to which has been added a variable amount of partially decayed vegetable matter. In the process of soil making, the more soluble elements have been carried off in solution, leaving the more insoluble parts, principally sand and clay, to form the soil. In regions where there are many kinds of rocks exposed at the surface, the soils show a corresponding variation, but not to the extreme limits of variation of the original rocks. In the Raleigh quadrangle the rocks are so similar in composition that the soils are practically the same throughout the entire area, except where the surface rock is a coarse, friable sandstone. The value of the land for agricultural purposes is determined more by the surface relief and by the condition of the streams than by the original composition of the underlying rocks, except in the small area southeast of Flat Top Mountain, where the red calcareous shales of the Bluestone formation produce the best natural soils of the quadrangle.

On account of the absence of hills and deep, sharp valleys, the plateau region in the vicinity of Oak Hill and Beckley is better adapted to farming than any other lands north of Flat Top Mountain. The same would be true for the nearly level country from Shady Spring to Flat Top were it not for the fact that this level country is floored by a coarse sandstone which yields only a scanty soil, even though the creeks are sluggish and much vegetable matter has accumulated in their upper courses.

The sluggish condition of Marsh Fork in the vicinity of Trap Hill has produced some valuable meadow land in that locality, but its occurrence is limited to the flat valley of the creek above the barrier of the Harvey conglomerate.

Owing to the vegetable matter which accumulated in the heavy forests that originally covered the region, the new land is very productive, but this material is soon exhausted and the soil is then thin and requires constant fertilization to produce remunerative crops.

December, 1901.

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

TOPOGRAPHIC SHEET

WEST VIRGINIA
RALEIGH QUADRANGLE

(Charleston)
(Kanawha Falls)
(Nicholas)

(Raleigh) (Hinton) (Taxewell) (Pocahontas) (Dublin)

LEGEND

RELIEF (printed in brown)

3088 — Figures (showing heights above mean sea level instrumentally determined)

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

DRAINAGE (printed in blue)

Streams

Springs

CULTURE (printed in black)

Roads and buildings

Trails

Railroads

Tunnels

Bridges

Ferries

County lines

Triangulation stations

Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
Topography by Hersey Munroe.
Surveyed in 1894-95.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

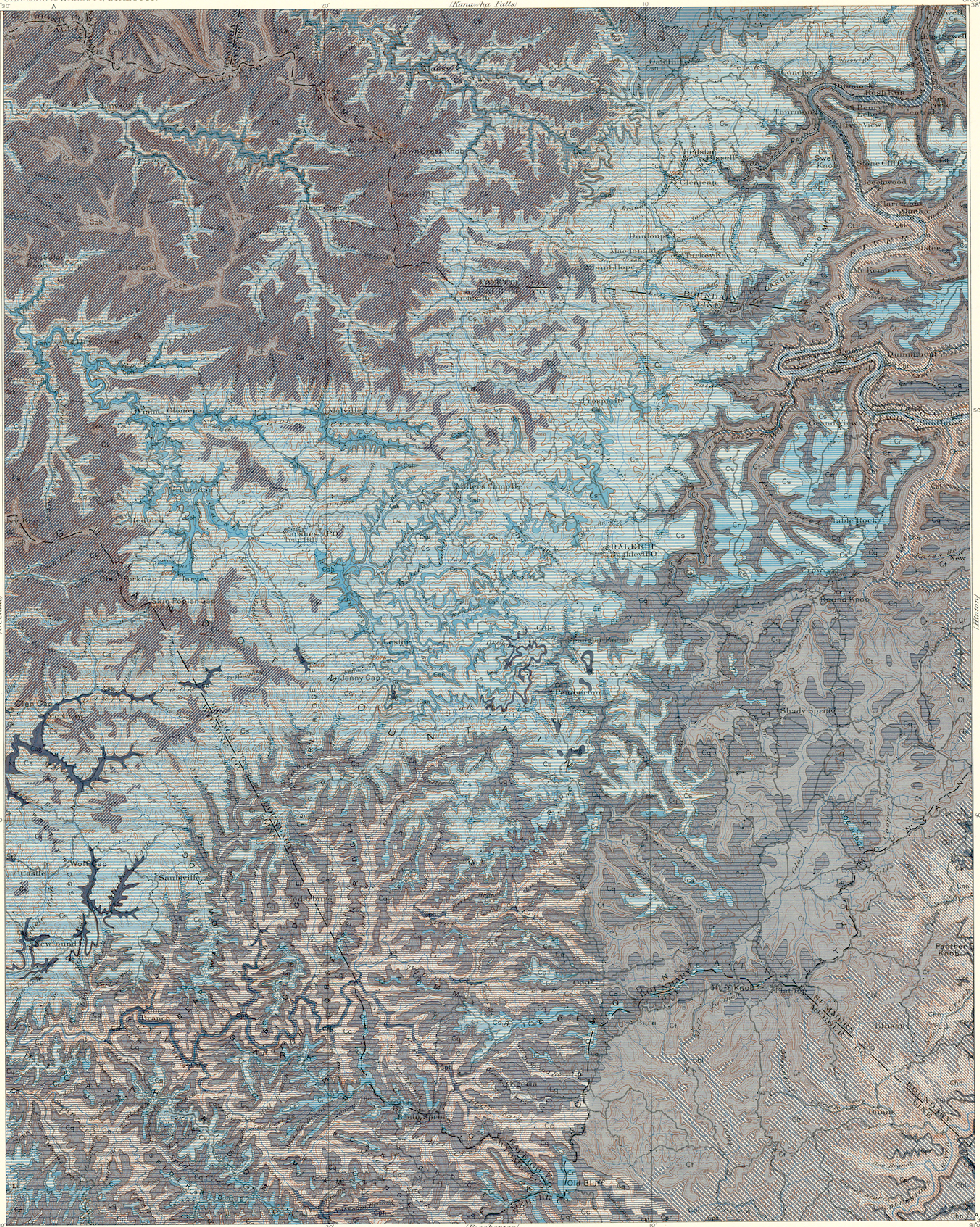
Contour interval 100 feet.
Datum is mean sea level.

Edition of May 1901.

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

HISTORICAL GEOLOGY SHEET

WEST VIRGINIA
RALEIGH QUADRANGLE



Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
Topography by Hersey Munroe.
Surveyed in 1894-95.

Scale $\frac{1}{125000}$

Contour interval 100 feet
Datum is mean sea level.

Edition of June 1901.

Geology by Marius R. Campbell,
Assisted by Walter C. Mendenhall.
Surveyed in 1894, 95, and 99.

LEGEND

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

CARBONIFEROUS

XIII and XIV (Rogers)

- **Cch** Charleston sandstone *(coarse sandstone or conglomerate with several thick beds of coal.)*
- **Ck** Kanawha formation *(sandy and argillaceous shale and soft sandstone with numerous coal beds of workable thickness.)*

XII (Rogers)

- **Cs** Sewell formation *(sandy and argillaceous shale and sandstone containing three lentils of coarse sandstone or conglomerate and the Sewell coal bed.)*

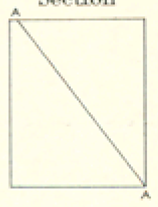
Lentils in Sewell formation

- **Csn** Nuttall sandstone lentil *(coarse sandstone or conglomerate.)*
- **Csh** Harvey conglomerate lentil *(coarse conglomerate.)*
- **Csg** Guyandot sandstone lentil *(coarse sandstone or conglomerate.)*
- **Cr** Raleigh sandstone *(coarse sandstone or conglomerate, massive along New River but thinner bedded elsewhere.)*
- **Cq** Quinnimont shale *(argillaceous and sandy shale with Quinnimont coal at the base and Beckley coal at the top of the formation.)*
- **Cc** Clark formation *(shale and sandstone.)*
- **Cph** Pocahontas formation *(shale and sandstone with Pocahontas coal at the top of the formation.)*
- **Ct** Thurmond formation *(shale and sandstone.)*

XI (Rogers)

- **Cbl** Bluestone formation *(red and green shales and green sandstone.)*
- **Cpr** Princeton conglomerate *(coarse conglomerate.)*
- **Chn** Hinton formation *(red and green shales with beds of sandstone and impure limestone.)*

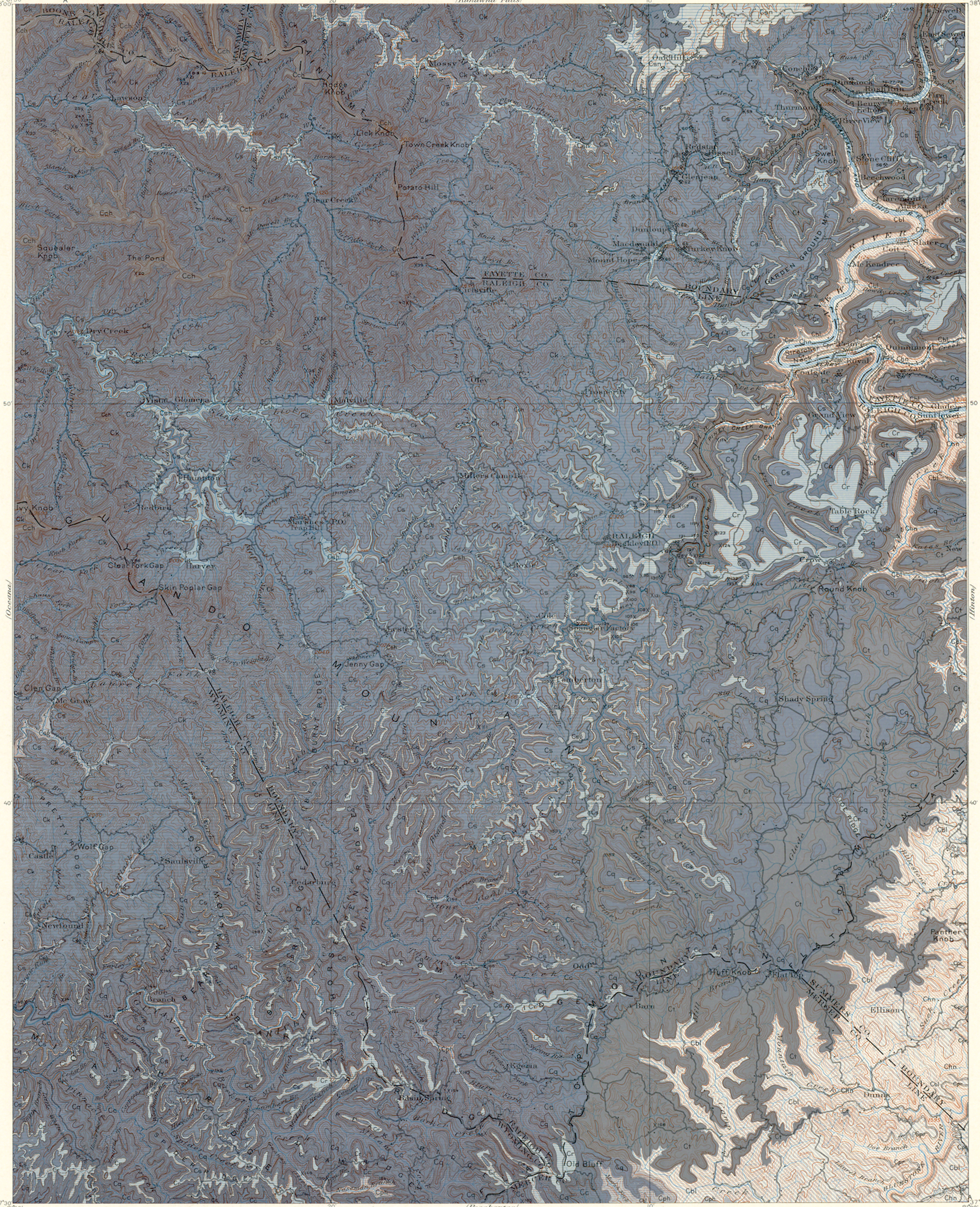
Section



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

ECONOMIC GEOLOGY SHEET

WEST VIRGINIA
RALEIGH QUADRANGLE



LEGEND

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

CARBONIFEROUS

XIII and XIV (Rogers)

Cch — Charleston sandstone *(coarse sandstone or conglomerate with several thick beds of coal.)*

Ck — Kanawha formation *(sandy and argillaceous shale and soft sandstone with numerous coal beds of workable thickness)*

XII (Rogers)

Cs — Sewell formation *(sandy and argillaceous shale and sandstone containing three lentils of coarse sandstone or conglomerate and the Sewell coal bed.)*

Lentils in Sewell formation

Csn — Nuttall sandstone lentil *(coarse sandstone or conglomerate)*

Csh — Harvey conglomerate lentil *(coarse conglomerate)*

Csg — Guyandot sandstone lentil *(coarse sandstone or conglomerate)*

Cr — Raleigh sandstone *(coarse sandstone or conglomerate, massive along New River but thinner bedded elsewhere)*

Cq — Quinnimont shale *(argillaceous and sandy shale with Quinnimont coal at the base and Beckley coal at the top of the formation.)*

Cc — Clark formation *(shale and sandstone)*

Cph — Pocahontas formation *(shale and sandstone with Pocahontas coal at the top of the formation.)*

Ct — Thurmond formation *(shale and sandstone)*

XI (Rogers)

Cbl — Bluestone formation *(red and green shales and green sandstone)*

Cpr — Princeton conglomerate *(coarse conglomerate)*

Chn — Hinton formation *(red and green shales with beds of sandstone and impure limestone)*

Section

⚒ Coal mines
× Coal prospects
(numbers refer to detailed sections on coal section sheets)

Known productive formations

Ck-Cs-Cq-Cc — *Coal* *(Kanawha, Sewell, Quinnimont, and Clark formations contain important coal seams)*

Cch-Ct — *Coal* *(Charleston sandstone and Thurmond formation contain coal seams)*

Csn-Csh-Csg Cr-Cph — *Coal* *(Nuttall, Harvey, and Guyandot lentils, Raleigh sandstone, and Pocahontas formation are associated with coal seams)*

Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
Topography by Hersey Munroe.
Surveyed in 1894-95.

Scale $\frac{1}{125000}$

Miles: 1 ½ 0 1 2 3 4 5

Kilometers: 1 ½ 0 1 2 3 4 5

Contour interval 100 feet.
Datum is mean sea level.

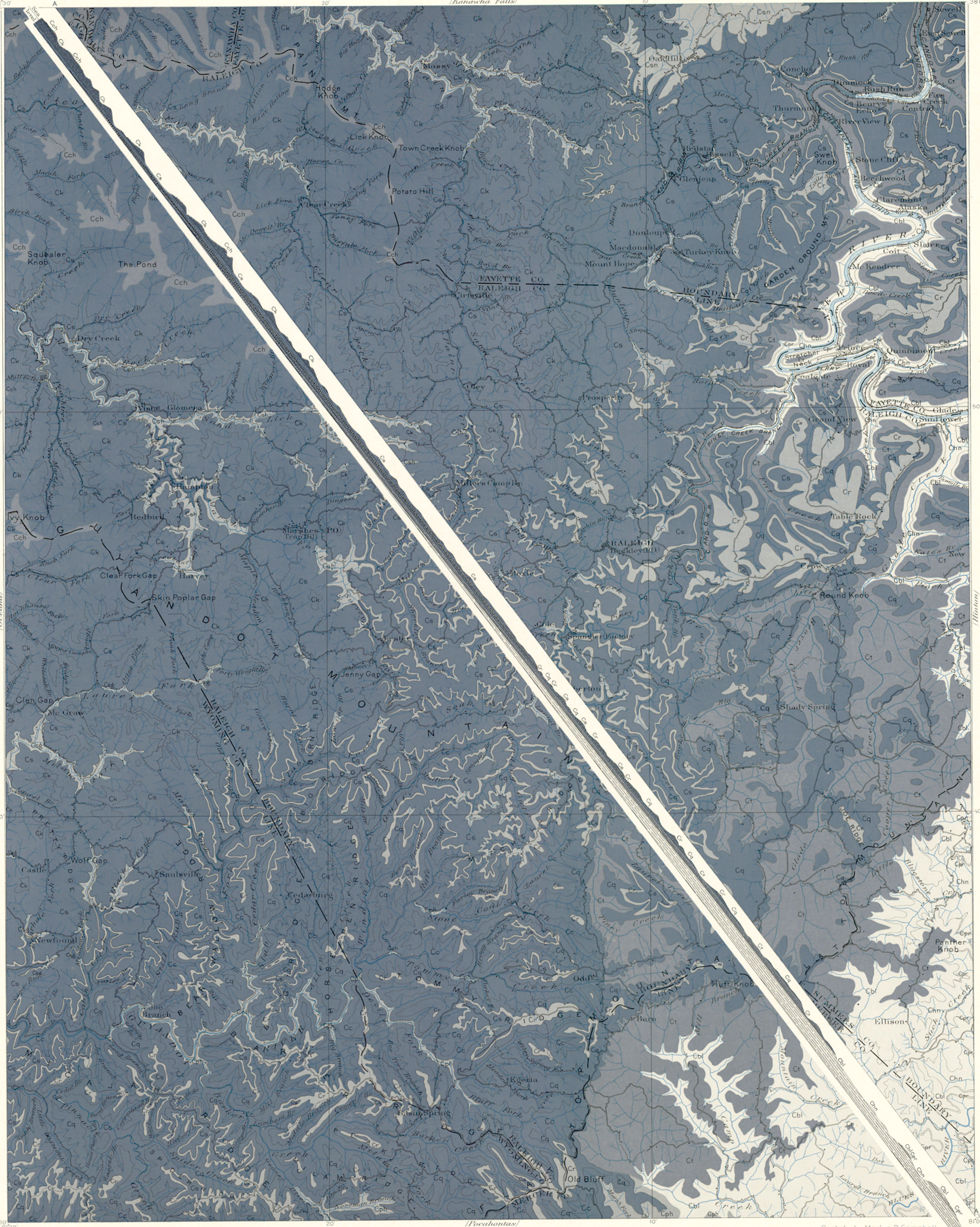
Edition of June 1901.

Geology by Marius R. Campbell.
Assisted by Walter C. Mendenhall.
Surveyed in 1894, 95, and 99.

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

STRUCTURE-SECTION SHEET

WEST VIRGINIA
RALEIGH QUADRANGLE



Henry Gannett, Chief Topographer.
H.M. Wilson, Chief Geographer in charge.
Triangulation by U.S. Coast and Geodetic Survey.
Topography by Hersey Munroe.
Surveyed in 1894-95.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Edition of Aug. 1901.

Geology by Marius R. Campbell,
Assisted by Walter C. Mendenhall.
Surveyed in 1894, 95, and 99.

LEGEND

SEDIMENTARY ROCKS

SHEET SYMBOL | SECTION SYMBOL

CARBONIFEROUS

XIII and XIV (Rogers)

Cch | Cch
Charleston sandstone
(coarse sandstone or conglomerate with several thick beds of coal)

Ck | Ck
Kanawha formation
(sandy and argillaceous shale and soft sandstone with numerous coal beds of workable thickness)

XII (Rogers)

Cs | Cs
Sewell formation
(sandy and argillaceous shale and sandstone containing three lentils of coarse sandstone or conglomerate and the Sewell coal bed)

Lentils in Sewell formation *(not differentiated on the section)*

Csn
Nuttall sandstone lentil
(coarse sandstone or conglomerate)

Csh
Harvey conglomerate lentil
(coarse conglomerate)

Csg
Guyandot sandstone lentil
(coarse sandstone or conglomerate)

Cr | Cr
Raleigh sandstone
(coarse sandstone or conglomerate, massive along New River but thinner bedded elsewhere)

Cq | Cq
Quinnimont shale
(argillaceous and sandy shale with Quinnimont coal at the base and Beckley coal at the top of the formation)

Cc
Clark formation
(shale and sandstone)

Cph
Pocahontas formation
(shale and sandstone with Pocahontas coal at the top of the formation)

Ct | Ct
Thurmond formation
(shale and sandstone)

XI (Rogers)

Cbl | Cbl
Bluestone formation
(red and green shales and green sandstone)

Cpr | Cpr
Princeton conglomerate
(coarse conglomerate)

Chn | Chn
Hinton formation
(red and green shales with beds of sandstone and impure limestone)

Known productive formations

Ck-Cs-Cq-Cc
(Kanawha, Sewell, Quinnimont, and Clark formations contain important coal seams)

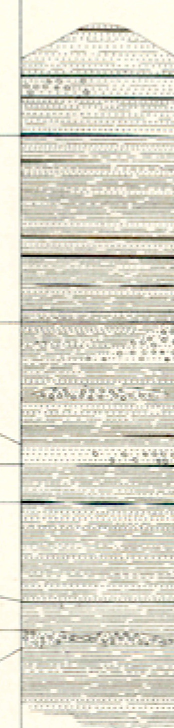
Cch-Ct
(Charleston sandstone and Thurmond formation contain coal seams)

Csn-Csh-Csg
Cr-Cph
Coal
(Nuttall, Harvey, and Guyandot lentils, Raleigh sandstone, and Pocahontas formation are associated with coal seams)

COLUMNAR SECTION SHEET

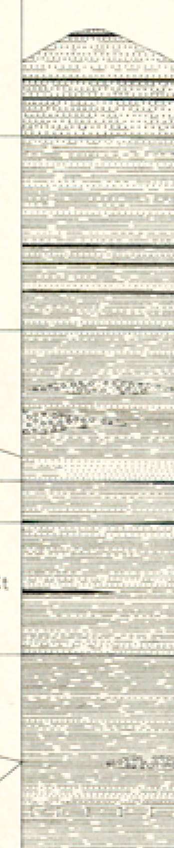
GENERALIZED SECTION FOR THE NORTHERN HALF OF THE RALEIGH QUADRANGLE.

SCALE: 1 INCH = 1000 FEET.

Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
CARBONIFEROUS	Charleston sandstone.	Cch		500+	Coarse sandstone with several thick seams of coal. Contains some conglomerate in the ridge north of Lawson.	Caps the summits of Guyandot, Pond, and Paint mountains.
	Kanawha formation.	Ck		1000±	Sandy and argillaceous shales and soft sandstone with numerous seams of coal, many of which are of workable thickness. Grades imperceptibly into the Sewell formation, except in the vicinity of Oak Hill.	Forms the rough mountainous region in the northwest corner of the quadrangle. Soil is thin and slopes are too steep to be cultivated.
	(Nuttall sandstone lentil.)	(Csn)		(0–200)	Massive sandstone or conglomerate.	The Nuttall sandstone forms high cliffs in the vicinity of Oak Hill. Soil is very sandy.
	(Harvey conglomerate lentil.) Sewell formation.	(Csh) Cs		(0–50) 600–625	Massive conglomerate. Sandy and argillaceous shale and sandstone. Sewell coal near the base.	Forms slopes of most of the uplands about Oak Hill, Beckley, and Trap Hill. Surface rolling and well disposed for farming. Soil is thin and poor.
	Raleigh sandstone.	Cr		75–150	Coarse sandstone or massive conglomerate.	Makes prominent cliffs along New River in the vicinity of Quinnimont.
	Quinnimont shale.	Cq		180–200	Sandy shale. Beckley coal at the top and Quinnimont coal at the base.	Forms steep slopes along New River and its tributaries.
	Thurmond formation.	Ct		450–550	Sandstone and shale.	Forms steep slopes along New River and its tributaries.
	Bluestone formation.	Cbl		180	Red and green shale and soft green sandstone.	Forms steep slopes along New River and its tributaries. Soil good.
	Princeton conglomerate.	Cpr		0–50	Coarse conglomerate.	Cliffs along New River above McKendree.
	Hinton formation.	Chn		450+	Red and green shale with beds of sandstone and impure limestone.	Forms steep slopes along New River and its tributaries. Soil good.

GENERALIZED SECTION FOR THE SOUTHERN HALF OF THE RALEIGH QUADRANGLE.

SCALE: 1 INCH = 1000 FEET.

Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
CARBONIFEROUS	Charleston sandstone.	Cch		500+	Coarse sandstone with several thick seams of coal.	Caps the summits of Guyandot Mountain.
	Kanawha formation.	Ck		1000±	Sandy and argillaceous shales and soft sandstone with numerous seams of coal, many of which are of workable thickness. Grades imperceptibly into the Sewell formation.	Forms the rough upper slopes of Guyandot Mountain. Soil is thin and slopes are too steep to be cultivated.
	Sewell formation. (Harvey conglomerate lentil.) (Guyandot sandstone lentil.)	Cs (Csh) (Csg)		650–700 (0–50) (0–100)	Sandy and argillaceous shale and sandstone. Massive conglomerate. Coarse sandstone or conglomerate.	Forms slopes of most of the upland about Beckley, Trap Hill, and McGraw. Surface rolling, about Beckley and Trap Hill. Soil is thin and poor.
	Raleigh sandstone.	Cr		75–150	Coarse sandstone.	Plateau surrounded by cliffs east of Beckley; not prominent in Guyandot Valley.
	Quinnimont shale.	Cq		200–225	Sandy shale. Beckley coal at the top, and Quinnimont coal at the base.	Rolling land east of Beckley and Pemberton. Steep slopes along Guyandot River.
	Clark formation. } Thurmond formation. Pocahontas formation. }	Cc } Ct Cph }		350–375 } 600–725 325–350 }	Sandstone and shale with Pocahontas coal seam near the middle of the formation.	Rolling land east of Beckley and Barn. Steep slopes along Guyandot River.
	Bluestone formation.	Cbl		400–700	Red and green shale and soft green sandstone.	Valleys and ridges southeast of Flat Top Mountain. Soil good.
	Princeton conglomerate.	Cpr		0–50	Coarse conglomerate.	Cliffs along Bluestone River.
	Hinton formation.	Chn		500+	Red and green shale with beds of sandstone and impure limestone.	Steep slopes along Bluestone River. Soil good.

NAMES OF FORMATIONS.

Period.	Names and Symbols used in this Folio.		Marius R. Campbell: Pocahontas Folio, U. S. Geological Survey, 1896.	Marius R. Campbell: Charleston Folio, U. S. Geological Survey, 1901.	Marius R. Campbell and Walter C. Mendenhall: Geologic Section along New and Kanawha Rivers in West Virginia, Seventeenth Annual Report, U. S. Geological Survey, 1896.	I. C. White: West Virginia Geological Survey, Vol. I, 1899, and Bull. 65, U. S. Geological Survey, 1891.	W. B. Rogers: Geology of the Virginias, 1884.
CARBONIFEROUS	Charleston sandstone.	Cch		Charleston sandstone.	Charleston sandstone.	Mahoning sandstone. (Elk River series.)	Lower Barren group. XIV.
	Kanawha formation.	Ck		Kanawha formation.	Kanawha formation.	Allegheny River Coal series.	Lower Coal group. XIII.
	(Nuttall sandstone lentil.)	(Csn)			Fayette sandstone.	Homewood sandstone.	
	Sewell formation.	Cs	Sewell formation.	Sewell formation.	Sewell formation.		
	(Harvey conglomerate lentil.)	(Csh)					
	(Guyandot sandstone lentil.)	(Csg)					
	Raleigh sandstone.	Cr	Raleigh sandstone.		Raleigh sandstone.	Pottsville conglomerate.	Great Conglomerate or Conglomerate Coal group. XII.
	Quinnimont shale.	Cq	Quinnimont shale.				
	Clark formation. } Thurmond formation.	Cc } Ct	Clark formation.		Royal formation.		
	Pocahontas formation. }	Cph }	Pocahontas formation.				
	Bluestone formation.	Cbl	Bluestone formation.				
	Princeton conglomerate.	Cpr	Princeton conglomerate.		Princeton conglomerate.	Mauch Chunk red shales.	Greenbrier shales. XI.
	Hinton formation.	Chn	Hinton formation.		Hinton formation.		

MARIUS R. CAMPBELL,
Geologist.

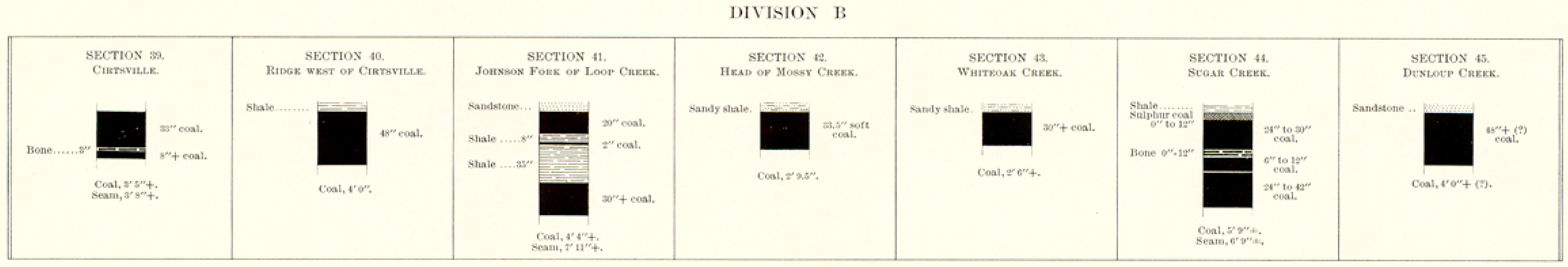
COAL-SECTION SHEET 1

SECTIONS OF COAL SEAMS IN THE RALEIGH QUADRANGLE AND VICINITY

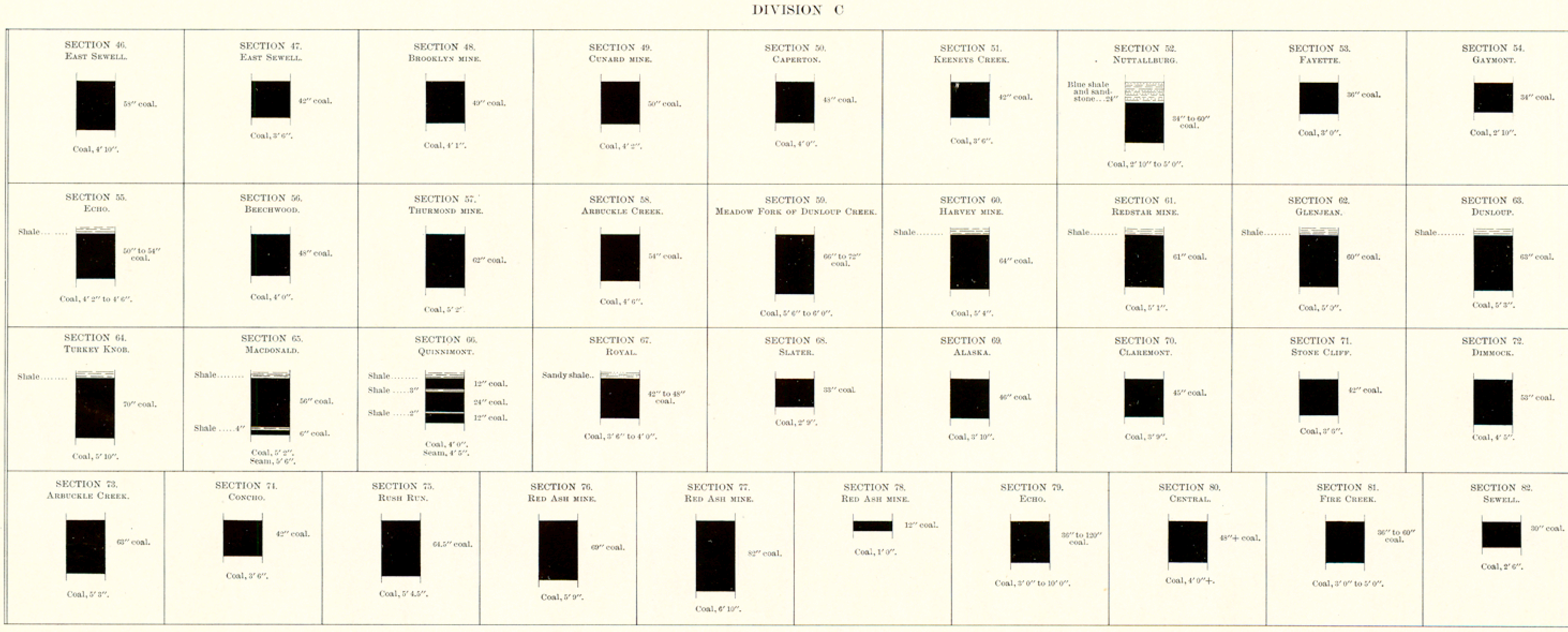
SCALE: 1 INCH = 10 FEET

DIVISION A

DIVISION B



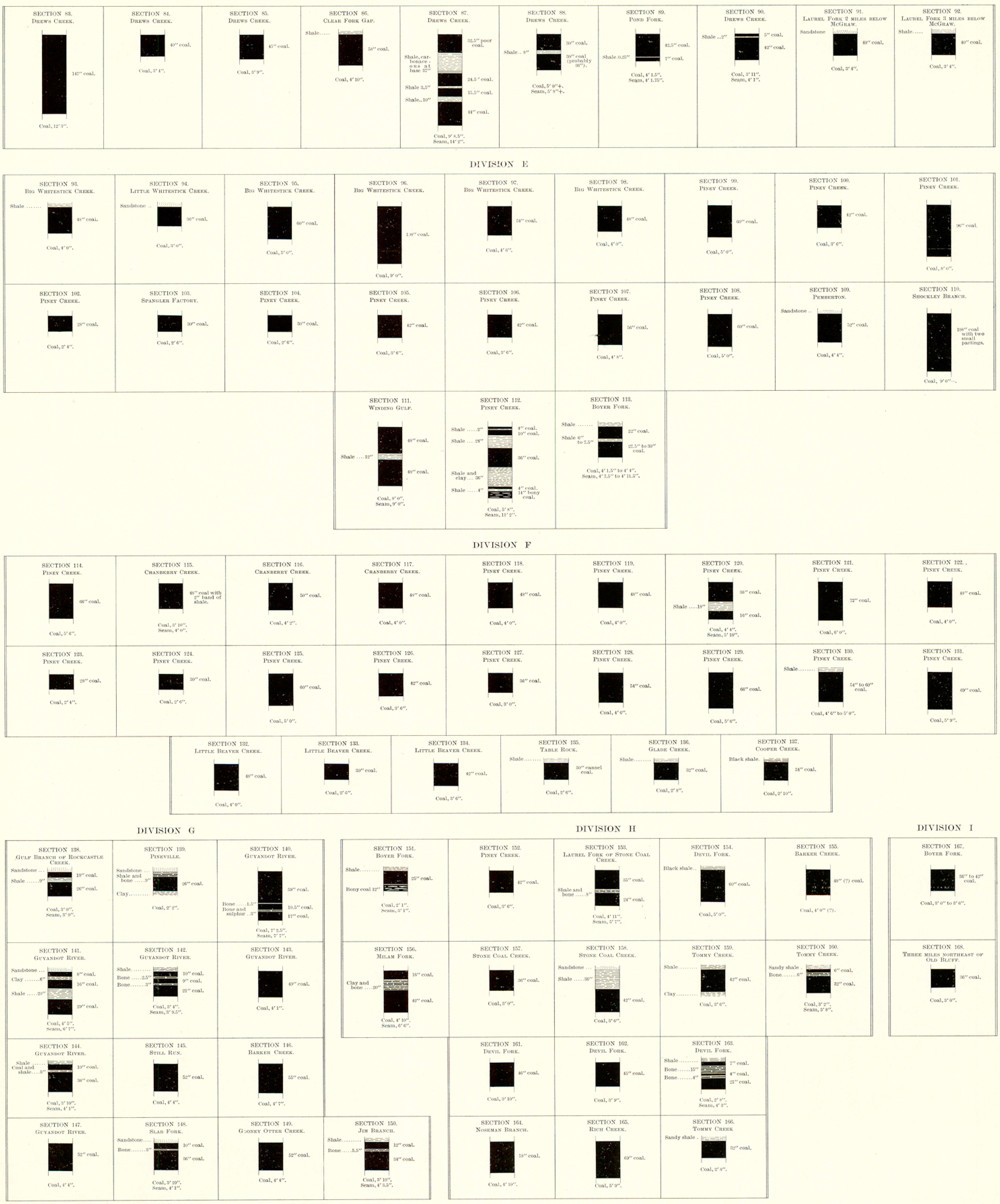
DIVISION C



COAL-SECTION SHEET 2

SECTIONS OF COAL SEAMS IN THE RALEIGH QUADRANGLE AND VICINITY

SCALE: 1 INCH = 10 FEET



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	Є	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:

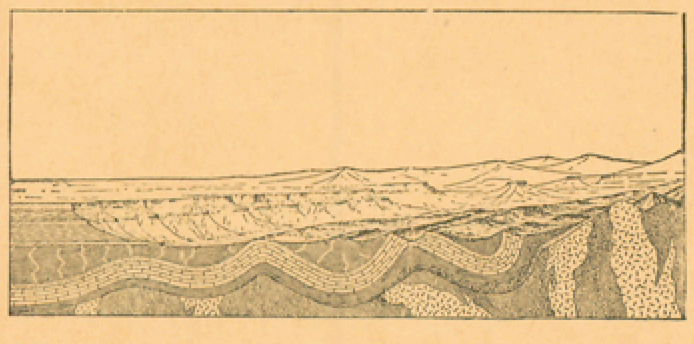


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

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:

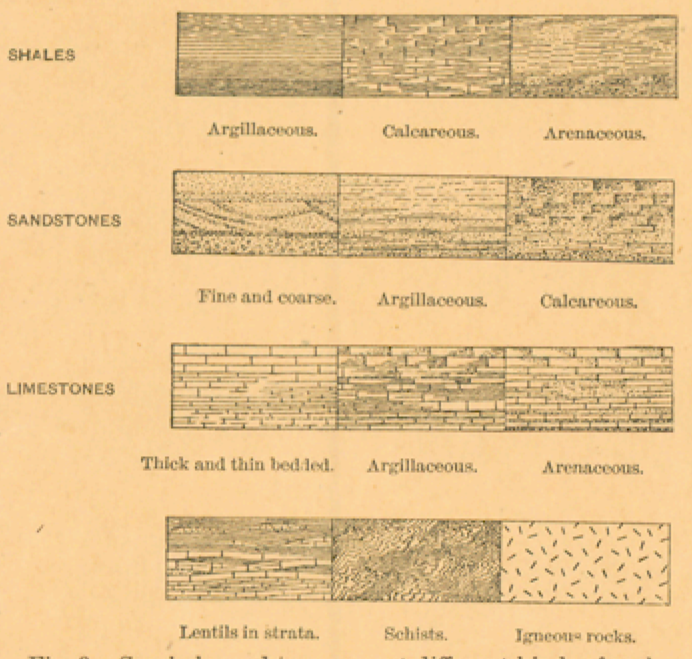


Fig. 3.—Symbols used to represent different kinds of rock.

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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