DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

BARNESBORO-PATTON FOLIO
PENNSYLVANIA

BY

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SURVEYED IN COOPERATION WITH
THE STATE OF PENNSYLVANIA

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GEOLOGIC ATLAS OF THE UNITED STATES.

The Geological Survey is making a geologic atlas of the United States, which is being issued in parts, called folios. Each folio includes topographic and geologic maps of a certain area, together with descriptive text.

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 of the most important ones 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 outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the vertical interval represented by each space between lines being the same throughout each map. These lines are called *contour lines* or, more briefly, *contours*, and the uniform vertical distance between each two contours is called the *contour interval*. Contour lines and elevations are printed in brown. The manner in which contour lines express altitude, form, and grade is shown in figure 1.

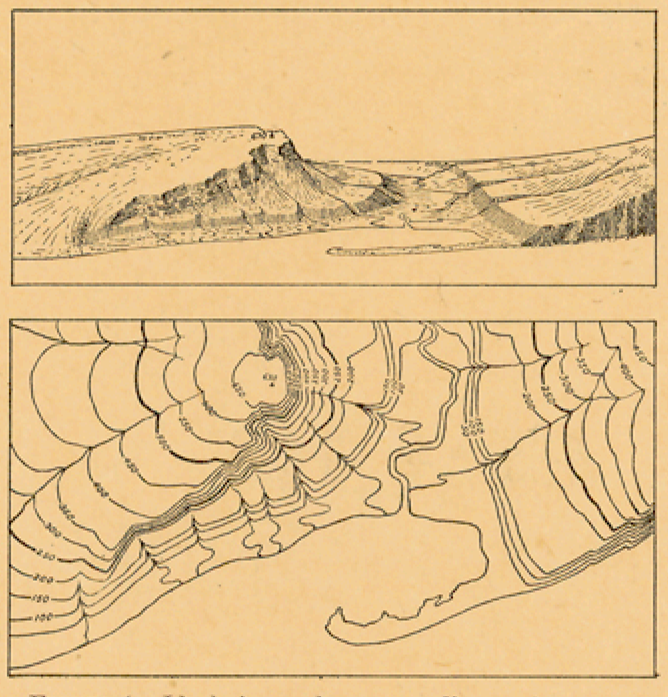


FIGURE 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly closed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle hill slope; that on the left is backed by a steep ascent to a cliff, or scarp, which contrasts with the gradual slope away from its crest. In the map each of these features is indicated, directly beneath its position in the sketch, by contour lines. The map does not include the distant portion of the view. The following notes may help to explain the use of contour lines:

1. A contour line represents a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contour lines are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above the sea—that is, this contour would be the shore line if the sea were to rise 250 feet; along the contour at 200 feet are all points that are 200 feet above the sea; and so on. In the space between any two contours are all points whose elevations are above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, and 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 the sea. The summit of the higher hill is marked 670 (feet above sea level); accordingly the contour at 650 feet surrounds it. In this illustration all the contour lines are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contour lines. The accentuating and numbering of certain of them—say every fifth one—suffices and the heights of the others may be ascertained by counting up or down from these.

2. Contour lines show or express the forms of slopes. As contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing around spurs or prominences. These relations of contour curves and angles to forms of the landscape can be seen from the map and sketch.

3. Contour lines show the approximate grade of any slope. The vertical interval between two contours is the same, whether they lie along a cliff or on a gentle slope; but to attain 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.

A small contour interval is necessary to express the relief of a flat or gently undulating country; a steep or mountainous country can, as a rule, be adequately represented on the same scale by the use of a larger interval. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the interval may be 250 feet and for less rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. For a perennial stream the line is unbroken, but for an intermittent stream it is broken or dotted. Where a stream sinks and reappears the probable underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are represented by appropriate conventional signs in blue.

Culture.—The symbols for the works of man and all lettering are printed in black.

Scales.—The area of the United States (exclusive of Alaska and island possessions) is about 3,027,000 square miles. A map of this area, drawn to the scale of 1 mile to the inch would cover 3,027,000 square inches of paper and measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and a linear mile on the ground by a linear inch on the map. 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 the inch" is expressed by the fraction $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; they are $\frac{1}{250,000}$, $\frac{1}{125,000}$, and $\frac{1}{62,500}$, corresponding approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale of $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale of $\frac{1}{125,000}$, about 4 square miles; and on the scale of $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map of the United States is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ represents one square degree—that is, a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ represents one-fourth of a square degree, and each sheet on the scale of $\frac{1}{62,500}$ one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, though they vary with the latitude.

The atlas sheets, being only parts of one map of the United States, are not limited by political boundary lines, such as those of States, counties, and townships. Many of the maps represent areas lying in two or even three States. 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 are printed the names of adjacent quadrangles, if the maps are published.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land and, by means of structure sections, their underground relations, so far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as *igneous*. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages to or nearly to the surface. Rocks formed by the consolidation of molten material, or magma, within these channels—that is, below the surface—are called *intrusive*. Where the intrusive rock occupies a fissure with approximately parallel walls it is called a *dike;* where it fills a large and irregular conduit the mass is termed a *stock*. Where molten magma traverses stratified rocks it may be intruded along bedding planes; such masses are called *sills* or *sheets* if comparatively thin, and *laccoliths* if they occupy larger chambers produced by the pressure of the magma. Where inclosed by rock molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. Where the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks that have solidified at the surface are called *extrusive* or *effusive*. Lavas generally cool more rapidly than intrusive rocks and as a rule contain, especially in their superficial parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows also are usually porous, owing to the expansion of the gases originally present in the magma. Explosive action, due to these gases, often accompanies volcanic eruptions, causing ejections of dust, ash, lapilli, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone disintegration, of volcanic ejecta deposited in lakes and seas, or of materials deposited in such water bodies by chemical precipitation are termed *sedimentary*.

The chief agent in the transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. Some of the materials are carried in solution, and deposits of these are called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the kinds of deposit named may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind, and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is loess, a fine-grained earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

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

The surface of the earth is not immovable; over wide regions it very slowly rises or sinks, with reference to the sea, and shore lines are thereby changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land areas are in fact occupied by rocks originally deposited as sediments in the sea.

Rocks exposed at the surface of the land are acted on by air, water, ice, animals, and plants, especially the low organisms known as bacteria. They gradually disintegrate and the more soluble parts are leached out, the less soluble material being left as a *residual* layer. Water washes this material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it forms *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by various processes, rocks may become greatly changed in composition and in texture. If the new characteristics are more pronounced than the old such rocks are called *metamorphic*. In the process of metamorphism the constituents of a chemical rock may enter into new combinations and certain substances may be lost or new ones added. A complete gradation from the primary to the metamorphic form may exist within a single rock mass. Such changes transform sandstone into quartzite and limestone into marble and modify other rocks in various ways.

From time to time during geologic ages rocks that have been deeply buried and have been subjected to enormous pressures, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structures may have been lost entirely and new ones substituted. A system of planes of division, along which the rock splits most readily, may have been developed. This structure is called *cleavage* and may cross the original bedding planes at any angle. The rocks characterized by it are *slates*. Crystals of mica or other minerals may have grown in the rock in such a way as to produce a laminated or foliated structure known as *schistosity*. The rocks characterized by this structure are *schists*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are many important exceptions, especially in regions of igneous activity and complex structure.

FORMATIONS.

For purposes of geologic mapping rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, an alternation of shale and limestone. Where the passage from one kind of rocks to another is gradual it may be necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation contains one or more bodies of one kind, of similar occurrence, or of like origin. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics or origin.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a varied formation, such parts are called *members*, or by some other appropriate term, as *lentils*.

AGES OF ROCKS.

Geologic time.—The time during which rocks were made is divided into *periods*. Smaller time divisions are called *epochs*.

DESCRIPTION OF THE BARNESBORO AND PATTON QUADRANGLES.[a]

By Marius R. Campbell, Frederick G. Clapp, and Charles Butts.

INTRODUCTION.

GENERAL RELATIONS OF THE QUADRANGLES.

The Barnesboro and Patton quadrangles are bounded by parallels 40° 30′ and 40° 45′ and by meridians 78° 30′ and 79° and thus comprise one-eighth of a square degree of the earth's surface, an area, in that latitude, of 453.46 square miles. They are situated in west-central Pennsylvania and include about one-half of Cambria County, parts of Indiana and Clearfield counties, and a little of Blair County. (See fig. 1.) They are named, respectively, for Barnesboro and Patton, the two principal towns in the area.

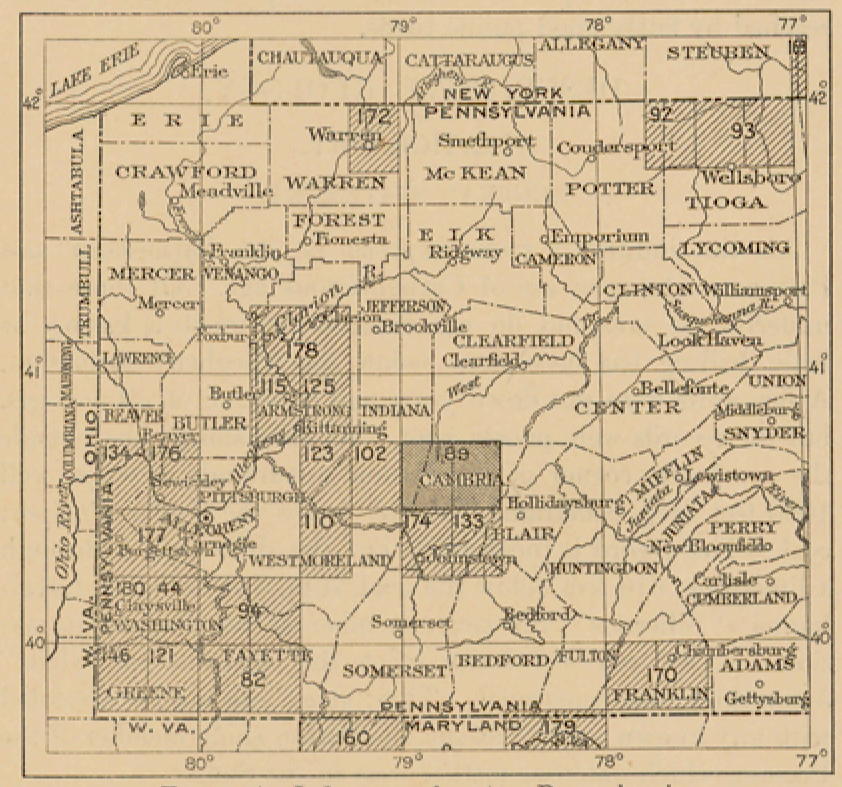


FIGURE 1.—Index map of western Pennsylvania.

The location of the Barnesboro and Patton quadrangles is shown by the darker ruling (No. 189). Published folios describing other quadrangles are indicated by lighter ruling and are listed on the back cover of this folio.

In their physiographic and geologic relations these quadrangles form a part of the Appalachian province, which extends from the Atlantic Coastal Plain to the Mississippi lowland and from central Alabama northeastward into Canada. All parts of this province have had a common history, recorded in its rocks, its geologic structure, and its topographic features.

GENERAL GEOGRAPHY AND GEOLOGY OF THE REGION.

DIVISIONS OF THE APPALACHIAN PROVINCE.

The Appalachian province is divided into two nearly equal parts by a line running along the eastward-facing escarpment known as the Allegheny Front in Pennsylvania, Maryland, and West Virginia, and the eastern escarpment of the Cumberland Plateau from Virginia to Alabama. (See fig. 2.) East of this line the rocks are greatly folded and faulted; west of it they lie nearly flat, the few folds that break the regularity of the structure being so broad that they are scarcely noticeable.

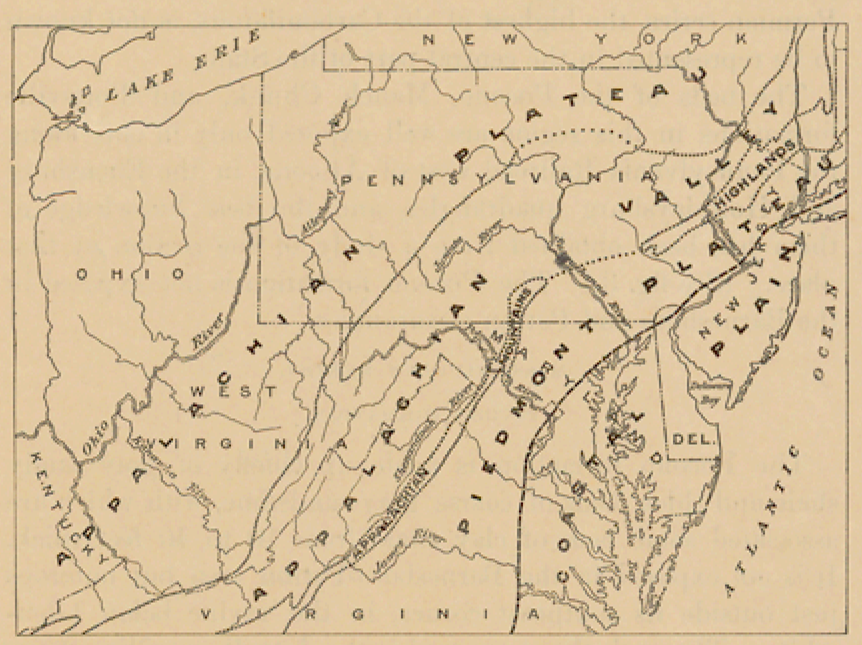


FIGURE 2.—Map of the northern part of the Appalachian province, showing its physiographic divisions and its relation to the Coastal Plain province.

Immediately east of the Allegheny Front is a belt of alternating ridges and valleys known as the Appalachian Valley. Farther east is the Appalachian Mountain belt, containing the highest and most rugged land in the province, and still farther east is a somewhat dissected upland known as the Piedmont Plateau. West of the Allegheny Front are more or less elevated plateaus, which are greatly dissected by streams and broken by a few ridges where minor folds have affected the rocks. This part of the province is called the Appalachian Plateau.

APPALACHIAN PLATEAU.

Topography.—The Appalachian Plateau is highest along its southeastern margin, where the general surface rises from an altitude of 1700 feet in southeastern Tennessee to 4000 feet in West Virginia and descends to 2400 feet in southern New York. The surface also slopes in a general way to the northwest in the northern part and southwest in the southern part.

In the southeastern part of the plateau region, in Tennessee and Alabama, is the Cumberland Plateau which stands 2000 feet above sea level; west of the Cumberland Plateau in Tennessee and Kentucky is the Highland Plateau, about 1000 feet above sea level. The region north of these well-defined plateaus as far as southern New York is greatly dissected, and the fact that it was once a plateau becomes apparent only in a view from some elevated point, from which the summits of the highest hills, rising to about the same altitude, appear to merge in the distance into a nearly horizontal surface, which is approximately the surface of the old plateau. This old plateau surface was probably a peneplain, perhaps a part of the Schooley peneplain, so named from its development on Schooley Mountain in northern New Jersey. In the Allegheny and Monongahela valleys, in western Pennsylvania, the higher divides and ridges probably coincide approximately with the surface of a second peneplain, which was developed later than the Schooley and now stands at a lower altitude. This peneplain has been named by Campbell the Harrisburg peneplain because it is well developed near Harrisburg, Pa. Along the Monongahela, Allegheny, and Ohio valleys a third peneplain, later, lower, and less extensive than the Harrisburg peneplain, has been recognized. It has been named the Worthington peneplain because it is well developed near Worthington, in Armstrong County, Pa.

The greater part of the Appalachian Plateau is drained into the Mississippi, but its northeastern part is drained either into the Great Lakes or directly to the Atlantic through Susquehanna, Delaware, and Hudson rivers. The arrangement of the drainage in the northwestern part of the plateau is due largely to former glaciation. Before the glacial epoch the streams of western Pennsylvania, West Virginia, Ohio, and northeastern Kentucky probably flowed northwestward and discharged their waters through the St. Lawrence system. The encroachment of the great ice sheet closed this northern outlet, and new drainage lines were finally established along the present courses of the streams.

Stratigraphy.—The rocks of the Appalachian Plateau are chiefly of Carboniferous age. Nearly everywhere about its margin the plateau is bordered by formations of the Devonian system, which extend beneath the Carboniferous throughout the greater part of the region. The Carboniferous system is divided into three series, the Mississippian, the Pennsylvanian, and the Permian. The rocks of the Mississippian series, the lowest of the three, are mainly sandstone and shale in the northern part of the region but include thick beds of limestone in its southern part. They outcrop around the margin of the plateau and underlie the rocks of the Pennsylvanian series in the interior of the region. The Pennsylvanian rocks are coextensive with the Appalachian coal fields. This series consists essentially of sandstone and shale, but contains extensive beds of limestone and fire clay. It is especially distinguished by its coal beds, one or more being found in nearly every square mile of its extent, from northern Pennsylvania to central Alabama. The Permian series, which consists chiefly of shale and sandstone but contains some limestone, overlies the Pennsylvanian rocks in a rudely oval area in southwestern Pennsylvania and northern West Virginia.

Structure.—For the purpose of this folio the discussion of the geologic structure may be confined to the Appalachian coal field, the structure of which is very simple, for the strata lie in a general way in a broad, flat, canoe-shaped trough, which is best developed in the northern part of the field. The axis of the trough extends southwestward from Pittsburgh across West Virginia to Huntington, on the Ohio. The beds southeast of this line dip northwestward; those northwest of it dip southeastward. In Pennsylvania the deepest part of the trough is in the southwest corner of the State, and the strata dip generally in a southwesterly direction. About the north end of this canoe-shaped trough the rocks outcrop in rudely semicircular belts and at most points dip toward the lowest part of the trough.

Although the structure is in general simple, the rocks on the eastern limb of the trough are crumpled into wrinkles or folds that make the details of the structure somewhat complicated and interrupt the regular dip. The undulations are parallel to and similar to the great folds east of the Allegheny Front but are much smaller and have not been broken by faults. These minor folds occur along the southeastern margin of the basin from central West Virginia to southern New York, and at the north end of the basin they are developed in large numbers for a considerable distance, the folded region extending at least halfway across Pennsylvania near the northern boundary of the State. In the southern part of the State there are only six pronounced anticlines, two of which disappear near the West Virginia line. Farther south their number is less, and on Kanawha River the regular westward dip is interrupted by only one or two small folds. West of the Allegheny Front each trough, as well as each arch, lies lower than the one next east, so that formations which are over 2000 feet above sea level at the Allegheny Front lie below sea level in the central part of the basin.

TOPOGRAPHY.

RELIEF.

The area included in the Barnesboro and Patton quadrangles is wholly in the Appalachian Plateau, its southeast corner lying on the summit of the mountainous escarpment commonly known as the Allegheny Front. The surface of the quadrangles is generally hilly and the summits range in altitude from 1500 to 2400 feet above sea level. The old surface of the upland or plateau, represented by hilltops that are of nearly concordant altitude, stands 1700 to 1800 feet above sea level in the northern part of the area and 1900 to 2000 feet above in the southern part. Three low, broad highland ridges that trend northeast and southwest rise several hundred feet above the upland. The upland surface is much dissected by valleys cut to a depth of 300 to 500 feet.

The greater part of the upland is characterized by rather softly rounded outlines and gentle slopes. The level areas are few and small, the hilltops rounding more or less imperceptibly into the valley slopes. In some parts of the area, however, notably in the southern part of the Barnesboro quadrangle, the altitude and form of the upland surface are controlled by a massive sandstone which is so resistant to erosion that wherever it occurs the surface is more nearly level and the transition to the valley slopes is more abrupt than it is elsewhere.

Higher ridges.—The easternmost of the highland ridges crosses the southeast corner of the Patton quadrangle, only about 4 miles of its length lying within the area. It forms the crest of the Allegheny Front and is the most conspicuous topographic feature of the region. Within the quadrangle the crest ranges in altitude from 2350 to 2460 feet, but farther south it is considerably higher. The highest point in the two quadrangles is a little northeast of Kittanning Gap, at the top of a hill that stands at an altitude of 2460 feet. In most places the surface of the western slope of the ridge is less rugged than that of the eastern slope, but in the Patton quadrangle, where the deep valley of Clearfield Creek has been cut close to the western foot of the ridge and runs parallel with it for several miles, this is not the case.

The next western highland ridge is the northeastern extension of Laurel Ridge of southern Pennsylvania. It extends across the area from Pindleton, in the southeastern part of the Barnesboro quadrangle, into Clearfield County, north of St. Lawrence, in the Patton quadrangle. The only considerable break in this ridge in the two quadrangles is in the vicinity of Thomas Mills, where it is cut through by Chest Creek, which flows from south to north in a deep gorge cut through the ridge.

The westernmost highland belt is a broad, flat ridge lying almost wholly in Indiana County, and having a maximum altitude of 2080 feet in the vicinity of Pineton. Northeast of

[a] Surveyed in cooperation with the State of Pennsylvania.

West Branch it gradually becomes less prominent until it is scarcely recognizable above the surface of the plateau. It is greatly dissected by the headwaters of Yellow Creek, which have cut deep gorges in its western slope and also by Little Yellow Creek, which has cut entirely across the ridge.

Valleys.—The valleys are eroded to depths of 300 to 500 feet below the upland and in their deeper parts the bottoms lie 1300 to 1400 feet above sea level. The lowest point in the area, in the valley of Two Lick Creek where it leaves the west side of the Barnesboro quadrangle, is at an altitude of about 1230 feet.

There is much difference in the shapes of the valleys in different parts of the area. In some places, especially where they cut through the highland ridges, the valleys are narrow and deep, their sides are steep, and their bottoms contain little or no flood plain. In other areas, particularly in the northeastern part of the Patton quadrangle, the valleys are broad and flaring, their sides have gentle slopes, and their flood plains are rather broad.

The bottoms of the valleys also differ in grade. The valley of West Branch of Susquehanna River, for example, in the eastern part of the Barnesboro quadrangle, is cut in relatively soft rocks, is deepened well up toward its head, and through much of its length has a rather flat slope. Yellow Creek and Little Yellow Creek, on the other hand, are cut in more resistant rocks and have a steeper and more uniform grade. Similar differences may be noted between other valleys in the area.

DRAINAGE.

The Barnesboro-Patton area extends across the divide that separates the streams flowing to the Atlantic by way of Susquehanna River from those flowing into the Allegheny and eventually to the Gulf of Mexico. The divide is sinuous, extending from Winterset, at the south side of the Patton quadrangle, northwestward through Nicktown and Spruce nearly to Purchase Line. About three-fifths of the area lies east of the divide and is drained into the Susquehanna, nearly all of it into the West Branch of that river. The slope west of the divide is drained by branches of Conemaugh River, a tributary of the Allegheny.

Susquehanna drainage.—The West Branch of Susquehanna River rises southwest of Carrolltown and flows northwestward to Garmans Mills, where it turns northward. From Elmora, almost at the head of its valley, to the point where it leaves the Barnesboro quadrangle the stream falls about 420 feet. The valley is narrow and steep walled and the river has developed very little flood plain. It drains the northeastern part of the Barnesboro quadrangle and a narrow strip along the west side of the Patton quadrangle. Its chief tributaries in the area are Moss and Cush Cushion creeks, both from the west. Beaver Run, which drains the northeast corner of the Barnesboro quadrangle, joins West Branch outside the area.

Chest Creek rises near Winterset, at the south side of the Patton quadrangle, and flows in a general northward course across the area, leaving its north side in the township of Westover. From Bradley Junction, near the head of its valley, to the point where it leaves the north side of the quadrangle it falls about 430 feet. Its valley in Cambria County is narrow and steep sided, being almost a gorge for several miles near Thomas Mills, but within a mile or so of the north margin of the quadrangle the valley widens and the stream has developed a narrow flood plain. Chest Creek drains about one-third of the Patton quadrangle in a narrow area extending north and south. The divide on the east is nowhere more than 3 miles from the stream, and it has no important tributaries on that side except Rogues Harbor Run, which enters it near the point where it leaves the quadrangle. The chief tributaries from the west are Laurel Lick and Brubaker runs.

Clearfield Creek, which drains about half of the Patton quadrangle, enters it from the south near Loretto and flows northeastward, leaving the area at the east side near Dean. It reenters the area a few miles north of Dean and flows northwestward, leaving the north side of the quadrangle near Coalport. In its course across the quadrangle it descends about 420 feet. Its main tributaries within the area are Beaverdam Run in White Township and Beaverdam Run in Allegheny Township. South Witmer Run drains a part of the north side of the quadrangle and joins Clearfield Creek outside the area. From the east the creek receives the waters of several small streams flowing down the northwest slope of Allegheny Mountain.

Both Clearfield and Chest creeks join West Branch of Susquehanna River some distance north of the quadrangles, but a little of the southeast corner of the Patton quadrangle is drained in the opposite direction by Burgoon Run and other small streams flowing down the Allegheny Front. The water of these streams eventually reaches the Susquehanna by way of Juniata River.

Allegheny drainge.—The southern and southeast-central part of the Barnesboro quadrangle and the southwest corner of the Patton quadrangle are drained by branches of Blacklick Creek, a tributary of the Conemaugh. North Branch rises southwest of Tunnel Siding and flows west-northwest nearly to the center of the Barnesboro quadrangle, where it turns south-southwest and leaves the area south of Nipton. It descends about 500 feet within the area. Elk Creek, its largest tributary in the area, rises in the western part of Cambria Township and flows west to the main stream north of Nipton. Dutch Run, the chief tributary from the north, rises northeast of Martintown and flows southward and then eastward to the main stream. South Fork of Blacklick Creek rises in the northeastern part of Cambria Township and flows southwestward, joining the main stream outside of the area.

The southwestern part of the Barnesboro quadrangle is drained by Yellow and Little Yellow creeks, both of which rise in the highland in the center of the Barnesboro quadrangle and flow southwestward to the west side of the area. Each follows a tortuous course in a valley of irregular width and character and each descends about 500 feet within the quadrangles. The valley of Little Yellow Creek is almost a gorge, especially southwest of Nolo, but that of Yellow Creek is more open.

The northwestern part of the Barnesboro quadrangle is drained by Two Lick Creek, which, like Yellow Creek, joins Blacklick Creek before reaching the Conemaugh. The stream is formed by the confluence of North and South branches, about a mile north of Mitchells Mills, and flows in a general westward direction to the border of the area through a deep, tortuous gorge. Above their confluence the valleys of the two branches are more open and South Branch receives a number of small tributaries from each side. Each of the branches descends about 300 feet to their confluence and the united stream descends about 70 feet more to the place where it leaves the area, at the lowest point in the quadrangles.

Relation of drainage to geology.—The streams of the area differ considerably in their relation to geologic structure. In a general way they fall into two classes—those which are consequent upon the structure and those which appear to be independent of it.

The courses of several of the larger streams, especially Clearfield, Blacklick, and Yellow creeks, follow in a general way the axes of synclines. Clearfield Creek, from its source near Munster to Frugality, 2 miles northeast of Dean, follows the eastern edge of the Wilmore syncline, but near Frugality it takes a northwesterly course and continues in that direction to Coalport. In changing its direction it crosses from the east side of the Wilmore syncline to the west side of the Bradley syncline, but this change of course is not out of harmony with the structure, as the Ebensburg anticline, which separates the two synclines in the area on the southwest, dies out near St. Augustine and the two are united. Beaverdam and Slate Lick runs follow closely the axis of the Bradley syncline. Similarly, the course of North Branch of Blacklick Creek follows approximately the axis of the Barnesboro syncline. The coincidence is very close in the vicinity of Nipton, and it is possible that in its downcutting the stream has shifted its course to conform to the troughlike structure of a thick bed of sandstone which there lies at the surface.

Yellow Creek below the junction of Laurel Run flows in a general way in the Brush Valley syncline, but above the junction it is located on the west flank of the Nolo anticline.

Of the streams that disregard the structure Chest Creek is the most prominent example. It rises near the crest of the Ebensburg anticline and flows to the axis of the Bradley syncline, which it follows as far as the mouth of Laurel Lick Run. Below Patton it turns slightly northwestward across the Laurel Hill anticline in a valley 500 feet deep and only three-quarters of a mile wide from hilltop to hilltop. This apparently abnormal course is not due to the presence of soft rocks, for some of the hardest sandstone in the region outcrops in the gorge. On reaching the Barnesboro syncline near Garway the creek turns northeastward and for some distance follows the soft rocks of the syncline. West Branch of Susquehanna River displays a similar though not so striking independence of structure. It rises on the Laurel Hill anticline and flows northwestward and northward, with the dip, into the Barnesboro syncline. In its northerly course it crosses the low eastern end of the Nolo anticline and then continues along the broad, flat bottom of the Brush Valley syncline. Little Yellow Creek follows the crest of the Nolo anticline for about 4 miles and then turns westward to the Brush Valley syncline. The courses of these streams, so different from what would seem to be their normal courses, are explained under the heading "Geologic history." Briefly, they were acquired before the present valleys were carved, at a time when the general surface was so nearly featureless that the hard rocks interposed no barriers to the paths of the streams.

CULTURE.

The quadrangles are settled throughout but the strictly rural population is rather sparse, the greater number of the inhabitants being concentrated in the large mining towns, of which the chief are Patton, Barnesboro, Spangler, Hastings, and Coalport. Smaller towns and villages are situated here and there, the largest being Carrolltown, Cherrytree, Loretto, Belsano, and Chest Springs.

The principal occupations are agriculture and coal mining. There is a little manufacturing in the larger towns, especially of clay products, but mining is the chief industry aside from farming.

The territory is reached by branch lines of the Pennsylvania and the New York Central railroads. The branch of the Pennsylvania enters the area from the south, leaving the main line at Cresson, and the New York Central enters it from the north, one line running up Chest Creek to Patton and another up West Branch of Susquehanna River to Cherrytree. Each road has built a number of branch lines to develop the coal resources of the region. Most of these lines follow the valleys, but some have been built across country, connecting the different valleys with a network of roads. The grade of these lines is rather heavy, but not so heavy as to make their operation unprofitable. The most recent line of this sort is one built westward from Cherrytree by the two systems jointly. It runs across the summit, down Two Lick Creek, and westward outside of the area, with a branch from Two Lick Creek to Possum Glory. It serves as an outlet for the whole northwest corner of the Barnesboro quadrangle and many new coal mines have been opened along it. All parts of the area are reached by fairly good public roads.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

GENERAL STATEMENT.

All the indurated rocks exposed in the Barnesboro and Patton quadrangles are of Carboniferous age. Of those that underlie the area but do not outcrop not much is known, as little drilling has been done below the Allegheny formation. A few wells were put down years ago in search of oil and gas, but the records were poorly kept. At Ebensburg, just outside the southwest corner of the Patton quadrangle, a water well 1000 feet deep penetrated 730 feet below the Upper Freeport coal. The record is incomplete, but the drill passed through a limestone, 610 feet below the coal, supposed to be the Loyalhanna ("Siliceous") limestone member of the Pocono formation. At a depth of 105 feet below the limestone red "slate," 5 feet thick, was penetrated. This "slate" can not be correlated with any known red bed except the Patton shale member of the Pocono, which outcrops farther west in the State.

All the formations from the Upper Freeport coal down to the Cambrian limestone, comprising a total thickness of probably 18,000 feet, are exposed along the eastern slope and east of the base of the Allegheny Front. As the beds dip to the northwest it is probable that all of them, as well as other formations older than the limestone and not exposed in the Nittany Valley, underlie the Barnesboro-Patton area. Most of the beds lie so deep that they are of no economic value or interest in the area, so they will not be considered further, and the stratigraphic description will begin with the Mississippian rocks, which are only a few hundred feet below the bottoms of the deeper valleys in the Barnesboro and Patton quadrangles.

ROCKS NOT EXPOSED.

CARBONIFEROUS SYSTEM.

The rocks of the Carboniferous system in central Pennsylvania are divided into the Pocono, Mauch Chunk, Pottsville, Allegheny, Conemaugh, and Monongahela formations, named in ascending order. The lower two constitute the Mississippian series and the upper four the Pennsylvanian series. The Permian series, the highest of the Carboniferous, is not known to be represented in the central part of the State.

The beds of the Pocono, Mauch Chunk, and Pottsville formations in this region are well exposed only in cuts along the Pennsylvania Railroad west of Altoona, in the Ebensburg and Hollidaysburg quadrangles, and the best knowledge of them has been obtained from a study of the section at that place. (See fig. 3.) The Pocono formation is not exposed in the Barnesboro and Patton quadrangles.

MISSISSIPPIAN SERIES.

POCONO FORMATION.

The Pocono formation is made up chiefly of gray sandy shale and thick beds of coarse gray sandstone, with which are associated some beds of clay shale from 10 to 40 feet thick. It is not exposed in the Barnesboro-Patton area but outcrops just outside its southeast corner, in the ravine below Glenwhite. The rock there exposed is the Loyalhanna limestone, which in the State reports was classed as part of the Mauch Chunk formation. It is now regarded as the uppermost member of the Pocono, as it lies directly upon the Burgoon sandstone, which it resembles more closely than it does the overlying red shale and green sandstone of the Mauch Chunk formation.

The whole thickness of the formation is well exposed along the Pennsylvania Railroad between Allegrippus and the curve where the track enters the gorge of Sugar Run. The northwestward dip of the beds ranges from 5° at Allegrippus to 10° at the lower end of the section. The thickness of the formation in this section (see fig. 3) is 1030 feet.

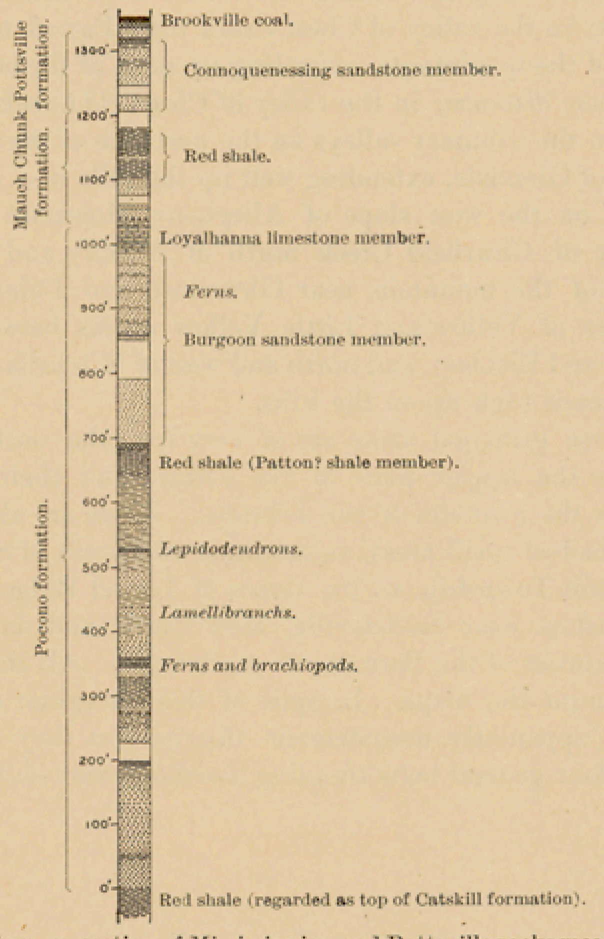


FIGURE 3.—Columnar section of Mississippian and Pottsville rocks measured along Pennsylvania Railroad on the Allegheny Front west of Altoona by Charles Butts.

At the base of the section there is 50 feet of soft red shale, regarded as forming the top of the Catskill formation. Above this shale is 180 feet of coarse sandstone, which is divided by a thin bed of red shale 50 feet from its bottom. The sandstone is overlain by about 530 feet of alternating shale and sandstone, prevailingly gray but containing beds of red shale and red sandstone and scattered beds of clay.

Patton ? shale member.—The top member of the mass of shale and sandstone just described is a bed of red shale about 40 feet thick. This has the same stratigraphic relations as the Patton shale of the Allegheny Valley and may be the equivalent of that bed, which is of considerable importance as a horizon marker. The top of this red shale is at track level 3000 feet east of Allegrippus.

Burgoon sandstone member.—Immediately upon the red shale lies 300 feet of coarse and very thick bedded gray sandstone, which is continuously exposed along the track from the top of the red shale member to Allegrippus, except in a concealed interval of about 60 feet in a small ravine. The rocks in this interval may include some shale, but they probably consist chiefly of sandstone. Thin layers and lenses of gray shale occur throughout the sandstone, and one of these, about 100 feet above the base, includes a coal bed 8 inches thick. The top of the sandstone is definitely marked by a peculiar-looking calcareous bed (Loyalhanna limestone member), which lies 10 feet above the railroad track in the cut just east of Allegrippus.

The Burgoon sandstone is a well-defined lithologic unit. In the western part of the State it is known to drillers as the Mountain sand and the Big Injun sand, but in the region of its outcrop it had no individual name until, in the mapping of the Ebensburg quadrangle, it was named Burgoon sandstone, from Burgoon Run below Glenwhite. It is not largely exposed in the valley of Burgoon Run, but is represented on the south side by abundant bowlders of coarse siliceous sandstone and by a soil that is almost pure sand.

Loyalhanna limestone member.—Immediately upon the Burgoon sandstone on the east side of the ravine at Allegrippus lies a stratum of coarse calcareous sandstone that is marked by a peculiar cross-bedding and a brownish weathered surface pitted by differential erosion, giving it a distinctive appearance, by which it is recognized at widely separated points in western Pennsylvania. It is thus sharply distinguished from the Burgoon sandstone below it, so that the contact between the two is plainly apparent. This contact is well exposed at the west end of the cut just east of Allegrippus, where, on account of the westward dip of the strata the Loyalhanna limestone slopes so that its top, which is 10 feet above the track on the west side of the ravine at Allegrippus, is at track level about 100 feet farther west. It is rather more calcareous at this place than on the east side of the ravine, a fact that may indicate that it is more calcareous near the top than lower down. It is overlain by a few feet of rock composed of thin layers of red shale and beds of gray sandstone, upon which in turn lies a considerable thickness of coarse thick-bedded gray sandstone.

The Loyalhanna is generally known in the region of its occurrence as the "Siliceous" limestone, though it is in most places rather a calcareous sandstone. In deference to general usage it is here called a limestone and the name Loyalhanna has been applied to it, from its good development along the gorge in which the stream of that name flows across Chestnut Ridge, in Westmoreland County.

At the top of the cut just east of Allegrippus 40 feet of the Loyalhanna limestone is exposed, but it is not certain that the top of the member is exposed at that point. Its thickness, however, is probably not much more than 40 feet.

Limits of the Pocono.—In the western Pennsylvania folios already published the top of the Loyalhanna limestone is regarded as the top of the Pocono, but there is uncertainty as to the horizon or stratum that should mark the bottom of the formation. A few fossil plants, mainly lepidodendrons, found in places down to a horizon about midway between the top of the Loyalhanna limestone and the top of the basal red shale shown in the columnar section, are regarded by David White as of Pocono age. Some fragments of a lamellibranch found about 100 feet lower and several specimens of a lingula found in a green clayey layer still lower, were examined by G. H. Girty with indefinite results. Mr. Girty expresses the opinion, however, that they exhibit Devonian rather than Carboniferous affinities. Associated with the lingulas were a number of species of ferns which David White thinks may be either Carboniferous or Devonian. In the rocks from the bed containing the lingulas down to the top of the basal red shale no fossils were found, so that no paleontologic evidence is now available to fix definitely the bottom of the Pocono. On lithologic grounds, however, there seems to be only one horizon at which to separate that formation from the underlying Catskill, and that is at the top of the red shale that lies stratigraphically about 380 feet below the bed containing the lingulas. Probably 80 per cent of the rocks for 2000 feet below the top of this shale are red and are thus sharply distinguished from the overlying and underlying rocks. Hence the lower limit of the Pocono and the boundary between the Devonian and the Carboniferous is placed at the top of this red shale.

ROCKS EXPOSED.

The rocks exposed in the Barnesboro and Patton quadrangles include small areas of the Mauch Chunk and Pottsville formations on the bottoms of the deeper valleys, the greater part of the area being occupied by the Allegheny and Conemaugh formations. The general character and thickness of these formations are shown in the generalized columnar section forming figure 4.

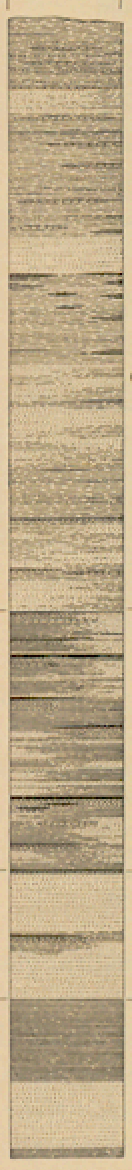
System.	Series.	Formation.	Section.	Thickness (feet).	Minor divisions.	Character of rocks.	Character of formation.
Carboniferous.	Pennsylvanian.				Little Pittsburgh ? coal.	Thin, no value.	Alternating sandstones and shales with a few thin limestones and unimportant coal beds. Includes the Mahoning, Buffalo, Saltsburg, and Morgantown sandstone members.
					Little Clarksburg ? coal.	Thin, no value.	
					Lonaconing coal.	Thin, no value.	
				(40±)	Morgantown sandstone member.	Flaggy to thick-bedded conglomeratic quartzose sandstone.	
					Ames limestone member.	Thin dark limestone with marine fossils.	
					Harlem coal.	Thin, no value.	
		Conemaugh formation.		600	"Pittsburgh red shale."	Thin sporadic lenses.	
					Maynardier ? coal.	Thin, no value.	
				(60-80)	Saltsburg sandstone member.	Thin and thick bedded coarse and fine grained sandstone. In places conglomeratic.	
					Bakerstown coal.	Thin; no value, except possibly in small areas.	
				(40 to 80)	Buffalo sandstone member.	Largely coarse thick-bedded conglomeratic quartzose sandstone.	
					Gallitzin coal.	Thin, persistent, no value.	
					Mahoning coal.	Thin, no value.	
					Mahoning sandstone member.	Thick and thin bedded, in places conglomeratic; variable in position and thickness.	
					Upper Freeport coal.	Valuable coal bed.	Shales and sandstones with several valuable coal beds and associated fire clays.
					Lower Freeport coal.	Valuable coal bed.	
					Upper Kittanning coal.	Locally valuable.	
		Allegheny formation.		300±	Middle Kittanning coal.	Thin coal, of little or no value.	
					Lower Kittanning coal.	Valuable coal bed, present throughout area.	
					Clarion coal.	Thin coal, in many places absent.	
					Brookville coal.	In many places workable.	
					Homewood sandstone member.	Very massive sandstone.	Massive sandstones, with one or more coal beds and associated fire clays and a little shale.
		Pottsville formation.		130±	Mercer coal.	Little value.	
					Mercer shale member.	Valuable in some other regions.	
					Connoquenessing sandstone member.	Massive sandstone.	
		UNCONFORMITY					
	Mississippian.	Mauch Chunk formation.		180±			Red and green shale and sandstone.

FIGURE 4.—Generalized columnar section of the rocks exposed in the Barnesboro and Patton quadrangles.
Scale, 1 inch = 200 feet.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

MAUCH CHUNK FORMATION.

The only exposures of unquestionable Mauch Chunk rocks are in the extreme southeast corner of the Patton quadrangle. The formation comprises a few feet of red and green shale resting on the Loyalhanna limestone, about 75 feet of thick-bedded fine-grained greenish sandstone, and 100 feet of red shale at the top, the total thickness being about 180 feet. Its thickness may not be uniform throughout the area, for in neighboring parts of the State it is much thinner in some places and is absent from others, where the Pottsville sandstone rests directly on Pocono strata.

A few feet of reddish and greenish shale is reported to be exposed in the bed of Chest Creek just below Thomas Mills. This shale was referred to the Mauch Chunk formation by Franklin and W. G. Platt, of the Second Pennsylvania Survey, in their report on Cambria County. No additional information regarding the character or age of the beds has been obtained, but comparison with the section at Gallitzin, on the Pennsylvania Railroad, seems to justify their assignment to the Mauch Chunk formation and they have been so mapped in this folio.

PENNSYLVANIAN SERIES.

GENERAL RELATIONS.

Almost all the strata exposed in the Barnesboro and Patton quadrangles are of Pennsylvanian age. The southeast corner of the area lies approximately at the eastern margin of the great bituminous coal field of the northern Appalachian basin, and nearly the whole of the area is underlain by coal-bearing rocks.

The Allegheny and Conemaugh formations occupy nearly the whole area of the quadrangles, but the Pottsville is exposed in a few places. The rocks are chiefly sandstone and shale, with beds of limestone in some places and at least seven fairly persistent beds of coal, most of which are in the Allegheny formation. The general sequence of the rocks is shown in the columnar section (fig. 4).

It is necessary to depend largely on drill records, mine data, and poor road sections in working out the stratigraphy, for the character of the topography is such that outcrops are rare.

Massive sandstones outcrop here and there in ledges and lines of cliffs, but more generally they appear on the surface only as bowlders, which in the course of time have worked down the slopes so that they cover not only the zone of their own outcrop but that of many beds below. This is a source of confusion in interpreting the geology, but the position of a bed that is sufficiently massive to form large blocks can generally be found by determining the upper limit of its débris.

Although the rocks have the same general relations throughout the area they show considerable difference in detail in different parts of it. Sections several miles apart and even sections within a short distance of each other are likely to exhibit differences in the character and thickness of the beds, most of which seem to be lenses. For example, a sandstone which at one locality is thick and prominent may not far away be shaly and inconspicuous. At a distance it may pass into sandy shale or even into clay shale with no sand, and still farther along the sandy phase may reappear at the same horizon. A prominent bed of sandstone may appear at a slightly different horizon from that at which a similar bed was found close by, and if the two such sandstones are correlated with each other a slight error is introduced into the determination of the stratigraphy. Just as sandstone merges into shale, so limestone gives place to shale, or the reverse. Such irregularities are characteristic of the coal-bearing rocks in the Appalachian field.

However, too much emphasis must not be placed on these irregularities. Uniform conditions seem to have prevailed throughout considerable areas at certain times, when strata of rather uniform character were deposited. Where such beds have distinguishing characteristics they serve as key rocks for determining the stratigraphic position of other beds and for working out the geologic structure, and they afford convenient division planes for geologic mapping. The Pottsville formation, Lower Kittanning coal, Lower Freeport coal, and Buffalo, Saltsburg, and Morgantown sandstones are fairly persistent strata, being distinguishable throughout a large part of the two quadrangles.

POTTSVILLE FORMATION.

The Pottsville is the lowest formation of the Pennsylvanian series and in most places rests unconformably upon the soft shale of the Mauch Chunk formation. In western Pennsylvania it generally consists of two massive sandstones and is in places conglomeratic. The lower sandstone is called the Connoquenessing, from Connoquenessing Creek, and the upper the Homewood, from the town of that name, both localities being in Lawrence County, in the western part of the State. These massive members are separated by shale of somewhat irregular thickness, which commonly contains a valuable bed of fire clay 6 feet of shale overlain by 9 feet of fire clay, at the top of which, partially included in the overlying sandstone, are small pockets of coal 2 inches thick. Some small specimens of Mercer plants were found in the shale, and these beds constitute the Mercer member of the Pottsville. Above the fire clay is the Homewood sandstone, coarse, thick bedded, and 15 feet thick. It shows well in the first cut east of Bennington and dips below track level 400 feet east of the station. Neither the Connoquenessing nor the Homewood sandstone is conglomeratic in this section.

The Pottsville formation is not well exposed in the Barnesboro and Patton quadrangles except about Glenwhite, in the southeast corner of the area. It dips northwestward and is below the surface throughout most of the area of the quadrangles, but only a few drill holes have penetrated to it. The sandstone below the Brookville coal, recorded in sections A, J, and P of figure 5, is supposed to be the Homewood.

Little is known of the Connoquenessing sandstone. Generally it is coarse and massive and ranges between 60 and 100 feet in thickness. The Homewood standstone is of the same general character but does not seem to be as uniform and in some places in the quadrangles it is not present. Along the Pennsylvania Railroad the Homewood sandstone is only 15 feet thick, but near Curwensville, 30 miles to the north, its thickness is about 60 feet.

The Pottsville outcrops at Glenwhite, on the slopes east of Dysart, and along Chest Creek north of Patton, in the Patton quadrangle, and in the valley of Two Lick Creek, at the west all the remainder except the few small areas where the Pottsville and Mauch Chunk formations are exposed. It is exposed in six principal areas—along the valley of West Branch of Susquehanna River from Tunnel Siding to a point near Cherrytree, extending up most of the side valleys well toward their heads; in the valley of Chest Creek from Patton to the north side of the quadrangle, extending up most of the lateral valleys for some distance; in the valley of Clearfield Creek below Dean and in the tributary valleys on the west side of the creek northwest of Glendale, extending well up the hills in a considerable area; on the west slope of Allegheny Mountain and in the valley of Clearfield Creek north of Amsbry and on the east slope of the mountain near Glenwhite and Delaney; in the valleys of Yellow and Little Yellow creeks between Martintown and Blaides; and north and west of Mitchells Mills, where it extends high up on the hills.

These principal areas are of very irregular outline, as they lie in the deeper parts of the valleys and their boundaries follow the contours of the hillsides. There are also a number of detached small areas, as southeast and south of St. Lawrence in Chest Township, on the slopes of Laurel Ridge in Cambria Township, near Seldersville, near Croft, and in the northwest corner of the Barnesboro quadrangle. All these areas are shown on the maps. In spite of their irregular outlines and their apparently unsystematic distribution they fall roughly into four general belts trending northeast and southwest across

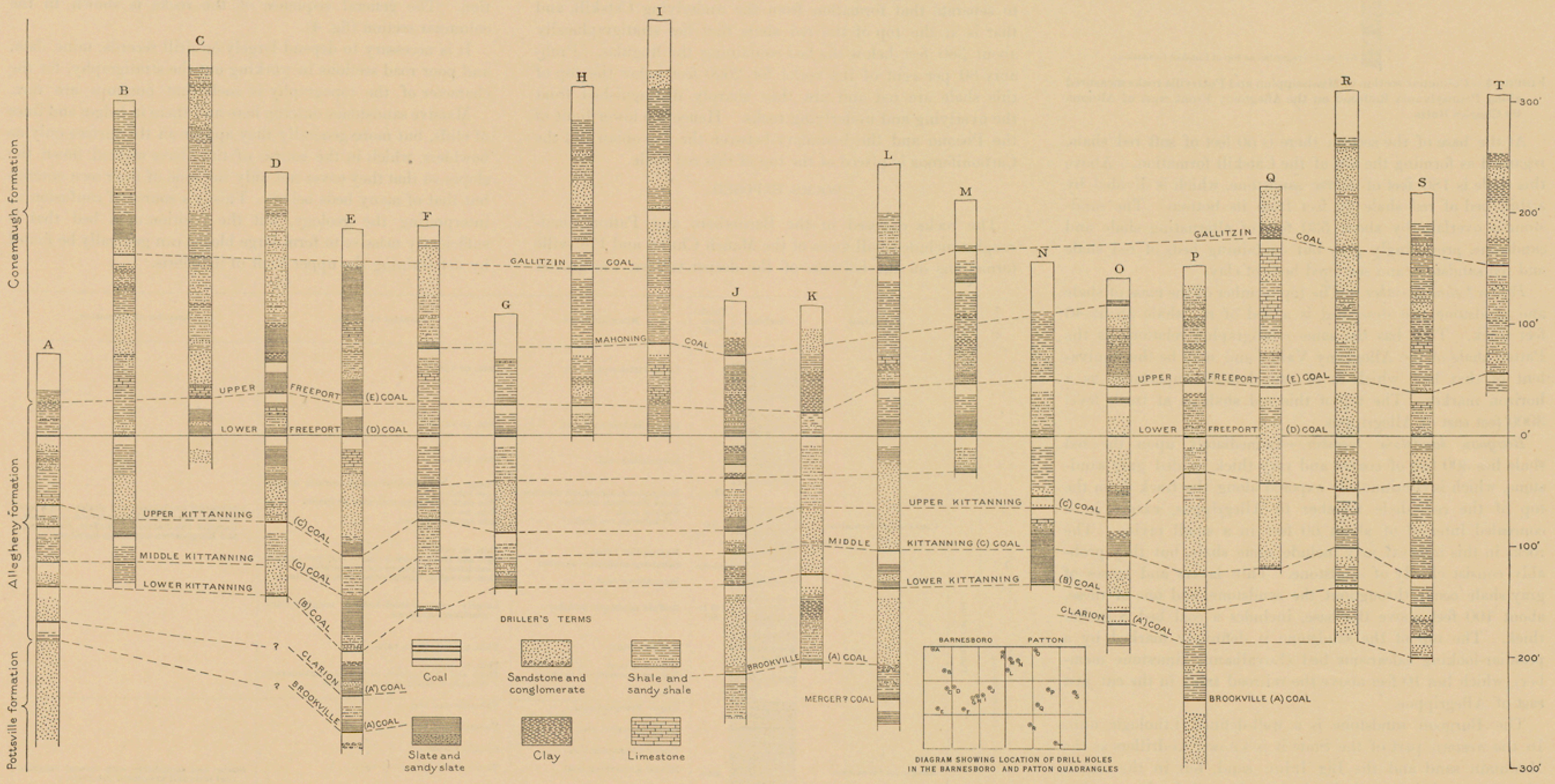


FIGURE 5.—Columnar sections of diamond-drill holes in the Barnesboro and Patton quadrangles, showing correlations of the coal beds. The thicknesses of the coals are not shown, as the records are confidential, so only the position of the top of each coal is indicated.

A.—2¼ miles northwest of Purchase Line. Altitude, 1524 feet.
B.—1½ miles southwest of Cookport. Altitude, 1500 feet.
C.—¾ mile east-northeast of Kenwood. Altitude, 1545 feet.
D.—1 mile southeast of Pine Flats. Altitude, 1515 feet.
E.—1¾ miles north of Nolo. Altitude, 1710 feet.
F.—1¼ miles east-northeast of Pineton. Altitude, 1860 feet.
G.—1¼ miles northwest of Nicktown. Altitude, 1828 feet.
H.—1¾ miles northwest of Nicktown. Altitude, 1828 feet.
I.—1¾ miles northwest of Nicktown. Altitude, 1845 feet.
J.—1½ miles west of Spangler. Altitude, 1635 feet.
K.—3 miles east-northeast of Cherrytree. Altitude, 1512 feet.
L.—½ mile east-northeast of Plattsville.
M.—1½ miles south of Sylvis. Altitude, 1666 feet.
N.—1¾ miles southwest of Garway. Altitude, 1721 feet.
O.—2 miles northeast of Garway. Altitude, 1753 feet.
P.—1½ miles northeast of Patton. Altitude, 1650 feet.
Q.—¾ mile north of Eckenrode Mill.
R.—¼ mile north of Bradley Junction. Altitude, 1768 feet.
S.—2 miles northwest of Dean. Altitude, 1440 feet.
T.—Syberton. Altitude, 1796 feet.

and in some places thin beds of coal, workable here and there. To this member of the formation, which has been recognized throughout most of western Pennsylvania and which contains a fossil flora, the name Mercer shale member has been applied, from Mercer County, where the coal beds and limestones are particularly well developed. The fire clay is known in western Maryland as the Mount Savage fire clay. It seems to be persistent throughout most of western Pennsylvania, but it has not been observed in the Barnesboro and Patton quadrangles, although it is of economic importance in neighboring regions.

The total thickness of the Pottsville formation in western Pennsylvania ranges between 80 and 250 feet. Along the Pennsylvania Railroad east of Bennington it is about 130 feet.

The best section of the Pottsville formation in the vicinity of the Barnesboro and Patton quadrangles is shown in the cuts along the Pennsylvania Railroad east of Bennington. It is described in the Ebensburg folio as follows:

> A rather thick-bedded sandstone outcropping near the bottom of the ravine just east of Bennington is regarded as the bottom of the Connoquenessing sandstone. Its top is about 30 feet above the track at the west end of the cut just east of this ravine. The face of sandstone, about 50 feet high, at the east end of this cut, near the end of the Mauch Chunk outcrop, is Connoquenessing. This member is 80 to 100 feet thick. It is a rather coarse gray sandstone, with small lenses or layers of gray sandy shale. Above the Connoquenessing are

side of the Barnesboro quadrangle. The outcrop is generally marked by massive white blocks, not uncommonly conglomeratic, lying on the hillsides and along the lower slopes and stream bottoms. In some localities these blocks are so large and so abundant as to be quarried. Near Dysart there are also quarries on the outcrop of the formation.

Here and there in the western part of the State a coal, known as the Sharon coal, occurs below the Connoquenessing sandstone and is underlain by the Sharon conglomerate member. This coal has not been identified with certainty in the Barnesboro-Patton region, but at several places in the Patton quadrangle a faint coal stain has been observed in outcrop at that horizon and it may be the equivalent of the Sharon coal.

ALLEGHENY FORMATION.

Definition.—The Allegheny formation comprises the strata between the Homewood sandstone and the top of the Upper Freeport coal, having a thickness of about 300 feet. It was formerly known as the Lower Productive Coal Measures from the fact that it contains nearly all the workable coal beds in the lower part of the Pennsylvanian series. It is named from Allegheny River, along which it is typically developed.

Distribution.—The formation occupies the surface of approximately one-fifth of the area of the quadrangles and underlies the quadrangles and coinciding in general position with the highland belts described under "Topography."

Thickness and character.—The thickness of the formation is best known from the records of diamond-drill holes, several of which have passed completely through it. The record of a well near Plattsville (section L, fig. 5) shows 281 feet of rock between the Upper Freeport and Brookville coals and 25 feet of shale below the Brookville coal. The thickness of the Allegheny at that locality is therefore probably about 315 feet. A boring in the vicinity of Nolo (section E, fig. 5) penetrated 304 feet of rock between the Upper Freeport coal and the top of the "conglomerate." The conglomerate is supposed to be the Homewood sandstone and the interval of 304 feet is supposed to represent the thickness of the Allegheny formation. The record of a boring northeast of Patton (section P, fig. 5) shows a thickness of 296 feet. Several other records give similar thicknesses, but owing to uncertainty regarding the position of the upper or lower limit, they can not be regarded as conclusive.

The formation is extremely irregular in the sequence of the strata that compose it, and no single section can, except in a general way, be regarded as representative. It consists of shale and shaly sandstone, interstratified in places with massive sandstone, thin beds of coal, fire clay, and some beds of limestone. One of the most typical sections is section P, figure 5, which shows all the principal beds of coal and sandstone. Other sections shown in figure 5 illustrate the extreme diversity of the strata and the way in which they thicken, thin out, or grade imperceptibly into other beds of different character.

Coal beds.—Just above the Pottsville formation there is ordinarily a bed of coal that is generally known in this region as coal bed A and is correlated with the Brookville bed of the Allegheny Valley. It is in some places separated from the Homewood sandstone by a bed of shale and fire clay. At a distance above the Brookville coal ranging from 20 to 40 feet is commonly a second bed, the Clarion or A′ coal. The Lower Kittanning or B coal is from 40 to 100 feet and the Upper Kittanning or C′ coal from 170 to 230 feet above the Brookville coal. Between the two Kittanning coals there are in many places thin beds that may perhaps be correlated with the Middle Kittanning coal of the Allegheny Valley. The Lower Freeport or D coal lies from 220 to 280 feet and the Upper Freeport or E coal from 270 to 320 feet above the Brookville coal. In many sections other beds occur between the principal coals just named, but they are as a rule too thin to be of value. The relation of the coal beds is shown in figure 6.

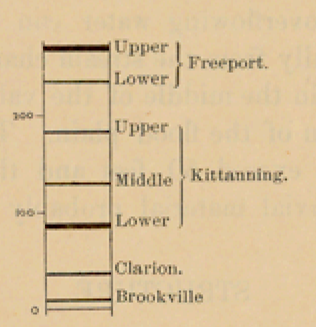


FIGURE 6.—Section showing coal beds of the Allegheny formation in the Barnesboro and Patton quadrangles.

Limestones.— In western Pennsylvania the Allegheny formation contains one or more beds of limestone of some economic importance that are valuable as key rocks in the identification of the coal beds. The most important is the Vanport ("Ferriferous") limestone member, averaging 8 to 10 feet in thickness and lying about 40 feet below the Lower Kittanning coal. Throughout most of the Allegheny Valley it is the recognized key rock of the oil-well driller and the coal prospector. It has also been recognized in the Indiana quadrangle,[a] but in that region it is thin and is supposed to die out toward the east. Traces of limestone at about its horizon are reported in a boring in the extreme southeast corner of the Punxsutawney quadrangle and in another northeast of St. Lawrence, in the Patton quadrangle. Elsewhere in the Barnesboro-Patton area no limestone is known at the horizon of the Vanport.

A bed of earthy limestone lying just below the Upper Kittanning coal occurs throughout considerable portions of Cambria and Indiana counties. It was at one time confused with the Vanport and called "Ferriferous." Later studies by geologists of the Second Pennsylvania Survey showed that it is above the horizon of the true "Ferriferous" and the name Johnstown cement bed was applied, because at Johnstown the rock was formerly used in the manufacture of natural cement. This use was discontinued years ago and, owing to its inappropriateness, the name "cement bed" has been discarded and the bed is now known as the Johnstown limestone member. In the Barnesboro and Patton quadrangles it has been noted only in diamond-drill holes in Allegheny Township west of Driscoll, in Susquehanna Township north of Shazen, and in Carroll Township near Elmora. At these places 5 feet of limestone, 4 feet 5 inches of limestone, and 43 feet of "limy fire clay" were reported respectively.

The Upper and Lower Freeport limestone members are of greater importance. It is not everywhere possible to discriminate them, for local limestones occur in nearly all relations to the Freeport coals. Commonly, however, each is directly beneath the bed of fire clay associated with the coal bearing the same name. As in Allegheny Valley, the Upper Freeport limestone is of greater purity and more widespread occurrence than the other limestones of the formation. In the region between Martintown and Sylvis it has been found in numerous diamond drill holes being reported in some places as 10 feet or more thick. It outcrops in both quadrangles and has been quarried and burned for agricultural lime in the northwest corner of the Barnesboro quadrangle and west and northwest of Mitchells Mills. At several places in Buffington Township there is a few inches of shaly limestone which is supposed to be at the horizon of the Upper Freeport limestone.

Sandstones.—The sandstones and shales of the formation are so diverse in character that it is difficult to make any general statement regarding them. At one place or another sandstone or shale occurs at probably every horizon through the entire formation. In general the fine-grained rocks predominate, but only a few sections lack coarse-grained sandstone and some of the coarse-grained beds are 50 to 100 feet thick. In other parts of the State names have been applied to sandstones of greater or less persistence in the formation and these names are applicable in parts of the Barnesboro-Patton region. One of the most conspicuous sandstone members in the formation is the Clarion, which generally lies between the Brookville and Clarion coals, although in some places it is in the position of the Clarion coal, which either was not deposited or was removed by subsequent erosion. It has massive phases resembling the Homewood, with which it is frequently confused. Another conspicuous sandstone is the Kittanning sandstone member, which lies between the Clarion and Lower Kittanning coals. These two sandstone members have in places a combined thickness of 60 feet. They are well exposed just above river level at Garmans Mills, where they are conspicuous as a ledge and form massive white sandstone débris. The sandstones between the Brookville and Lower Kittanning coals are recorded as 60 feet thick in borings near Purchase Line and as somewhat thinner at several other places. At Gettysburg and in Burnside Township, according to the records of diamond-drill holes, they range in thickness from 5 to 15 feet. They are entirely lacking in the vicinity of Spangler and Moss Creek.

Sandstones also occur at different horizons in the interval of 130 to 170 feet between the Lower Kittanning and Lower Freeport coal beds. That in the upper part of the interval is regarded as the Freeport sandstone member. These sandstones are generally so variable, as shown by many diamond-drill records, that the enumeration of localities is of little value. Nearly all the drill records note some sandstone between the coal beds mentioned. A record of a hole in Burnside Township shows 150 feet of solid sandstone occupying the entire interval between the two coals.

As a rule the interval between the Lower and Upper Freeport coals is occupied mostly by shale. In a number of localities, however, it is wholly or partly occupied by a massive sandstone (Butler), which rests directly upon the Lower Freeport coal. Such a condition prevails in a large area in the vicinity of Westover, where the sandstone occupies the whole interval. In that locality the Butler and Freeport ? sandstones are massive and are practically continuous with the Mahoning sandstone of the Conemaugh formation, except for the slight interruptions formed by the Lower and Upper Freeport coal beds. The Butler sandstone member is reported to be more than 30 feet thick in borings at Patton and near Driscoll.

CONEMAUGH FORMATION.

Definition.—The Conemaugh formation comprises the strata lying between the Upper Freeport coal and the Pittsburg coal, neither coal being included. It is named from Conemaugh River, in the valley of which it is typically exposed. It was formerly called the Lower Barren Coal Measures because except in a few places it does not contain workable coal beds.

Distribution.—The Conemaugh formation occupies more than three-fourths of the area of the quadrangles. It underlies all the uplands and interstream areas and caps nearly every hill, even in the general areas occupied by the Allegheny formation. As a rule its base lies well down the slopes; indeed, many of the valleys are not cut down through it.

It therefore extends throughout the two quadrangles in a continuous mass except for a few small detached areas on hilltops surrounded by the Allegheny formation. The outline of this mass is extremely irregular because of the diversity of the areas of the Allegheny formation which lie within or border it. These areas divide it into three broad belts having a northeast-southwest trend and coinciding roughly with the belts of upland between the highland ridges.

The formation includes not only those beds mapped as undifferentiated Conemaugh but also several sandstone lentils that are parts of the formation though shown by separate patterns.

Thickness. — The upper part of the formation has been removed by erosion from the Barnesboro-Patton area, hence its total former thickness is not known. The maximum thickness remaining, in the hill a mile south of Eckenrode Mill and in the ridge north of Chest Springs, is about 600 feet. In regions where the whole of the formation is present it is from 500 to 900 feet thick. In the Johnstown quadrangle, south of the Barnesboro, the thickness is estimated at 900 feet.[a] This makes it probable that at least 300 feet of the formation has been removed from the Barnesboro and Patton quadrangles.

Character.—Like the Allegheny formation, the Conemaugh consists chiefly of alternate beds of sandstone and shale of irregular thickness and character. Minor beds of limestone and thin coals are of local occurrence. A number of prominent sandstones have been recognized, but none of them are known to be persistent throughout the area. They have the form of lentils, most of them of small extent though some are large. Because of their lenticular shape it may be impossible to establish the identity of two sandstones at about the same horizon, as they may be overlapping lentils whose stratigraphic positions are only approximately the same, and they should not be considered as identical. For this reason the sandstone members in these quadrangles are mapped only where they are conspicuous and especially where they form broad topographic features, as on the flats around Belsano and Plattsville. Because of the number of local lentils the mapping of all of them would be confusing, hence three of the most important have been selected and have been mapped wherever they can be traced.

These sandstones resemble one another so closely that they can be distinguished only by their stratigraphic position. They range from fine-grained buff or brownish shaly sandstone to hard white coarse quartzitic sandstone, which on weathering breaks up into large blocks that are thickly clustered on the hillsides. Here and there the beds are conglomeratic, some of the pebbles being as large as marbles.

The general nature of the beds in the lower part of the Conemaugh formation is shown by diamond-drill records. In figure 5 several sections are given which show as much as 300 feet of the formation. It will be noticed by comparison of the sections that there is a general resemblance in some particulars, but no similarity that prevails throughout wide areas.

Coals.—There are at least twelve horizons at which coal occurs in the Conemaugh formation in western Pennsylvania. About the same number have been recognized and named in the Conemaugh of Maryland.[a] The coals of the Conemaugh in the Barnesboro-Patton region have been tentatively correlated with those of western Maryland, and to some of them Maryland names have been applied. None of the beds are of workable thickness throughout areas of sufficient extent to make them of economic importance. They are described below and are shown in the generalized columnar section (fig. 4). Further data on them will be found under the heading "Economic geology."

The Mahoning coal is a thin bed lying between the lower and upper parts of the Mahoning sandstone member and about 44 feet above the Upper Freeport coal. It is not persistent but occurs here and there and is associated with limestone, fire clay, and iron ore. The clay and ore are of no importance in this area but have been exploited in the Johnstown quadrangle, south of the Barnesboro. The clay and the ore, the latter as nodules associated with calcareous beds, show in the road west of Yellow Creek and southeast of Nolo. The coal was penetrated in a number of borings. (See fig. 5.)

The Gallitzin coal lies from 70 to 110 feet above the Upper Freeport coal and just above the Mahoning sandstone where that member is developed to its full thickness. It is thin, rarely exceeding a foot in thickness. In western Pennsylvania and Maryland it is known under a number of other names, as Brush Creek, Masontown, and Farmington. Brush Creek is probably the name most commonly used, but as the Barnesboro-Patton region is near the type locality of the coal at Gallitzin, the name Gallitzin is preferred in this folio.

A thin coal shows in places just below the Buffalo sandstone member and is penetrated in several drill holes. It has not been recognized elsewhere.

The Bakerstown coal lies between the Buffalo and Saltsburg sandstones, as in other parts of the State. Its average distance above the Upper Freeport coal is 217 feet. It is rather persistent throughout western Pennsylvania, Maryland, and West Virginia and in places is of workable thickness and good quality. It is about 3 feet thick on Yellow Creek at the west side of the Barnesboro quadrangle.

A thin coal about 20 feet above the top of the Saltsburg sandstone and about 270 feet above the Upper Freeport coal is possibly the Maynardier bed of Maryland, which is about 260 feet above the Upper Freeport coal and a short distance above the Saltsburg sandstone member.

The Harlem coal is a thin bed lying just below the Ames limestone member and 300 to 400 feet above the Upper Freeport coal, the average distance being 350 feet. It has also been called the Friendsville, Ames, and Crinoidal coal. It is possibly of minable thickness at one point.

A thin coal 40 feet above the Morgantown sandstone member and 430 feet above the Upper Freeport coal occupies about the same position as the Lonaconing coal of Maryland, which is 410 feet above the Upper Freeport coal, hence the name Lonaconing is adopted for the bed in this area. It is exposed, associated with limestone, on the hills northeast of Ebensburg and on the railroad between Loretto Road and Driscoll.

At a few points in the Barnesboro-Patton and Ebensburg quadrangles a thin coal occurs about 500 feet above the Upper Freeport coal. It is correlated with the Franklin or Little Clarksburg coal of Maryland, which lies 475 feet above the Upper Freeport coal.

About 600 feet above the Upper Freeport coal is a persistent thin coal, associated with limestone, that may be the equivalent of the second or lower Little Pittsburgh coal of Maryland. It shows at a number of points on the ridge within a mile north of Chest Springs.

Mahoning sandstone member.—The name Mahoning has generally been applied to two or more of the beds of sandstone

[a] Indiana folio (No. 102), Geol. Atlas U. S., U. S. Geol. Survey, 1904, p. 3.

[a] Phalen, W. C., Johnstown folio (No. 174), Geol. Atlas U. S., U. S. Geol. Survey, 1910.

[a] Maryland Geol. Survey, vol. 5, 1905, p. 319.

overlying the Upper Freeport coal. These sandstone are usually separated into an upper and a lower division by the Mahoning coal, which, where present, is generally underlain by fire clay, thin limestone, and iron ore.

The Mahoning member in places rests directly upon the Upper Freeport coal but elsewhere is separated from it by a little shale. Here and there it is lacking, but it probably persists throughout the greater part of the area, and it reaches a maximum thickness of 80 feet or more. Its most typical development is on the hilltops west and north of Patton, where it forms a flat surface of considerable extent. Great blocks, some of them more than 10 feet in diameter, are strewn over the surface. They are as a rule composed entirely of coarse white sand, but many of them are conglomeratic. The rock is quarried for building stone.

The Mahoning member is well developed throughout the northern part of the Patton quadrangle west of Clearfield Creek, where it caps most of the hills. It is massive in the southeastern part of the quadrangle also, particularly east of Ashville and Amsbry. In the remainder of the Patton quadrangle it is either thin or absent or else lies so deep that the valleys are not cut down to it. It is well exposed in the northeastern part of the Barnesboro quadrangle, east of West Branch of Susquehanna River, and in the western part of the quadrangle, in the valleys of Two Lick and Yellow creeks. It occurs about the head of Long Run, near Martintown, but in the remainder of the quadrangle it is inconspicuous or is deeply buried.

Buffalo sandstone member.—The name Buffalo sandstone was given by I. C. White to a sandstone above the Mahoning member on Buffalo Creek, Butler County,[a] and in accordance with the precedent set by Phalen[b] the name is here applied to a sandstone at approximately the same horizon in Cambria County. The name Saltsburg was erroneously applied to the same sandstone in the Ebensburg quadrangle,[c] south of Patton. The member is generally a massive coarse-grained quartzose sandstone, in places pebbly. In some places it forms massive débris covering the hillsides; in others it weathers to sandy soil and small slabs. Its thickness is usually 40 to 50 feet but in places may be as much as 80 feet.

The Buffalo sandstone extends almost continuously throughout the southwestern part of the area. It is especially well developed on the ridge north and south of Strongstown and thence eastward to the ridge northeast of Pindleton. It extends northward beyond Pineton and northwestward beyond Nolo. Throughout the greater part of its area, where not cut out by the streams, it underlies broad flats or gentle slopes, covered with sandy soil or slabs or large blocks of sandstones. At a few places patches of shale show above the sandstone, as on Blacklick Creek 2 miles south of Nicktown, where a little red shale lies close above the Buffalo sandstone.

Owing to irregularities in the thickness of the beds, the interval between the Buffalo member and the Upper Freeport coal is not uniform. In a boring north of Nolo (No. 178) the bottom of the sandstone is 125 feet and its top 200 feet above the coal. In the ravine three-fourths of a mile northeast of Blaides a thin limestone lies 200 feet below the top of the Buffalo sandstone. If the limestone is the Upper Freeport, the interval agrees very well with that north of Nolo. The average distance of the top of the sandstone above the Upper Freeport coal is therefore about 200 feet.

Saltsburg sandstone member.—The name Saltsburg sandstone, from the town of Saltsburg, where the bed is about 120 feet thick, was given by Stevenson to a massive and supposedly persistent sandstone that outcrops above the Mahoning member in parts of the Monongahela and lower Conemaugh valleys. The member has the same general character as the other sandstones in the "Coal Measures" of western Pennsylvania, being commonly composed of medium-coarse quartz sand, in places mingled with small quartz pebbles. Its thickness in these quadrangles is from 60 to 80 feet.

The Saltsburg member occurs generally throughout the northern part of the Barnesboro quadrangle, as far south as the hills north of Yellow Creek on the west side of the quadrangle and as Barnesboro on the east side. In the Patton quadrangle it is confined to the area northwest of Brubaker Run. It occupies the hilltops and stretches of the flat upland or outcrops on the higher slopes and underlies a greater area of nearly level land than any other sandstone in the formation. It lies in the first 100 feet above the Buffalo member and its base is from 200 to 320 feet above the Upper Freeport coal, the average interval between the two being 240 feet.

Red shale.—In many places thin beds of red shale occur at several horizons between the Saltsburg and Morgantown sandstone members, most commonly close below the Morgantown member. The shale is bright red and weathers to red clay. A red shale in this part of the section in western Pennsylvania is known as the "Pittsburgh red shale." It is well developed in the area within a radius of 3 miles about Nicktown and shows at many other points. It is of importance as being a sure criterion for identifying the Morgantown member.

Ames limestone member.—Associated with the uppermost red shale, but everywhere above it, is a fossiliferous limestone or in places a highly calcareous dark shale crowded with marine or brackish-water fossils. This is the Ames limestone member, formerly known as the "Crinoidal" limestone. It is of interest and significance as marking one of the most extensive incursions of the sea into the northern Appalachian coal field. It is known throughout a wide area in southwestern Pennsylvania, southeastern Ohio, northeastern Kentucky, and western West Virginia.

The best-known development of the Ames member in the quadrangles is in a cut of the Cambria & Clearfield division of the Pennsylvania Railroad three-fourths of a mile north of Bradley Junction, where the following section was measured:

Section north of Bradley Junction.

	Ft.	in.
Morgantown sandstone member	30	
Ames limestone member:		
Shale, black, carbonaceous and calcareous, with fossil shells	4	
Limestone, dark, earthy, with fossil shells		4
Shale, carbonaceous, full of Cordaites leaves (Harlem coal)	1	
Shale, dark green	10	

At this place the bed is chiefly calcareous shale and has weathered to a disintegrated friable condition. It is associated with a layer of carbonaceous shale crowded with Cordaites leaves, which is probably equivalent to a thin coal bed that is known to occur at this horizon elsewhere (as near the old Conemaugh dam site east of South Fork, in the Johnstown quadrangle) and that is probably the bed known elsewhere as the Harlem coal.

In the south road between Eckenrode Mill and Carrolltown, 2 miles north of the locality of the section near Bradley Junction, the Ames limestone member appears as shown below:

Section 1½ miles southwest of Eckenrode Mill.

	Ft.	in.
Sandstone	5	
Clay, thin.		
Ames limestone member, with fossil shells		6
Shale, black	2	
Coal, dirty (Harlem)	1	
Clay	1	
Concealed	8	
Clay, red, good show.		

In a railroad cut three-fourths of a mile north of Eckenrode Mill the limestone is lacking and the Morgantown sandstone lies directly on an 8-inch coal bed that is underlain by a foot of carbonaceous shale with Cordaites leaves. On the road about midway between Dysart and St. Augustine a coal bed has been opened at this horizon. Above the coal are indications of rotten limestone—the Ames member—and close below the coal is a comparatively pure limestone with Spirorbis underlain by a thick bed of red clay. The red shale and limestone with Spirorbis show in the road 2 miles north of the southwest corner of White Township and half a mile east of its west boundary.

Morgantown sandstone member.—The Morgantown member is a coarse thick-bedded siliceous sandstone, in some places cross-bedded and here and there conglomeratic. Its thickness probably does not exceed 50 feet. It occurs throughout the southeast half of the Patton quadrangle and in the central and eastern parts of the Barnesboro quadrangle, being best displayed on the northwest slope of Allegheny Mountain. On a high ridge 3 miles northeast of Patton it makes a conspicuous ledge. In some places it is coarse and massive, forming conglomeratic bowlders; in others it is thin bedded and easily eroded.

The interval between the Upper Freeport coal and the base of the Morgantown sandstone member ranges from 270 to 400 feet. The contact of the sandstone with the underlying beds is uneven and in places it lies on the beds lower than the Ames limestone and Harlem coal, those members being absent. It is probable that a period of emergence and erosion preceded the deposition of the sandstone, which is thus unconformable on the underlying beds.

Upper part of formation.—The Morgantown sandstone member is overlain by about 250 feet of rocks containing no beds worthy of special note. The greatest thickness appears to be in the high hill toward the east side of Carroll Township, 2½ miles due east of Tunnel Siding. This part of the formation is composed mainly of gray shale and thin-bedded fine-grained sandstone, with more massive sandstone in places, as in a railroad cut near Driscoll. Coarser sandstone is indicated by débris along the ridge from Loretto Road to St. Augustine and Patton. Thin layers of earthy limestone also occur in the shale. None of these limestones seem persistent or of stratigraphic or economic importance.

QUATERNARY SYSTEM.

PLEISTOCENE SERIES.

HIGH-LEVEL GRAVEL.

At a few points along Chest Creek and Brubaker Run patches of rounded gravel, not represented on the map, lie at a height of 20 feet or more above the present streams. They are composed mostly of sandy material and sandstone pebbles half an inch or less in diameter. They are probably remnants of old flood plains deposited at a time when the streams flowed at a higher level, before the present channels were cut, and are probably of Pleistocene age.

RECENT SERIES.

ALLUVIUM.

The recent sediments of the region consist of silt, clay, sand, and gravel, which form the flood plains of the streams. In the wider valleys the deposits are broad enough to be shown on the map, but many narrow belts along the streams are not shown. In but few places are the flood plains extensive enough to be of importance as farming land. The coarser material that makes up the bulk of the flood-plain deposit lies below and is covered by a mantle of finer alluvium a few feet thick, this arrangement being due to the fact that only the finer sediment held in suspension in the overflowing water can be transported any great distance laterally from the stream channel. The deposits tend to be thickest in the middle of the valley and to thin out at the outer margin of the flood plain. Their total thickness does not generally exceed 50 feet and the thickness of the mantle of finer alluvial material probably ranges from 1 to 5 feet.

STRUCTURE.

GENERAL STATEMENT.

Method of representing structure.—The strata in the Barnesboro and Patton quadrangles, which must have been deposited in a nearly horizontal position, are now horizontal in but few places. They have been warped into low folds having a northeast-southwest trend, complicated here and there by minor irregularities. An accurate knowledge of the folding, worked out from surface exposures and from data obtained in mines and borings, is of the greatest value in determining the position, attitude, and probable line of outcrop of coal beds and other strata of economic value. It is also useful in determining the probability of obtaining oil, gas, or artesian water and in locating wells for such purposes.

The geologic structure of the quadrangles is shown graphically on the structure and economic geology maps by contour lines. The horizon of some persistent and easily recognized bed is taken as a datum surface, and its altitude above sea level is determined at as many points as possible. The datum surface in these quadrangles is the top of the Lower Freeport coal. The contour lines are drawn at vertical intervals of 50 feet, each one passing through all points on the datum surface that have the same altitude. The structure contours are thus the lines of intersection of the datum surface with a series of imaginary level surfaces 50 feet apart, and they show the altitude and slope of the datum surface throughout the quadrangles. For example, at all points along the 1850-foot contour the top of the Lower Freeport coal is 1850 feet above sea level and slopes from the 1900-foot contour toward the 1800-foot contour.

Use of the contours.—The intersections of structure contours with surface contours of the same altitude mark the outcrop of the horizon of the Lower Freeport coal. Where the coal lies beneath the surface its depth can be found by subtracting its altitude from that of the surface. Where the altitude of the structure contours is greater than the surface altitude the coal has been removed by erosion and the contours simply show its approximate position before it was removed. If the depths of beds other than the Lower Freeport coal are desired, their distances above or below that bed must be added or subtracted accordingly.

In order to illustrate the use of structure contours, let it be supposed that it is desired to ascertain the depth of the Lower Freeport coal at the Plattsville road corner. The altitude of the surface at that place is given on the map as 1830 feet. The road corner is at three-fifths of the distance from the 1450-foot to the 1500-foot structure contour, hence the altitude of the coal beneath the corner is about 1480 feet. Therefore the depth of the Lower Freeport coal at that place is 1830 feet minus 1480 feet, or about 350 feet.

Reliability of contours.—It is impossible to make structure contours strictly accurate in all parts of the field, and allowance for possible errors should be made in using them. Throughout large areas the Lower Freeport coal lies far beneath the surface and no facts are at hand by which its exact depth can be determined. Even where the horizon of the coal reaches the surface, the bed does not everywhere show, and in places only its approximate position is known. Where the coal has been removed by erosion, its former position can be determined only from its known distance above other beds that have not been removed, and by assuming that the intervals between these beds

[a] White, I. C., Rept. A, Second Geol. Survey Pennsylvania, 1878, p. 78.

[b] Phalen, W. C., Johnstown folio (No. 174), Geol. Atlas U. S., U. S. Geol. Survey, 1910, p. 6.

[c] Butts, Charles, Ebensburg folio (No. 133), Geol. Atlas U. S., U. S. Geol. Survey, 1905, p. 4.

and the coal were the same there as elsewhere. In all such places the contours may be somewhat in error, but the error is probably never great and generally it is well within the contour interval, 50 feet. For most of the southern half and portions of the western and northern parts of the Barnesboro quadrangle and for large areas in the central and southern parts of the Patton quadrangle the contours are based on such indirect evidence and are therefore generalized—that is, they are drawn more smoothly and lack the details that they have in maps of better-known regions where mining is being carried on.

Notwithstanding the uncertainties in the structure contours, for most of the area they are reasonably accurate, especially where active mining and drilling has been done, as in the mining region about Barnesboro and Patton. The contours in that part of the area are plotted directly from mine levels furnished by the coal companies and hence are accurate. A few mine levels have also been obtained in the Delaney and Glenwhite regions and at Amsbry. For parts of the area where drilling has been done the contours have been drawn to correspond to the altitudes of the beds as noted in the records that have been furnished by many operators in the region.[a] For that part of the district actually explored by mining the location of the contours is extremely accurate, but for the intermediate spaces they are based only on surface observations or on well records.

In regions where levels have not been run on the Lower Freeport coal it was necessary to use other means of determining the altitude of the bed. This was done by adding or subtracting the vertical distance from some bed exposed on the surface. Nearly all the roads and some parts of the intervening areas were traversed, and the positions and altitudes of the different outcrops were noted. These data, as well as the drill records, were used in determining the position of the structure contours and of the coal horizons. It is believed, therefore, that in general the structure of the area has been determined with a fair degree of accuracy.

DETAILED STRUCTURE.

Nittany anticline. — The most pronounced fold affecting the structure of the Barnesboro and Patton quadrangles is the great Nittany anticline, which lies along the east side of the Allegheny Front. The main body of the anticline has been eroded away, leaving an escarpment formed by the upturned beds on its northwestern flank. The rise of the beds on the northwestern limb of the fold begins in the Patton quadrangle about 6 miles from the southeast corner and continues southeastward at a fairly uniform rate beyond the limits of the area. The altitude of the Lower Freeport coal increases from about 1350 feet at the western base of the arch to 2350 feet at the corner of the quadrangle.

Wilmore syncline.—Northwest of the Nittany anticline is a structural trough long known as the Wilmore syncline, from the town of that name on the Pennsylvania Railroad south of Ebensburg. The axis enters the south side of the Patton quadrangle a little east of Loretto and extends about N. 30° E. to a point 3 miles northeast of St. Augustine. Just southwest of St. Augustine the Ebensburg anticline, which lies northwest of the Wilmore syncline, disappears, and the Wilmore syncline unites with the Bradley syncline in a broad, open basin on Slate Lick and Beaverdam runs. In the Patton quadrangle the Wilmore trough is narrow and not very deep, but farther south it is much more pronounced. Between St. Augustine and Loretto the altitude of the Lower Freeport coal along the axis is supposed to be about 1350 feet. This is only an estimate, however, as no drilling has been done and the position of the coal bed is determined from rocks that outcrop at the surface from 300 to 600 feet above the coal.

Ebensburg anticline.—In the State geologic reports the next fold to the northwest is called the Viaduct anticline, from a stone viaduct on the Pennsylvania Railroad about a mile east of Mineral Point, on the axis of the fold, but as the name does not appear on maps of the region it is not regarded as appropriate and the name Ebensburg was proposed for this anticline in the Ebensburg folio (No. 133).

The axis of the anticline enters the Patton quadrangle from the south at a point about 1½ miles west of Winterset and extends N. 65° E. for 5 miles. Two miles north of Loretto it changes its course abruptly to N. 20° E. and it continues in that direction to Chest Springs, whence it bears about N. 45° E. to St. Augustine and dies out. In this area the fold is of small proportions, being at most not more than 200 feet higher structurally than the bottoms of the synclines on either side. In breadth it ranges from 2 to 3½ miles. The altitude of the Lower Freeport coal along the axis decreases from about 1800 feet at Ebensburg to less than 1500 feet in the vicinity of Driscoll and 1200 feet at St. Augustine.

[a] The Survey is especially indebted for much valuable information of the sort to Mr. Rembrandt Peale and Mr. W. D. Duntmore, of Peale, Peacock & Kerr; to Mr. H. J. Hinterleitner, of Spangler; to Mr. Thomas Barnes, of Barnes & Tucker; to the Altoona Coal & Coke Co.; to Mr. George G. Brooks, of the Central Coal & Coke Co. of Scranton; to Mr. E. C. Brown, of the Beech Creek Coal & Coke Co.; to Mr. Saxman, of the Greenwich Coal & Coke Co. of Latrobe; and to the Clearfield Bituminous Coal Corporation.

Bradley syncline.—Lying northwest of and approximately parallel to the axis of the Ebensburg anticline is the Bradley syncline, which extends across the Patton quadrangle in a northeasterly direction. Its axis enters the quadrangle near the southwest corner, where it is poorly defined, and runs N. 60° E. nearly horizontally for about 3 miles. Thence it takes a N. 30° E. course and pitches steeply to a point a mile west of Driscoll, where the altitude of the Lower Freeport coal is 1400 feet. From that point the axis pitches northeastward at a small angle to its deepest point, 2 miles northwest of St. Augustine, where the altitude of the coal is apparently less than 1200 feet. Thence the axis rises to the eastern margin of the quadrangle, where the Lower Freeport coal bed has an altitude of 1400 feet.

Laurel Hill anticline.—One of the most pronounced folds in the plateau region is called the Laurel Hill anticline, because for a long distance in the southern part of the State it forms a belt of highland known as Laurel Hill. In the Barnesboro and Patton quadrangles the ridge is not particularly well marked, but taken as a whole it is one of the most extensive belts of highland west of the main crest of the Allegheny Mountains. The axis of the fold enters the south side of the Barnesboro quadrangle just south of Pindleton in a course averaging N. 40° E. The direction is maintained to the northern border of the Patton quadrangle, which it crosses near the boundary of Beccaria Township. The axial line as represented on the map is somewhat generalized, as the data were not sufficient to give all the details of its course. Mine workings near Carrolltown and Thomas Mills show several minor variations from a direct course, and probably other irregularities exist that can not be correctly represented on the map until the coal has been extensively mined and altitudes have been determined.

The general structure of the anticline appears to be fairly regular, the dips being approximately equal on both sides. The highest point of the fold is in Cambria Township, where the altitude of the Lower Freeport coal is 2150 feet. Northeast of that point the crest of the anticline is undulating. Its form and altitude are shown by numerous workings and borings. The Lower Freeport coal has an altitude of about 1950 feet east of Elmora, 2030 feet northwest of Carrolltown, about 2050 feet east of Benedict, and 2100 feet half a mile north of Thomas Mills. Toward the Curwensville quadrangle the axis pitches, and beyond the Clearfield County line the coal passes below the 1800-foot contour.

Barnesboro syncline.—The Barnesboro syncline was named by W. G. Platt the Centerville Synclinal, from the town of Centerville, situated near the axis of the syncline on Conemaugh River.[a] Originally it was known as the Second Basin, but Franklin Platt called it the Ligonier Basin, on the assumption that it is continuous with the syncline occupying Ligonier Valley.[b] On the map of Cambria County, published in 1888, it was called the Westover Basin. There is, therefore, considerable confusion regarding the proper name of this feature.

The recent geologic work on which this folio is based has shown that the syncline is not nearly so prominent a structural feature at Westover as it is at Barnesboro. Indeed, at Sylvis the trough is nearly divided by a cross anticline. As the term "Centerville" seems to have gone out of use, it is desirable to select a new name and for this purpose Barnesboro is chosen, from the town where the mine operations are most extensive.

From Wehrum, on Blacklick Creek south of the southwest corner of the Barnesboro quadrangle, the axis of the syncline runs about N. 45° E., passing through Nipton and continuing in this direction to a point a mile or so beyond the southern boundary of Barr Township. From this point it swings to about N. 25° E., passing just west of Nicktown, and thence to Barnesboro, where it bends to the northeast and north, passing through Shazen and Sylvis to Westover, on the edge of the Curwensville quadrangle.

The Barnesboro trough is deepest at the southern edge of the quadrangle, where the Lower Freeport coal is about 1350 feet above sea level. From that locality the axis rises to the northeast and in the southwestern part of Barr Township the coal is at an altitude of nearly 1500 feet. Farther north the axis pitches again, probably descending in places to about 1400 feet, as indicated by the elliptical area near Nicktown.

South of Nicktown the only data available for use in correlation were furnished by the massive sandstone which outcrops extensively throughout that section. In much of the region to the north, however, mine levels are available and the structure contours have been drawn with considerable accuracy. A great number of diamond-drill records furnished by the operators have also been of valuable assistance in determining the depths of the coals.

The data at hand seem to indicate a rather peculiar structure, or a division of the trough into two branches. At Nicktown the syncline broadens out, and its flat bottom covers an area about 2 miles in width. The exact shape of this flat

[a] Indiana County: Rept. H4, Second Geol. Survey Pennsylvania, 1878, p. 33.

[b] Somerset and Cambria district: Rept. HH, Second Geol. Survey Pennsylvania, 1877. p. 155.

area is unknown for the reason that only along the center of the basin has any mining been done, but from surface exposures and drill records the area included within the 1450-foot contour appears to be roughly heart-shaped. That there is a small secondary trough about a mile west of the main axis is proved by the levels of Sterling No. 11 mine, which show the 1500-foot contour to have a decided loop toward the north.

In the vicinity of Barnesboro only one mine is located on the axis of the syncline, but data afforded by several mines and drill holes, on both the east and west sides of the basin, have revealed the structure more clearly than elsewhere. At Barnesboro the horizon of the coal, which has here been removed by erosion, is at an altitude of about 1500 feet, but as the axis of the syncline veers to the north it pitches steeply, and north of Shazen it descends below 1400 feet. From that point it rises gently to about 1500 feet at Westover.

Nolo anticline.—The Nolo anticline is named from Nolo, in the southwest part of the Barnesboro quadrangle. It is a rather sharp fold, having dips in extensive areas as great as 3° and in at least one locality of 5°. In the Barnesboro quadrangle the dip is steeper on the west side than on the east side of the axis.

The available data indicate that in the southwest corner of the Barnesboro quadrangle, on the axis of the Nolo anticline, the altitude of the coal is just below 1750 feet. From that point the axis rises to 1850 feet at Pineton and thence it runs nearly level to a point 1½ miles north of Martintown, whence it descends to 1600 feet at Garmans Mills and to 1400 feet at the north side of the quadrangle. The only place where the exact position of the axis is open to question is just north of Grip, where there is some difficulty in distinguishing between the Upper and Lower Freeport coals. At Garmans Mills the axis may be mapped 1000 or 2000 feet horizontally from its true position. North of that place the data are still more scanty, but the sandstones in that area are believed to mark the position of the axis with fair accuracy.

Brush Valley syncline.—The trough west of the Nolo anticline is known as the Brush Valley syncline, from the village of that name in the Indiana quadrangle, west of the Barnesboro. Its axis enters the west side of the area about a mile north of Kellers Mill and trends on the average N. 40° E., passing through Kenwood, three-fourths of a mile west of Pine Flats, east of Cookport, and 2 miles northwest of Cherrytree.

At the west side of the quadrangle the Lower Freeport coal is at a minimum elevation of 1200 feet. In the vicinity of the junction of Laurel Run with Yellow Creek is a col where the coal rises to about 1250 feet, but north of that point it plunges again to 1200 feet or less northeast of Cookport. The part of the basin between Kenwood and the north side of the quadrangle is unusually flat, the bottom having a maximum breadth of over 3 miles, with dips not exceeding 1°. Southeast of a line drawn from Pine Flats to Uniontown, however, the dips increase to 3° or 4°. The same is true northwest of a line drawn from Mitchells Mills to the center of the north side of the quadrangle. The exact shape of the local trough in the northern part of the quadrangle is rather indefinite, but it is believed to be long and narrow with a slight bifurcation near Painters Run. On the east side of the Brush Valley syncline the rise of the strata is uncommonly steep.

Chestnut Ridge anticline.—One of the strongest folds of the Appalachian Plateau is the Chestnut Ridge anticline, which extends continuously from a point near the southern boundary of the State through Fayette, Westmoreland, Indiana, and Clearfield counties and a considerable distance beyond. About 7 miles of its length lies in the Barnesboro quadrangle, extending in a fairly direct course from Two Lick Creek 1¼ miles west of Diamondville to the Punxsutawney quadrangle north of Purchase Line. The highest point on the axis is at the north side of the area, where the Lower Freeport coal is about 1600 feet above sea level. The axis rises rapidly northward and just north of the Barnesboro quadrangle reaches an altitude of nearly 1900 feet. There is a prominent local enlargement of the anticline east of Taylorville, on which the coal reaches an altitude of 1600 feet.

Dixonville syncline. — A relatively unimportant syncline crossing the northwest corner of the Barnesboro quadrangle is a part of the Dixonville syncline. It is broad, with gentle dips, and along its axis the Lower Freeport coal rises from 1400 feet on the western border of the quadrangle to 1500 feet on the northern border.

GEOLOGIC HISTORY.

PALEOZOIC ERA.

EARLY PALEOZOIC TIME.

The crystalline rocks of the Blue Ridge and of the Piedmont Plateau are the oldest known in the Appalachian province. They are believed to have formed one of the oldest lands of which there is any record on this continent. The western shore of the land area lay near the present position of the western flank of the Blue Ridge, and the land extended to an unknown distance eastward, possibly far beyond the present shore of the

Atlantic. To the northeast lay another area of crystalline rocks, forming a land area in the Adirondack Mountains region. Extending west of the latter region to the vicinity of Lake Superior was the southern shore of a vast land area, now occupied by the crystalline rocks of Canada. The rocks of the two regions last mentioned are of the same age as those of the Blue Ridge. Thus the ancient land of the eastern United States had a rudely V-shaped form, inclosing within its arms a body of water known to geologists as the interior Paleozoic sea. Into this sea flowed rivers bearing the materials of which the sedimentary rocks of the Appalachian province are composed. While these rocks were accumulating to the thickness of many thousand feet new species of animals and plants made their appearance from time to time, and the earlier forms became extinct. The earlier organisms were chiefly animals or the lower forms of plants, such as sea weeds. Later, land plants made their appearance and the conditions began which eventually resulted in the formation of the coal beds of the province. After a great thickness of sediments had been accumulated an uplift occurred, the axis of which extended from the Great Lakes to western Tennessee. This is known as the Cincinnati uplift. The sea bottom along a part or the whole of the axis was probably raised into dry land. A barrier was thus formed that still more completely inclosed the interior sea, which then approached the form of a narrow embayment extending from Alabama to eastern New York and which is appropriately called the Appalachian Strait. In this strait sedimentation continued, in the progress of which the earliest rocks known in the Barnesboro and Patton quadrangles were accumulated.

MIDDLE DEVONIAN TIME.

The rocks of the Hamilton, Genesee, Portage, and Chemung formations were laid down in a more or less completely landlocked bay or gulf and were apparently derived from land to the northeast and southeast, whose western shore probably extended from the Adirondack region southward along the present line of the Blue Ridge.

The character of these formations indicates a long period of repose or of gentle oscillations throughout the Appalachian Strait and the bordering lands. The fine sediments of which the rocks are generally composed are apparently due to one or both of two conditions. They may have been derived from a land surface of low relief, or they may have been transported a long distance from shore and deposited in water of considerable but not great depth. In the first case, on account of the low gradient and slow current of the streams, only comparatively fine material would have been discharged into the strait. In the second case, whatever may have been the character of the sediment discharged by the streams, only fine material that could be held in suspension a long time would be transported by the existing currents to the area of deposition, the coarser material, if any, being deposited near the shore. A deepening or at least a clearing of the water is indicated by thin impure limestones at the top of the Hamilton.

The absence of Hamilton fossils from the Genesee and higher formations is good evidence that conditions changed or that the character of the Genesee sediment was unfavorable to the Hamilton forms and caused their extinction or migration to more favorable regions.

It has been suggested by Clarke[a] that, after the analogy of deposits now being formed in the Black Sea, the Genesee shale was deposited in deep water with imperfect vertical circulation, and that the carbonaceous matter to which it owes its color was supplied by the abundant vegetation of the marsh lands from which the sediment was derived.

The conditions existing during Genesee time continued into Portage time, as is indicated by the character of the rocks, the scarcity of fossils, and the probable entire absence of truly littoral or shallow-water forms. The steady accumulation of fine sediment, however gradually raised the sea bottom, and there are many evidences that the succeeding Chemung rocks were accumulated in comparatively shallow water. The relative abundance of fossils also indicates that the conditions prevailing throughout Portage time had passed away.

CATSKILL DEPOSITION.

It is believed that before the beginning of Chemung deposition—indeed, soon after the close of Hamilton time—the Catskill phase of sedimentation (red arkosic sand and clay) began at the northeast extremity of the Appalachian Gulf, in eastern New York, with the deposition of the Oneonta beds. From this time onward the deposition of these rocks continued, the beds being contemporaneous at first with the marine Portage, later with the Chemung, and still later possibly with the lowest Mississippian deposits.

Thus it happens that the Catskill rocks, which have a probable thickness of several thousand feet in the Catskill Mountains region, where sedimentation was continuous, grow thinner from the bottom upward as they extend westward until, in western Pennsylvania and western New York, they are represented by only a few hundred feet of beds characterized by red shale. The Appalachian Strait was apparently deeper along the eastern shore and shallower on the west at the beginning of the Catskill deposition. The great thickness of these sediments in the east seems to indicate that during this period differential subsidence carried the eastern marginal area constantly deeper compared with the area at the west. This movement of subsidence may have been accompanied by an elevation of the land still farther east, from which the sediments of the Catskill rocks were derived, for these rocks are coarser along their eastern margin and bear evidence of rapid accumulation, such as would result from their deposition by swift streams flowing from a land mass more elevated than that from which the sediments composing the underlying rocks were derived. A different interpretation of the relation of the Catskill is possible, however.

[a] Clarke, J. M., Mem. New York State Mus. No. 6, pt. 2, 1903.

A notable characteristic of the Catskill rocks is the general absence of fossils, except in the lower part of the formation in eastern New York, where fresh-water forms occur in considerable abundance. Remains of what are regarded as fresh-water fishes also occur at other points and at higher horizons. These fossils may indicate bodies of fresh water, or they may have been washed in from the rivers in which they lived. In central Pennsylvania marine fossils occur at a few horizons in the Catskill, and in its equivalent in western Pennsylvania and western New York they are common in the gray and green rocks interbedded with the red beds. These fossils indicate that marine conditions recurred in the west—the more frequently the farther west. The general absence of life during the deposition of the beds, whether they were laid down in fresh, brackish, or salt water, may be due to the rapidity of sedimentation, which made the conditions unfavorable to life.

The origin of the red deposits is a question of interest that has not received a satisfactory solution. It may be surmised that they were derived from the highly oxidized residuum of the deeply decayed crystalline rocks of a very old land surface, such as exists to-day in parts of the Southern States.

CARBONIFEROUS PERIOD.

MISSISSIPPIAN EPOCH.

POCONO TIME.

The deposition of the Carboniferous rocks of this region appears to have succeeded that of the Devonian rocks without a break, though there is evidence of uplift of at least minor importance. After the Catskill rocks were laid down fresh-water conditions probably continued throughout the north end of the Appalachian Strait, but there was a decided change in the character of the material brought in. The succeeding rocks are prevailingly gray instead of red. During the later part of Pocono time vast quantities of coarse sand were brought into the Appalachian Strait and spread widely over the sea bottom to form the coarse Burgoon ("Mountain" or "Big Injun") sandstone. As the deposition of this coarse, sandy material was drawing to a close a large quantity of calcium carbonate accompanying the sand made the Loyalhanna ("Siliceous") limestone, which is a widely extended and highly characteristic stratum at the top of the Pocono throughout southwestern Pennsylvania. Possibly the source of the calcareous material was the same as that of the great limestone formations of the Mississippi Valley, which are probably contemporaneous in part with the Pocono formation in the Appalachian trough. One of the most striking and persistent features of the Loyalhanna limestone is its cross-bedding, which shows that the limestone is of clastic origin and indicates that the material was distributed by powerful currents. The calcium carbonate in suspension may reasonably be assumed to have been carried from its source by oceanic currents sweeping up from the southwest into the probably shallow waters of the Appalachian Strait. It may afterward have been worked over by wave action or by tidal currents, which developed the cross-bedding.

One of the most interesting and significant features of Pocono history was the accumulation of coal beds of considerable extent and thickness in Virginia and West Virgnia. There are thin beds in central Pennsylvania also. These coal beds herald the approach of the biologic and physiographic conditions under which the great deposits of coal in the later formations were accumulated.

MAUCH CHUNK TIME.

The deposition of the prevailingly gray Pocono formation was succeeded by a second extensive deposition of red beds, composing the Mauch Chunk formation. The change in the kind of sediments was probably gradual, for in the region of the Allegheny Front the bottom beds of the Mauch Chunk consist of sandstone very much like the sandstone of the Pocono. The great mass of the formation, however, is red shale. In eastern Pennsylvania it reaches a thickness of over 2000 feet, a fact which indicates continued subsidence along the axis of the Appalachian Strait. The conditions during Mauch Chunk time seem to have been unfavorable for life, for the formation contains no coal beds and shows but little evidence of the presence of either plants or animals.

PENNSYLVANIAN EPOCH.

POTTSVILLE TIME.

The thickness of the Mauch Chunk formation is more than 2000 feet in northeastern Pennsylvania but diminishes from this locality westward. On the Allegheny Front west of Altoona it is 180 feet. At Blairsville it is recorded in deep wells as about 50 feet. On Allegheny River in Armstrong County and farther west the formation is probably not present.

These facts indicate an uplift that raised above water a large land area extending from southern New York at least to Armstrong County and probably as far east as the Allegheny Front. From this land area in the Allegheny Valley and to the west the Mauch Chunk and possibly the top of the Pocono were eroded before the deposition of the overlying Pottsville. The region of the Allegheny Front, including the Barnesboro and Patton quadrangles, was probably dry land during most of Pottsville time, and the erosion of the greater part of the Mauch Chunk formation before the deposition of the Pottsville rocks resulted in an unconformity between the two formations in that region. Just when the uplift occurred can not be definitely determined, but presumably it was during the later part or at the close of Mauch Chunk time. It may have been contemporaneous with an uplift of the region east of the Blue Ridge which led to the discharge of the coarse sand and gravel of the Pottsville rocks in the anthracite basins of eastern Pennsylvania.

The Pottsville was one of the most important and interesting epochs in the history of the province, for in it the accumulation of coal on a large scale began. If such movements in this part of the earth's crust as are indicated in the preceding paragraph took place, there existed at the beginning of Pottsville deposition a narrow and deepening trough in eastern Pennsylvania and southward, bordered around the north end by land on both sides and farther south by land, probably high, on the southeast. From these border lands the rapid streams brought in immense quantities of coarse material, including a large proportion of quartz pebbles, which occur in the thick, extensive, and coarse conglomerates of the Pottsville formation. It is believed that the Pottsville sediments were derived largely from the north end and southeast side of the trough, because there is no near-by source of quartz pebbles on the other side. This deposition of coarse material went on until more than 1200 feet of strata were laid down in the southern anthracite field. At times conditions were favorable to a luxuriant growth of plants, and thick, extensive, and valuable beds of coal were accumulated, parts of which are now preserved in the southern anthracite field.

While 800 or 900 feet of the Pottsville sediments were accumulating in the southern anthracite field erosion had probably been going on from central Pennsylvania westward, and the land surface had been worn down nearly to sea level and then submerged, so that toward the close of Pottsville time sedimentation was resumed over the former land area. Thus it happened that the Connoquenessing sandstone, the lowest Pottsville stratum of the Allegheny Valley and also of the Barnesboro and Patton quadrangles, was deposited in the former region on the surface of the Burgoon ("Mountain") sandstone at the top of the Pocono formation, and in the latter on the probably eroded surface of the Mauch Chunk formation. After the deposition of the Connoquenessing there was a change to more quiet conditions and the Mercer shale member, with its limestone, clay, and coal, was accumulated. This period was followed by one of more active outwash of sand and the Homewood sandstone was laid down, marking the last episode in Pottsville history in western Pennsylvania.

ALLEGHENY TIME.

The Allegheny epoch was marked by very rapidly alternating conditions. Its distinguishing characteristic was the formation of the coal beds. The origin of the coal and the method of its accumulation in beds of great areal extent are subjects that have provoked much discussion. That coal is of vegetal origin hardly anyone would now venture to question. As to the method of accumulation of the vegetal matter there is greater difference of opinion. It seems safe to say that in the main the coal beds of the Appalachian province were formed near sea level in marshes, many of which extended over thousands of square miles. Plants of various types grew very luxuriantly in these marshes. Their remains fell into the water and were preserved from decay until vast accumulations of vegetal matter resulted, not unlike the peat bogs in certain parts of the world at the present day but much greater in extent. It is believed that the plants grew in or near water or very damp places, because this was necessary for the preservation of their remains from subaerial decay. That the water was shallow seems obvious, because the plants grew in the air with their roots in the soil below, which would have been impossible in deep water. That the water was fresh is evident from the fact that plants of the same classes at the present day do not grow in salt water. Finally, that the vegetation grew and accumulated over tracts of great extent is shown by the fact that one and the same coal bed is continuous over thousands of square miles. The Pittsburgh coal is an example. It is known over an area exceeding 10,000 square miles and in all probability originally extended over an area several times as great, from which it has been eroded. It is also evident that these marshes were near sea level and were separated from the sea by barriers that were low, at least in places, for many thin beds bearing marine fossils are found throughout the coal-bearing formations in close proximity to coal beds and a few even in the midst of the coal beds themselves, thus showing that there were temporary incursions of sea water. That the coal beds accumulated near water level is further shown by the fact that they contain many partings of fine shale and clay and other material, some of which are traceable over thousands of square miles. These partings indicate temporary floodings of large areas and the deposition of fine silts while the coal beds were in process of accumulation, and such extensive floodings of quiet water could take place only over areas standing approximately at water level. Along certain lines the coal-forming material might be eroded away at such times by a stream and the channel be subsequently filled with sand to form a "horseback" or roll in the coal bed.

With the foregoing discussion in mind, the sequence of events during the deposition of the Allegheny formation may be conceived to have been somewhat as follows: After the Homewood sandstone was laid down there was a slight subsidence and an accumulation of 10 to 30 feet of clayey sediment, which raised the bottom approximately to water level and caused marshy conditions over a large area. The vegetation of the time established itself on this marshy land and continued until the remains of many generations of plants had formed an extensive area of peat moss. From time to time different parts of this marsh were flooded and thin layers of sediment were deposited, which form the partings or binders of the resulting coal bed. The accumulation of vegetal matter differed in amount at different places, causing coal beds of irregular thickness. After a long period of comparative quiescence the region was depressed, sedimentation was resumed, the plants were killed, the vegetal matter was buried, and, under the pressure of the superincumbent rocks subsequently deposited, it was compressed and hardened into the coal bed now known as the Brookville (or A) coal. The subsidence which led to the burying of the Brookville coal was accompanied by a deposition of shale and sandstone; the sea bottom was again raised to water level, coal-forming conditions were restored, and the Clarion coal bed was laid down. By a repetition of such periods of oscillation and repose the Lower Kittanning, Middle Kittanning, Upper Kittanning, Lower Freeport, and Upper Freeport coal beds and their underclays were accumulated, with intervening beds of sandstone, shale, and limestone.

Although there may have been uplifts at times during the deposition of the Allegheny formation, the prevailing movement was evidently one of subsidence, for each coal bed was accumulated at the surface and then buried. Evidently the rate of subsidence varied.

Certain practical deductions can be derived from an understanding of the formation of coal beds. It is a rather current belief in western Pennsylvania that the thickness of a coal bed is proportionate to the size of the hill containing it. Another belief held by even intelligent men is that a bad streak in a coal bed is in some way related to an adjacent valley, and that better conditions will be encountered on the opposite side. The fallacy of such ideas is at once apparent when it is understood that the thickness, quality, and condition of the coal beds were determined ages before the hills and valleys were formed.

CONEMAUGH TIME.

A marked change in the conditions of vegetation and deposition took place at the close of Allegheny time and continued during the laying down of the 600 feet or more of the sediments of the Conemaugh formation. Marine conditions seem to have prevailed in places after the formation of the Upper Freeport coal bed, for salt-water fossils are found here and there in the roof shale of that bed. Recent studies by Raymond have shown that there were five incursions of the sea after the one just mentioned, but it is possible that some of these did not extend as far east as the Barnesboro-Patton region. In these quadrangles the highest known marine stratum is the Ames limestone, which seemingly marked the most extensive incursion of marine waters in the Pennsylvania coal field during the Conemaugh epoch. In the Barnesboro-Patton region coal-forming conditions were reestablished for a brief time after about 100 feet of sand and clay had been deposited. At this time the Gallitzin coal accumulated. The other thin beds throughout the formation indicate brief recurrences of coal-making conditions. The predominating accumulations in the Barnesboro and Patton quadrangles were sand and mud, the former making the sandstones already described and the latter becoming the shale which forms so large a portion of the beds. Thin limestones of probably nonmarine origin were also deposited in places, indicating small basins from which muddy and sandy sediments were excluded for a short time.

MONONGAHELA TIME.

The beginning of the Monongahela deposition was marked by another great period of coal formation—that of the Pittsburgh coal. At that time the vegetation that was the characteristic feature of the Carboniferous period reached its culmination. The peculiar conditions requisite for the growth and accumulation of vegetal matter were long continued and widespread, as is indicated by the thickness and great extent of the coal. The accumulation of the Pittsburgh coal was followed by a series of events similar to those outlined in the history of the Allegheny formation, and the minor coal beds of the Monongahela formation were laid down. The Monongahela formation is not now present in these quadrangles.

PERMIAN EPOCH.

DUNKARD DEPOSITION.

The deposition of the Monongahela formation was succeeded by that of the shales, sandstones, limestones, and thin coals of the Dunkard group, which have no existing representatives in these quadrangles. The luxuriant vegetation so characteristic of the Carboniferous period gradually diminished and finally became extinct, and this great period, so important in the history of the earth, came to an end.

POST-CARBONIFEROUS DEFORMATION.

With the close of Dunkard deposition, sedimentation in the northern part of the Appalachian trough came to an end, and a long-continued series of events of a totally different kind began. From the beginning of sedimentation in the interior sea intermittent subsidence of the region had been going on, and water had covered the surface in which the sediments from the surrounding land were deposited until tens of thousands of feet of rocks had accumulated. From the close of Carboniferous deposition until the present time the reverse movement of uplift has prevailed and dry land has existed in the north end of the Appalachian coal field.

The period of uplift was inaugurated by an epoch of mountain making during which the sedimentary rocks of the Appalachian Valley were folded into a series of high anticlines and deep synclines and those west of the Allegheny Front were warped into the low anticlines and shallow synclines of the bituminous coal fields.

MESOZOIC ERA.

The Mesozoic era began with the mountain-building epoch just mentioned. In other parts of the United States and of the world the history of this era is amply recorded by sedimentary rocks, but in the Appalachian province the geologic processes since Mesozoic time have been mostly destructive and only a meager record can be found in certain topographic and drainage features that are still preserved and in the relation of those features to the folds of the region.

Evidence of at least one cycle of erosion and of subsequent uplift in the Mesozoic era is preserved in the Appalachian province. The effect of folding the strata would be to produce a strongly undulating surface, yet in the Appalachian Plateau and valley the sky line viewed in any direction from an elevated position is nearly horizontal. The effect is the same as it would be if the present valleys were filled up to the level of the higher ridge crests. It is that of a vast plain. Such a landscape would be impossible if the crests of the great anticlines had not been worn down at least to the level of the bottoms of the synclines, for if any great arch were restored its crest would rise high above the present sky line. The conclusion follows that the old folded and elevated surface was once, at least, worn down nearly to a plain called a peneplain. The Appalachian Mountains in North Carolina and east Tennessee and possibly part of the Appalachian Plateau in the Barnesboro-Patton region were not reduced to the peneplain level but stood above its surface. Later the peneplain was uplifted and more or less warped, its surface rising from an altitude of 600 feet in Alabama to 2000 feet on the Cumberland Plateau and to 4000 feet in West Virginia, whence it descended to 2000 feet in central Pennsylvania, where it is well represented by the crests of the sandstone ridges, such as Dunning and Tussey mountains. If any part of the Barnesboro-Patton area was reduced to this peneplain no clearly recognizable remnants of it remain, as it has been entirely obliterated by subsequent erosion. Yet, as shown below, some of the drainage features of the region point strongly toward its former existence. The valleys in the Appalachian Valley have been eroded since the uplift, and only the ridge crests at about the 2200-foot level remain to attest the former existence of the peneplain in that region.

The old peneplain can be traced eastward and southward and in New Jersey and Alabama passes beneath deposits of early Cretaceous age. This fact proves that the peneplain was completed and submerged around the margins previous to early Cretaceous time, and this is the only event of the Mesozoic history of the Appalachian Plateau of which any evidence has been preserved and of which the geologic date is at all definitely indicated. This peneplain is called the Schooley peneplain because it is well developed and displayed on Schooley Mountain, N. J.

In the light of the history outlined above it is possible to understand the drainage features described on page 2. The courses of the streams were assumed on the nearly flat surface of the peneplain before its uplift. All inequalities due to the folds had been removed, so that the streams were uninfluenced by the structure and some of them flowed across anticline and syncline alike. As the country was slowly raised the streams intrenched themselves in their previously established courses, which they have since maintained. Other explanations of these drainage features are possible, but this one seems the simplest.

CENOZOIC ERA.

TERTIARY PERIOD.

Uplift of the Appalachian province, perhaps in late Cretaceous time, succeeded the Cretaceous transgressions; the processes of degradation that had produced the Schooley peneplain were repeated; and the Harrisburg peneplain, which may be the same as the Highland Rim of Kentucky and Tennessee, is believed to have been formed. This was perhaps less extensive and less completely reduced than the Schooley peneplain. As the preceding uplift occurred in the Cretaceous period and as the time necessary for the formation of a later peneplain was great the Harrisburg peneplain is probably in part of Tertiary age.

QUATERNARY PERIOD.

In the Pleistocene epoch of the Quaternary period the glaciation of the northern and central parts of the United States took place, but the Barnesboro-Patton area was not reached by the ice sheet, the southern margin of which crossed Potter and Tioga counties, on the north. With the possible exception of the high-level gravel described on page 6 no record of Pleistocene events in this area is recognizable, and it is assumed that erosion of the surface continued, with the consequent modification of surface features. It is possible, however, that the high-level gravel was distributed by Pleistocene streams. In the Recent epoch, possibly in very recent time, there seems to have been a diminution of the transporting power of the streams or an increase in their supply of sediment, due perhaps to increased precipitation. Whatever the cause, the streams have evidently been unable to carry away all the material that has been supplied to them and have left part of it in the valleys, where it now constitutes the flood-plain deposits.

The history of the occupation of this region by man, so far as it has been affected by the topography and geology, is interesting. Most of the early travel followed large streams, for these afforded broad highways down which it was easy to float or up which reasonable progress could be made with boats by poling, and regions near the large streams were naturally settled first along the minor valleys, for these afforded lines of easiest access to the interior. Consequently roads were built and farms were cleared first in the valleys, and as the settlements grew to villages and the villages to towns, they still continued to be more numerous in the valleys than on the upland.

The Barnesboro-Patton region, however, is far removed from large streams. It is, in fact, a part of the subcontinental divide across which the emigrant was forced to travel by land. The first fur traders who entered the Barnesboro and Patton quadrangles may have traveled by canoe up some of the head streams of the Susquehanna and then by short portages reached the streams flowing into the Ohio. It is probable, however, that most of the early settlers came overland across the mountains, and the first settlements were naturally made on the upland rather than in the valleys. Most of the thriving towns of to-day are located in the valleys, but these are of recent growth. The older places, like Carrolltown, Chest Springs, and Loretto, are on the upland. The earliest settlements, therefore, being located upon the hilltops, had not only the advantage of easy access from the main roads over the mountains, but also were surrounded by the best farming land of the region. These upland settlements probably continued to be the more important centers of population until the advent of railroads and the beginning of coal mining brought into the problem new factors which completely changed the trend of events.

Valleys are evidently more favorable than hilltops for railroad construction, and thus in the course of time most of the valleys of the region have been occupied by railroad lines. Mines have been opened; such towns as Barnesboro, Spangler, Hastings, Patton, and Coalport have sprung up; and now the great bulk of the population is settled in the valleys, where most of the business is done.

The mining of coal is not necessarily limited to the valleys. Hence in the future large mines may be opened in the uplands, but as mining is almost always more economical in the valleys it seems probable that until the coal is exhausted they will continue to hold the centers of industry and population.

ECONOMIC GEOLOGY.

The mineral resources of the Barnesboro and Patton quadrangles comprise coal, clay, building stone, and limestone. Natural gas is also present, although hardly sufficient in amount to be regarded as a resource. Other resources dependent in large part on the geology are water, soils, and forests.

COAL.

OCCURRENCE.

Principal beds.—Coal is by far the most important mineral of the Barnesboro and Patton quadrangles. At least seven beds have been mined and several more are workable here and there. There are few parts of the quadrangles that are not underlain by at least one or two workable beds.

Nearly all the coals are in the Allegheny formation, though one bed, the Mercer, is in the Pottsville, and two are in the Conemaugh. A number of other coals of only local importance have been noted at various horizons in the Conemaugh formation.

The seven important coal beds in the Allegheny formation correspond in sequence and stratigraphic position to the seven important coals of the Allegheny and Monongahela valleys, commonly known by the names (from below upward) Brookville, Clarion, Lower Kittanning, Middle Kittanning, Upper Kittanning, Lower Freeport, and Upper Freeport.

As the Barnesboro and Patton quadrangles lie in three counties that were mapped by the Second Pennsylvania Geological Survey at different times, considerable confusion has arisen in the nomenclature of the coals. The following table gives the designations that have been applied to them in the various State reports. The letters used for the Brookville, Lower Kittanning, Middle Kittanning, and Upper Freeport coals are common to all the reports, but in the use of the letters A′, C′, D, and D′, there has been disagreement. The Allegheny Valley names are used in the text of this folio. Figure 5 gives the names that are in common use among the coal operators.

Coals in the Barnesboro and Patton quadrangles.

Allegheny Valley names (used in this folio).	Names used by Franklin and W. G. Platt in report on Cambria County (Second Geol. Survey Pennsylvania, Rept. HH, 1877).	Names used by W. G. Platt in report on Indiana County (Second Geol. Survey Pennsylvania, Rept. H4, 1878).	Names used by H. M. Chance in report on Clearfield County (Second Geol. Survey Pennsylvania, Rept. H7, 1884).	Other names.
Gallitzin.				
Upper Freeport	E	E	E	Lemon.
Lower Freeport	D′	D′	D	
Upper Kittanning	D	D	C′	
Middle Kittanning	C	C	C	
Lower Kittanning	B	B	B	Miller.
Clarion		A′	A′	
Brookville	A	A	A	
Mercer				Mount Savage.

Further confusion arises from the uncertainty whether the coals are in reality continuous throughout large areas, as has generally been supposed. For example, there is no evidence that the Upper Freeport coal mined at Delaney is continuous with the bed called by the same name at Dixonville, or that either is continuous with the Upper Freeport coal of the Allegheny Valley. In fact, the comparison and correlation of records from numerous borings throughout the area furnish almost conclusive evidence that, with the possible exception of the Lower Kittanning and Lower Freeport coals, the beds are not so continuous as has been supposed.

Notwithstanding this uncertainty, it is known that the principal workable beds in the different parts of the area correspond in sequence and approximately in horizon, and such names as Upper Freeport and Lower Freeport are therefore used to designate the coals occurring at those horizons respectively. In some areas the character, composition, and persistence of certain beds make their correlation practically sure throughout a hundred or more square miles, but for the others only questionable correlations can be made.

Mercer coal.—Throughout Pennsylvania the principal coal bed in the Mercer shale member of the Pottsville formation is known as the Mercer coal. In parts of the State there are two or more coals in that member. In such places they are called the Upper Mercer coal, Lower Mercer coal, etc. In the Barnesboro-Patton region, as in many others, there is but one coal in the Mercer member, and it is accordingly termed the Mercer coal.

The Mercer coal is reported in several borings in the Barnesboro and Patton quadrangles, but little is known in regard to it. It is generally a rather poor coal and probably is rarely worth mining on a commercial scale. The only localities where its horizon outcrops in the quadrangles are on Chest Creek near Thomas Mills, in the gap of Two Lick Creek, and near Glenwhite. At the first two localities no coal is known. Near Glenwhite, where the coal lies about 60 feet below the top of the Pottsville formation, it has been opened in several banks. The thickness, including partings, averages 6 feet 3 inches, as shown in section 1, figure 7.

Brookville or A coal.—The Brookville coal either lies directly upon the Pottsville formation or is separated from it by a few feet of shale. It outcrops in the quadrangles only on the east slope of Allegheny Mountain, and near Dysart on the west slope of the mountain. It should outcrop also in the gap of Chest Creek between Patton and Aldburn, in the gap of Two Lick Creek west of Mitchells Mills, and possibly at Garmans Mills, but it is not exposed at those localities. It is reported in a number of diamond-drill records, several of which are given in figure 5 (see sections E, J, K, P, and S). The interval between it and the Lower Kittanning coal ranges from 40 to 100 feet.

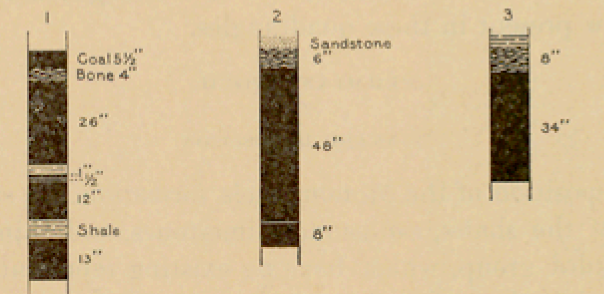


FIGURE 7.—Sections of Mercer, Brookville, and Clarion coal beds.

1. Mercer coal, one-half mile east of Glenwhite.
2. Brookville coal, 1 mile east of Dysart.
3. Clarion coal, nearly 1 mile east of Glenwhite.

Scale, 1 inch = 5 feet.

The Brookville coal is mined in these quadrangles only in the Richland mine, east of Dysart, where it is 4 feet thick, as shown in section 2, figure 7. A coal opened on Chest Creek $1\frac{1}{4}$ miles south of Westover is possibly the Brookville but more probably the Clarion.

Clarion or A′ coal.—Information as to the thickness and character of the Clarion coal in these quadrangles is meager, but the bed is not at all persistent although reported in a number of borings. Its normal position is 25 to 50 feet above the Brookville coal. It has been worked at only one place in the area, in the ravine at Glenwhite, where it was opened 40 feet above the Brookville fire clay and is 2 feet 10 inches thick, as shown by section 3, figure 7.

Lower Kittanning or B coal.—The Lower Kittanning coal, known as the B vein in all the Pennsylvania reports bearing on this region, is one of the most persistent and valuable coals in western Pennsylvania. Its horizon is from 50 to 100 feet above the top of the Pottsville formation, and the interval between it and the Lower Freeport coal ranges from 120 to 200 feet. So far as is known, the coal is persistent throughout the region. In many places it is 5 feet or more in thickness. It outcrops in the quadrangles in five principal districts—on the east and west slopes of Allegheny Mountain, in the valley of Clearfield Creek near Coalport, on Chest Creek between Patton and Aldburn, along the upper part of West Branch of Susquehanna River near Elmora, and on Two Lick Creek between Pleasant Valley and the west margin of the Barnesboro quadrangle.

The coal is extensively mined in the quadrangles at the Sterling Nos. 1, 3, 5, and 6 mines of the Sterling Coal Co., the Nanty Glo No. 2 of the Nanty Glo Coal Co., and the Logan No. 5 of the Logan Coal Co., all in the vicinity of Elmora. At Hastings the bed is being worked by the Pennsylvania Coal & Coke Co. at its No. 12 mine. In the Coalport district the Blair Run Coal Co. operates several mines, and the Oakland No. 3 and Alpha mines are worked by other companies. On the east slope of Allegheny Mountain the Altoona Coal & Coke Co. is operating the Horseshoe mine, and the Glenwhite Coal & Lumber Co. the Miller mine. The Greenwich Coal & Coke Co. has recently opened its Nos. 5 and 8 along the North Branch of Two Lick Creek in the vicinity of Pleasant Valley.

The Lower Kittanning coal of these quadrangles is not equal in quality to the Freeport coals. It is, however, regarded as a superior coal for generating steam, and this opinion is sustained by analyses made of the coal from a number of mines. (See table of analyses, p. 13.) It appears to contain a slightly higher percentage of sulphur than the Freeport coals mined in the region. The sulphur occurs mainly in pyrite lenses and is therefore not all reported in many analyses. The Lower Kittanning coal contains, however, a little less ash than the Freeport coals.

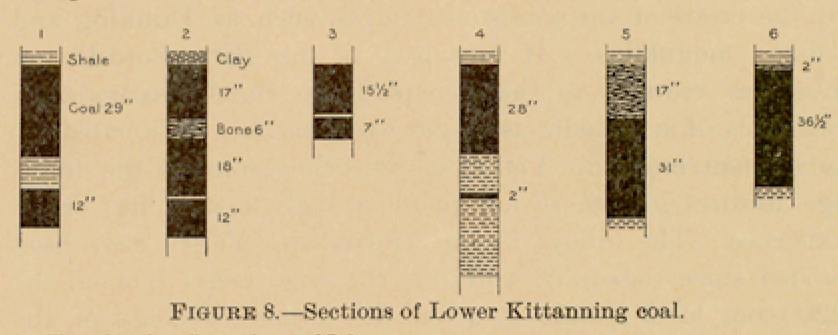


FIGURE 8.—Sections of Lower Kittanning coal.

1. Three-fourths mile southeast of Delaney.
2. Oakland No. 3 mine, one-half mile southeast of Coalport.
3. One mile south of Westover.
4. Browns bank, 1 mile north of Patton.
5. Victor No. 10 mine, Benedict.
6. Rodkey mine, 2 miles northwest of Mitchells Mills.

Scale, 1 inch = 5 feet.

The thickness of the coal is extremely irregular. It is commonly from 4 to 6 feet thick, with two or more partings of clay, shale, or bone, ranging from a thin film to a parting more than a foot thick. Several sections measured near Delaney, Coalport, Westover, Patton, St. Benedict, and north of Mitchells Mills (fig. 8) show the general character of the bed.

Middle Kittanning or C coal.—The Middle Kittanning coal is probably the least important coal in the Allegheny formation, being rarely recognized. It is of workable thickness in only one or two places in the quadrangles.

Upper Kittanning or C′ coal.—The horizon of the Upper Kittanning coal is generally from 30 to 60 feet below the Lower Freeport coal. It outcrops in these quadrangles on Allegheny Mountain, in the vicinity of Coalport, along Chest Creek and Brubaker Run north of Patton and Hastings, in the valley of West Branch of Susquehanna River south of Cherrytree, in the area west of North Branch of Two Lick Creek, in the valleys of Yellow and Little Yellow creeks south of Possum Glory, and at several other places. Its principal development at present is in the vicinity of Patton, where it is extensively mined by the Pennsylvania Coal & Coke Co. It is also mined by the Rich Hill Coal Mining Co. in the Rich Hill mine at Hastings and at several country banks along Brubaker Run. The Patton Clay Manufacturing Co. mines this coal at Patton in connection with the accompanying fire clay.

In the area north and northeast of Patton the Upper Kittanning coal is believed to be of some importance and has been opened in a few banks. Near Frugality it is mined by the Cresson & Clearfield Coal & Coke Co. West of Hastings the coal is of very little value and it is probably not of workable quality anywhere in the Susquehanna Valley. It is reported here and there in the valley of Two Lick Creek and may be of workable thickness in some places, but little is known of it. Nothing certain is known of the coal in the large area south and southeast of Patton.

The general character of the bed may be judged by its composition as shown by analyses 7955, 7959, 7961, and 7965 in the table of analyses.

The average thickness of the coal near Patton is 55 inches, as shown in figure 9. Near the bottom the bed contains several shale partings, and "knife blades" of pyrite are abundant. The coal is reported by the Pennsylvania Coal & Coke Co. as an excellent steam coal, but it has not been coked in this region.

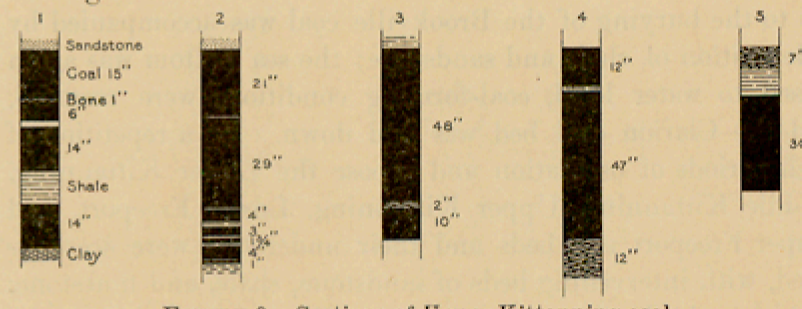


FIGURE 9.—Sections of Upper Kittanning coal.

1. Dean No. 10 mine, one-half mile northeast of Dean.
2. Moshannon No. 33 mine, Patton.
3. One and one-half miles southwest of Patton.
4. Rich Hill mine, Hastings.
5. On Brubaker Run, 2 miles north of Hastings.

Scale, 1 inch = 5 feet.

Lower Freeport or D coal.—The Lower Freeport coal is by far the most important and valuable coal in the Barnesboro and Patton quadrangles. It is not everywhere present, but it is generally found 40 to 50 feet below the Upper Freeport coal. Several measured intervals near Barnesboro are almost exactly 40 feet. Its distance above the Lower Kittanning coal ranges from 120 feet in the valley of West Branch of Susquehanna River to more than 200 feet near Coalport.

The coal is extensively mined along the valley of West Branch and its tributaries, on Chest Creek and Brubaker Run, and in the region about Coalport. The greatest development has been in the vicinity of Barnesboro, Spangler, Elmora, Moss Creek, Carrolltown, St. Bonifacius, and Hastings, where no less than 40 mines are in operation at present. The list of mines is too long to be given here, but most of them are shown on the structure and economic geology maps.

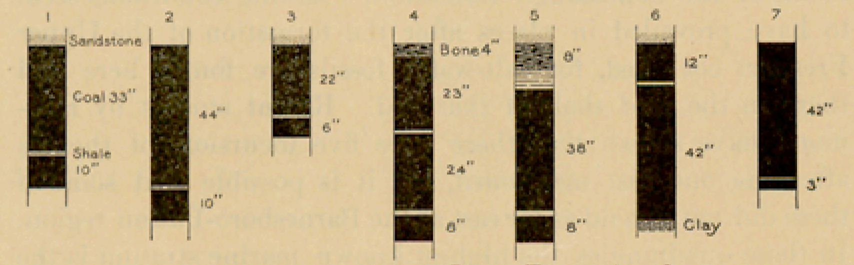


FIGURE 10.—Sections of Lower Freeport coal.

1. About one-half mile north of Ashville.
2. Oakland No. 4 mine, one-half mile north of Flinton.
3. Southern Coal & Coke Co. mine, just south of Westover.
4. Patton No. 1 mine, one-half mile northeast of Carrolltown.
5. West Branch mine, Barnesboro.
6. Susquehanna No. 2 mine, one-half mile south of Garmans Mills.
7. Greenwich mine, Punkey Hollow.

Scale, 1 inch = 5 feet.

This coal is supposed to be identical with the Moshannon bed, which has for many years been a source of supply in the Houtzdale Basin, in eastern Clearfield County. Throughout the northern two-thirds of the Patton quadrangle and the northeastern third of the Barnesboro quadrangle it is believed to be more commonly present than absent. West and south of that area it is known in places but is generally of little importance. Along the entire southern border of the two quadrangles and the western border of the Barnesboro quadrangle it is almost unknown.

In quality the Lower Freeport coal ranks very high for a bituminous coal. It is lower in sulphur than any other coal of the quadrangles, and in percentage of ash it compares most favorably with the Lower Kittanning coal. It is a good coking coal. The table of analyses illustrates its composition.

The average thickness of the coal, where mined in the Barnesboro-Patton region, is 47½ inches. The greatest recorded thickness is 71 inches near Barnesboro. The coal is characterized by a binder 1 or 2 inches thick, which occurs with remarkable persistence 8 to 12 inches from the bottom of the bed. In places there is a bony layer at the top of the bed. The sections in figure 10 may be regarded as typical of the Lower Freeport coal.

Upper Freeport or E coal.—The outcrop of the Upper Freeport coal horizon is shown on the map as the boundary between the Allegheny and Conemaugh formations and its workable outcrop is shown by the corresponding solid blue line. The coal is extensively exposed in the valleys of West Branch of Susquehanna River, Chest Creek, Clearfield Creek, and Little Yellow Creek and their tributaries, and along the Chestnut Ridge anticline. Its horizon is also cut through in numerous small areas lying along the flanks of the anticlines.

Like the Lower Freeport coal, this coal is extensively developed. Near Barnesboro it is worked at Lancashire mines Nos. 9 and 10, operated by Barnes & Tucker; at the Alport No. 1, by the Alport Coal Co.; at the Walnut Run No. 2, by the Walnut Run Coal Co.; and at the Cymbria mine of the Cymbria Coal Co. At Hastings the Rich Hill Coal Co. is working this bed, together with the Upper Kittanning and Lower Freeport coals. In the Allegheny Mountain district the bed is extensively operated at the Delaney mines by the Altoona Coal & Coke Co., at the Glenwhite mines by the Glenwhite Coal & Lumber Co., at Amsbry by the Pennsylvania Coal & Coke Co. at its mines Nos. 7 and 16, and at the Penn-Mary, at Possum Glory, by the Pennsylvania Steel Co. The Greenwich Coal & Coke Co. formerly operated a mine in this bed on Two Lick Creek. A number of country banks throughout the quadrangles are also operated on the bed.

The maximum thickness of the Upper Freeport coal is 5 feet, but it probably does not average more than 3 feet 6 inches. In many places it contains one or two partings or binders, and in some places layers of "bone" as much as a foot in thickness. The sections in figure 11 illustrate the character of the Upper Freeport coal bed.

The Upper Freeport coal is slightly inferior in quality to the Lower Freeport coal. It has generally a columnar structure, is rather hard, with a bright fracture, and is moderately low in sulphur. Its chemical character is shown in the table of analyses.

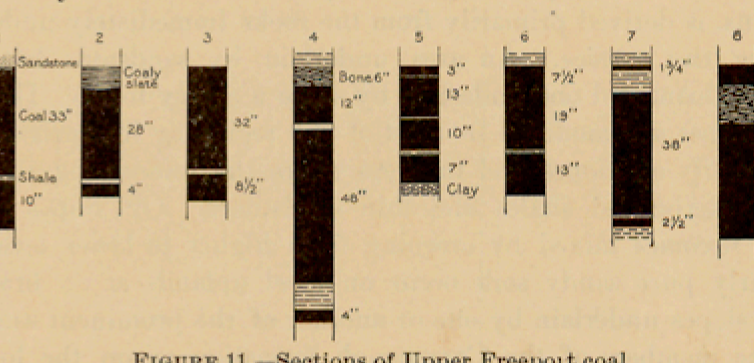


FIGURE 11.—Sections of Upper Freeport coal.

1. About one-half mile north of Ashville.
2. Beaverdam mine, Fiske.
3. Rich Hill mine, Hastings.
4. Lancaster No. 9 mine, Barnesboro.
5. Three miles north of Pindleton.
6. On Little Yellow Creek, about 1 mile southeast of Nolo.
7. At Possum Glory.
8. About one-half mile northwest of Pleasant Valley.

Scale, 1 inch = 5 feet.

Coals of the Conemaugh formation.—As stated under "Descriptive geology," several coal beds occur in the Conemaugh formation, but none of them are of great economic value. The most important is that known as the Gallitzin bed, which lies 70 to 110 feet above the Upper Freeport coal. It is occasionally opened in country banks but nowhere exceeds about 2 feet in thickness. Another coal, probably the Bakerstown, has been noted at many places in the southwestern part of the Barnesboro quadrangle at a horizon presumed to be 215 to 225 feet above the Upper Freeport coal. At one point south of Kellers Mill this coal is 3 feet or more thick, but elsewhere it is known only by blossoms. It seems to be rather persistent in a considerable area.

The coals at higher horizons here and there in the quadrangles appear to be persistent in small areas, but where measured they are as a rule less than 2 feet thick. One of these coals, the Harlem, has been opened in a country bank 1½ miles southeast of St. Augustine and is said to be 3 feet thick, but this reported thickness, remarkable for that bed, has not been verified.

Diamond-drill records.—Through the courtesy of coal operators and other persons who have prospected in the region the Geological Survey has obtained many records of diamond-drill borings, a number of which are given in figure 5, page 4. All coals are represented in the drawing as of the same thickness, a heavy line being drawn at the top of the bed and a break of 10 feet or so being made below each coal. This has been done because some owners have objected to the publication of the thickness of coals as shown in their records, and it was therefore necessary to devise some plan by which the records could be published without revealing the thickness of the coal beds. In other respects the records are published exactly as furnished to the Survey.

The dotted lines connecting the sections are drawn to express the most probable correlations, which have been made after a study of all the available drill records and other data in the region. This method brings out graphically the difference in the thickness and character of the intervals between the coal beds and shows that important coals are missing from some sections. The common occurrence of extra coals and the extreme diversity of the sandstones are also well shown.

CHEMICAL CHARACTER.

In the accompanying table (at end of text) are given analyses of the coal from the principal beds mined in the area, except the Brookville and Mercer beds. All the samples were collected in the standard manner. A cut of equal width and depth and of sufficient thickness to yield 5 pounds of coal to the vertical foot was made across the clean face of the bed. After rejecting such impurities as are rejected in mining, the coal was pulverized so as to pass through a half-inch mesh, mixed, and quartered down to 1-quart samples. These were sealed in galvanized-iron cans and sent directly to the chemical laboratory, where they were transferred to glass jars, in which they were sealed until analyzed. All the analyses were made by the technologic branch of the United States Geological Survey or by the Bureau of Mines.

In order to bring out the general characteristics of the coals of this field and to make comparisons between them and coals of other regions with which they come into competition, the following tables of averages are given. For the purposes of this comparison the dry-coal or moisture-free analysis is used.

Average of the dry-coal analyses of coals in Barnesboro and Patton quadrangles.

	Upper Freeport.	Lower Freeport.	Upper Kittanning.	Lower Kittanning.
Moisture	0.9	0.7	0.8	0.7
Volatile matter	24.00	22.50	22.60	19.50
Fixed carbon	66.80	69.40	63.80	73.10
Ash	8.32	7.36	12.88	6.53
Sulphur	1.60	1.53	2.56	1.53
Calorific value, British thermal units	14,290	14,460	13,510	14,680
Moisture in samples as received	3.3	3.2	2.8	3.1
Air-drying loss	2.4	2.5	2.0	2.4

The analyses available for the Upper Freeport and Upper Kittanning coals are numerically inadequate as a basis for conclusive comparisons as to the quality of the coal. Those for the Lower Freeport and Lower Kittanning coals afford a better basis for an opinion and may be regarded as fairly indicating the average character of the beds.

The analyses show that these coals either belong to the semi-bituminous class or approach it very closely, being of the highest bituminous rank. According to another classification they are grouped as dry-burning coals or steaming coals. They have long held a deservedly high reputation for their excellence. In fact the Barnesboro and Patton quadrangles are included in the Clearfield district, which is the original type locality of the semi-bituminous coals in the United States.

In order to compare these coals with those of like grade from other regions with which they naturally come into competition, the following averages of dry-coal analyses are given. These are arranged by regions.

Average of dry-coal analyses from several regions in Pennsylvania.

	Houtzdale.		Johnstown-South Fork			Windber.	
	1	2	3	4	5	6	7
Moisture	0.7	0.64	0.62	0.65	0.74	0.71	0.8
Volatile matter	22.75	20.77	15.17	15.23	15.68	16.33	13.46
Fixed carbon	71.20	71.32	74.1	74.21	78.18	77.05	79.64
Ash	6.05	7.81	10.67	10.5	6.	6.6	6.88
Sulphur	1.25	2.31	2.35	2.5	1.22	.7	1.36
Calorific value, British thermal units	14,660	14,275	13,860	13,971	14,720	14,650	14,700
Moisture in samples as received	3.1	2.84	2.82	3.15	2.6	3.91	3.1
Air-drying loss	2.4	2.2	2.2	2.5	1.86	3.2	2.3

NOTE.—In the following paragraphs * indicates analyses published in Bull. Bureau of Mines No. 29; † indicates analyses published in Bulls. U. S. Geol. Survey Nos. 316 and 447. The numbers given are laboratory numbers.

1. Lower Freeport. Average of analyses *8483, *8482, *8488, and 8489.
2. Lower Kittanning. Average of analyses *8481, *8480, *10258, *10259, *10264, *10265.
3. Upper Freeport. Average of analyses †3825, †3784, †3843.
4. Upper Kittanning. Average of analyses †3844, †3833, †3834, *10249, *10252, *10251, *10250, †3785, †3836.
5. Lower Kittanning. Average of analyses †2014, †2015, †3838, *7624, *7625, †3786, *9041, *9042, *9043, *9044, *9045.
6. Upper Kittanning. Average of analyses *6261, *6262, *6263, *6264, *6265, *6266.
7. Lower Kittanning. Average of analyses *8975, *8976, *8977, *9028, *9031, *9032, *9029, *9051.

For several coals the number of analyses in the preceding table is hardly sufficient for reliable conclusions, but for others the number is ample and the analyses have been selected as representative from a much greater number. Even where the analyses are few it is believed that a greater number would change the averages but little, so that the table indicates pretty accurately the regional differences in the character of the coals.

The more important facts indicated by the table are a decrease in volatile matter southward from the Houtzdale region, with a slight increase in calorific value, and a progressive increase in volatile matter westward. In general there is also a decrease in calorific value with increase of volatile matter except where the calorific value is unfavorably affected by higher content of ash, sulphur, or moisture, especially the ash.

USES.

Steam coal.—Most of the coal from the quadrangles is used for generating steam, the principal markets being New York and Philadelphia. For such use these coals are surpassed in quality, if at all, only by the purer coals of the Pocahontas and New River districts of Virginia and West Virginia, and they easily outrank those of Ohio and Illinois and of the western fields in general. The results of a few steaming tests made of coals from these quadrangles by the fuel-testing plant at St. Louis have been published.[a]

Coke.—A considerable quantity of the coal is used for coke, the Upper Freeport coal from the Penn-Mary mines, amounting to nearly 800,000 tons annually, being so used by the Pennsylvania Steel Co. The coal is shipped to the works in Dauphin County and coked by the Semet-Solvay process, the yield of coke being 76.8 per cent.

Both the Upper Freeport and Lower Kittanning coals will make coke. Besides the coal from the Penn-Mary mines the Upper Freeport coal mined at Gallitzin and Cresson, a few miles south of these quadrangles, is extensively coked in beehive ovens. No statements are at hand concerning the yield and quality of the coke.

The Lower Kittaning coal at Bennington was at one time coked by the Cambria Steel Co. for use in its furnaces at Johnstown. The yield is reported to have been 64 per cent. Coking tests of Lower Kittanning coal from Wehrum and Ehrenfeld, a few miles south of the Barnesboro-Patton area, were made in beehive ovens at the fuel testing plant at St. Louis with the results shown below:

Partial statement of coking tests of Lower Kittanning coal from Wehrum and Ehrenfeld; coke produced from raw coal.

	Wehrum.[a]	Ehrenfeld.[b]
	Per cent.	*Per cent.*
Coke	59.27	52.23
Breeze	2.69	16.00
	61.96	68.23

[a] Bulls. U. S. Geol. Survey Nos. 332 and 447. [b] Bulls. U. S. Geol. Survey Nos 290 and 447.

The coke from Wehrum was dull gray, soft, and dense and was high in sulphur; that from Ehrenfeld was dull gray, soft, and dense, in large and small chunks, with heavy black butt. The cell structure was small and the coke hard to burn. The total yield of coke shown by these tests is fairly satisfactory, but the quality of the product does not indicate a high grade of coking coal. The indications from the tests probably hold good for the Lower Kittanning of the Barnesboro-Patton region also. No tests of the Lower Freeport or Upper Kittanning coals have been made and their coking qualities are unknown.

NATURAL GAS.

A number of attempts have been made in the Barnesboro and Patton quadrangles to reach oil and gas bearing strata by boring So far as oil is concerned all the attempts have failed. No petroleum has been struck so far east and south in the State, nor within many miles to the west and north of the quadrangles. There are, however, a number of borings that have struck small quantities of gas. Between Carrolltown and Elmora five wells yield gas enough to supply a part of Carrolltown. One of them was drilled years before this report was written and is reported to be 3300 feet deep and to have reached gas at a depth of about 2200 feet.

A well was drilled about 1865 on the east bank of West Branch of Susquehanna River at Cherrytree. Its depth was 652 feet and a heavy flow of gas was struck in it at a depth of 250 feet, at the base of a tough sandstone. The stratigraphic position of the sandstone is not certainly known, but it is supposed to lie between the Lower Kittanning and Upper Kittanning coals. However, as the exact location of the well is in doubt, there is a possibility of a mistake in the identification of the sandstone, which may be a part of the Pottsville formation. Such was supposed to be the case by Platt, who gave the record of the the well.[b] The illuminating power of the gas is said to be small. The record of the well is given on page 12.

Although there is no certainty that gas is present in quantity at any horizon in the Barnesboro and Patton quadrangles, reservoirs of it may exist. Farther west in the State the rocks are arched into broad, low folds, a sort of structure very favorable to the accumulation of oil and gas. Near the Allegheny Front, however, the folds are sharper and the rocks more

[a] Bulls. 290, 332, and 447 and Prof. Paper 48, U. S. Geol. Survey, and Bull. 23, U. S. Bureau of Mines.

[b] Rept. HH, Second Geol. Survey Pennsylvania, pp. 178-180.

crushed, and in the Houtzdale quadrangle, northeast of the Patton, a number of faults are known. Such conditions are much less favorable for the accumulation of gas. The region has, however, never been thoroughly tested, and it is not impossible that by drilling at suitable points along the anticlines gas may yet be found in paying quantities.

Record of well at Cherrytree, Pa.

	Feet.
Surface soil and river gravel	33
Coal bed	2
Soapstone (fire clay shale?)	10
Sandstone, conglomeratic	40
Coal bed	5
White slate (fire clay?)	8
Slate, ultimately changing to black carbonated slate	21
Coal bed	5
Fire clay	4
Sandstone	19
Coal, thin.	
Slate, changing in color to black	20
Coal bed	5
Fire clay	7
Sandstone, massive, hard; heavy flow of gas	75
Shale	20
Sandstone	40
Hard boring (sandstone?)	68
Very hard flint rock	1½
Sandstone, massive	20
Black slate	15
Coal bed	4½
Fire clay	5
Sandstone, massive	35
Shale	5
Sandstone, massive (?)	165
Shale	2
Sandstone	18
	653

FIRE CLAY.

Clay beds immediately underlie most of the coals in these quadrangles, but so far they have been utilized only to a small extent. The quadrangles are rich in clay and shale suitable for making clay wares, but the deposits have not yet been fully explored.

In the eastern part of Cambria and Clearfield counties a valuable bed of fire clay, known as the Mount Savage fire clay, occurs in the Mercer member of the Pottsville formation. It is extensively mined for the manufacture of fire brick in the Curwensville, Houtzdale, and Altoona quadrangles but has not been observed in the Barnesboro and Patton quadrangles. Its horizon outcrops about 60 feet below the top of the Pottsville formation, and the clay may occur in this area.

On Two Lick Creek at the western margin of the Barnesboro quadrangle a bed of clay reported to be 32 feet thick lies just beneath the Lower Kittanning coal. It is utilized by the Clymer Brick & Fire Clay Co. for making hollow, paving, and common brick. The bed beneath the Upper Kittanning coal is mined at Patton, where it is more than 6 feet thick, by the Patton Clay Manufacturing Co. The Upper Kittanning coal is mined for use in the plant. The principal manufactured products are fire brick and sewer pipe.

Beds of fire clay of considerable thickness and of possible value occur in the Conemaugh formation, and one or more of them are mined, in connection with the including shale, by the Patton Clay Manufacturing Co. The material is mixed with the clay from the bed beneath the Upper Kittanning coal for use in making wares of certain grades.

SANDSTONE.

There are several massive sandstone beds in the quadrangles, and it is possible that some of them may be of future economic value. The only beds that have been worked, however, are the Homewood, Clarion, Kittanning, and Mahoning.

Homewood sandstone.—The Homewood is a massive sandstone member at the top of the Pottsville formation. It is a pure quartz sandstone, coarse, conglomeratic in many places, and suitable for foundations and bridges. It is quarried extensively at a number of points outside of the quadrangles and is used in bridge construction. It has also been used to a small extent for building.

The sandstone crops out along the east side of Clearfield Creek between Dysart and Dean and on the steep slope to the east, lying on the surface in great blocks that are quarried to some extent. In the bottom of the valley, halfway between Dean and Dysart, the rock, which is quarried in places and appears to be a first-class stone for bridge work, is coarse and somewhat conglomeratic and is of unknown thickness. At the quarries southeast of Dysart, operated by the Conemaugh Stone Co., the stone is of the same general character.

Clarion and Kittanning sandstones.—The Clarion and Kittanning sandstone members lie between the Brookville and Lower Kittanning coals and are commonly mistaken for the Homewood, to which they are similar. In fact, there is no lithologic character by which they can be certainly distinguished from the Homewood. All three are very hard and massive and their bowlders and blocks pave the hillsides in places, concealing all beds outcropping between and below them. The thickness of the Clarion and Kittanning sandstones is very irregular, as shown by diamond-drill records. Borings in Buffington, near Pleasant Valley, and northeast of Patton each show about 30 feet of sandstone. Drill holes in the vicinity of Moss Creek show 40 to 60 feet of sandstone. A boring at Hillsdale notes only 5 feet, and in the record of one near Spangler no sandstone is given.

These sandstones are extensively quarried at Aldburn, on Chest Creek, and are used principally for constructing bridges on the Pennsylvania Railroad.

Mahoning sandstone.—The Mahoning sandstone member is in many places as massive and thick as the Homewood and seems to be suitable for the same purposes. It is not known to have been quarried in place, but on the ridge west of Patton the slope is covered thickly by huge blocks that are being worked to a considerable extent. The court house of Indiana County is said to be built of Mahoning sandstone.

Other sandstones.—Sandstone that is regarded as the Freeport sandstone member was at one time quarried on a small scale near Westover by the Central Coal Mining Co., for use in the foundations of buildings at its mines. The stone appears to be of good quality, but it is not known to have been used elsewhere. The Saltsburg and Ebensburg sandstones may be of some value, but they have never been tested.

LIMESTONE.

Limestones in the Pennsylvanian series have been opened at several points on Allegheny Mountain. About 2 miles east of Ashville a bed supposed to be about 130 feet above the Upper Freeport coal has been opened to a thickness of 6 feet. The stone is hard, compact, and appears to be of good quality. An entire thickness of 15 feet is reported, but the report is possibly somewhat exaggerated. A short distance west of Chest Creek at Eckenrode Mill a gray flintlike limestone was once opened. About a mile northwest of Winterset a bed of hard gray limestone has in the past been burned for lime. A number of farmers in eastern Indiana County, especially north of Yellow Creek, have opened limestone beds on their farms and have burned the stone for fertilizer. Outcrops of thin limestones are scattered throughout the area, but at only a few points can the thickness be observed.

A somewhat typical section of a limestone in the Conemaugh formation, exposed on the Pennsylvania Railroad about a mile northwest of Loretto Road station, is as follows:

Section in railroad cut near Loretto Road.

	Ft.	in.
Coal		3
Sandstone, calcareous		9
Limestone, brownish, earthy		7
Shale, sandy, with layers of calcareous sandstone	1	8
Limestone, earthy	1	8
Shale		4
Limestone, drab	1	6
Shale, soft, gray	1	2
Limestone, earthy	2	

In addition to the outcropping limestones a number are known only from records of borings.

WATER RESOURCES.

Water in the farming districts is commonly taken from springs, which furnish plenty of excellent soft drinking water.

The municipal supply of Carrolltown comes from a spring and is reported to be of the best quality. At Hastings water is obtained from a reservoir in the ravine below Pennsylvania No. 20 mine. Water from Chest Creek is used almost exclusively at Patton. The water supply of Barnesboro and Spangler, which is taken from a reservoir in the ravine below the mining town of Benedict is probably polluted by drainage from Benedict. The reservoirs of the city of Altoona, near Kittanning Point, just outside of the Patton quadrangle, derive their supply from Burgoon Run below Delaney and Glenwhite Run below Glenwhite. These supplies, which have been repeatedly subjected to bacteriological tests, are apparently free from infectious material. Possibly the small amount of ferrous sulphate normally present in the waters assists in their self-purification.

Conditions are similar, although on a smaller scale, at other mining towns in the quadrangles. At present many of them have satisfactory supplies, but some have not, and it seems probable that the problem of water supply will become serious in the near future. As only temporary relief will be afforded by changing from one surface source to another, it will be necessary to prospect underground.

Heretofore the abundance of good springs in the region has made it unnecessary to sink many wells, although shallow wells are numerous in some localities and deep wells have been driven at a few places. The water supply of Coalport is obtained from deep wells. Such wells have also been sunk at the tannery at Westover, on the hills east of Chest Springs, and at Barnesboro. The water is usually of excellent quality.

There are a few flowing wells in the area, as at Syberton, in the Patton quadrangle. The flow is due to a head of 1000 feet caused by the anticlinal structure of Allegheny Mountain on the east; it indicates that when the surface supply becomes scarce or contaminated, an abundant supply can perhaps be obtained by drilling deep wells along the Wilmore syncline. Water has also been observed to flow from a diamond-drill hole on Laurel Lick Run, 1½ miles southeast of Tunnel Siding. Although it is not certain that favorable artesian conditions prevail throughout the several basins in the quadrangles, the general structural conditions are promising, especially along the deeper parts of the Wilmore, Bradley, Barnesboro, and Brush Valley synclines. The question can be definitely settled only by drilling at favorable points in the basins.

SOILS.

The soil of the quadrangles, except the alluvium of the flood plains, is derived primarily from the rocks immediately underlying the surface. An area underlain by sandstone has a sandy loam and one underlain by shale a clayey loam. These soil types are modified in most of the region by intermixture, especially on slopes and in areas where the underlying rocks are interbedded shales and thin sandstones. On slopes the soil becomes mixed by creeping from higher to lower levels. Nearly pure sandy soils occur on level uplands or on broad dip slopes underlain by one or another of the prominent sandstone members of the Conemaugh formation, as on the long slope east of Strongstown, underlain by the Buffalo sandstone, and on the uplands at Pine Flats and Nicktown, underlain by the Saltsburg and Morgantown sandstones, respectively.

Pure clayey soils probably are of rather scanty occurrence, the mixed soil predominating. A good example may be seen on the upland extending from Loretto to St. Augustine.

The soils are especially well adapted to cereals, grass, leguminous crops, potatoes, and fruits. Corn, wheat, and hay are the principal crops, and grazing and dairying are carried on to a considerable extent. The mining population affords an excellent market for hay, dairy products, fruits, and vegetables.

May, 1913.

Analyses of coals in the Barnesboro and Patton quadrangles.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Calorific value.		Notes.
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.	
														UPPER FREEPORT (E) COAL.
7957	1.8	A	2.7	22.0	66.4	8.9	1.54					7,680	13,820	7957. Barnesboro, Lancashire No. 10 mine; right heading 5, 39½-inch cut.
		B	.9	22.4	67.6	9.1	1.57					7,820	14,170	
		C		22.6	68.3	9.1	1.58					7,895	14,210	
		D		24.9	75.1		1.74					8,685	15,630	
7958	1.8	A	2.5	21.8	67.7	7.97	2.02	5.07	78.67	1.24	5.03	7,805	14,050	7958. Same; right heading 4, 44½-inch cut.
		B	.8	22.2	68.9	8.12	2.06	4.96	80.11	1.26	3.49	7,950	14,310	
		C		22.3	69.5	8.18	2.07	4.93	80.74	1.27	2.82	8,010	14,420	
		D		24.3	75.7		2.25	5.36	87.93	1.38	3.08	8,725	15,700	
7972	2.7	A	3.6	23.6	67.4	5.45	1.30	4.98	79.80	1.31	7.16	7,890	14,200	7972. Possum Glory (Heilwood), Penn-Mary No. 1 mine; right heading 3 off town drift, 48½-inch bed, 38-inch cut.
		B	.9	24.2	69.3	5.60	1.34	4.81	82.01	1.35	4.89	8,110	14,590	
		C		24.4	69.9	5.65	1.35	4.75	82.80	1.36	4.09	8,185	14,730	
		D		25.9	74.1		1.43	5.03	87.76	1.44	4.34	8,675	15,620	
7973	3.0	A	4.0	23.4	67.4	5.2	.85					7,880	14,180	7973. Same; right heading 1, 61-inch bed, 39-inch cut.
		B	1.0	24.1	69.6	5.3	.88					8,125	14,620	
		C		24.3	70.3	5.4	.89					8,205	14,770	
		D		25.7	74.3		.94					8,675	15,610	
10278	2.5	A	3.5	24.5	61.4	10.6	1.79					7,480	13,460	10278. Fallen Timber, Peerless No. 4 mine; right main entry 1,250 feet from drift mouth, 26½-inch cut.
		B	1.0	25.1	63.0	10.9	1.84					7,670	13,810	
		C		25.4	63.6	11.0	1.85					7,750	13,950	
		D		28.5	71.5		2.08					8,705	15,670	
10279	2.7	A	3.3	24.8	63.1	8.8	1.64					7,680	13,820	10279. Same; left main entry 1,200 feet from drift mouth 27½-inch cut.
		B	.6	25.5	64.8	9.1	1.69					7,895	14,210	
		C		25.6	65.3	9.1	1.70					7,940	14,300	
		D		28.2	71.8		1.87					8,740	15,730	
10298	2.6	A	3.3	24.1	62.7	9.85	1.80	4.96	76.78	1.25	5.36	7,565	13,620	10298. Same; composite of Nos. 10278 and 10279.
		B	.8	24.7	64.4	10.11	1.85	4.79	78.83	1.28	3.14	7,770	13,980	
		C		24.9	64.9	10.19	1.86	4.76	79.44	1.29	2.46	7,825	14,090	
		D		27.7	72.3		2.07	5.30	88.46	1.44	2.73	8,715	15,690	
														LOWER FREEPORT (D) COAL.
4028	2.3	A	2.9	22.6	67.7	6.8	1.42							4028. Hastings, No. 20 mine; room 19 of left heading 29 several hundred feet from opening, sample 1a, 59-inch cut.
		B	.6	23.2	69.3	6.9	1.45							
		C		23.3	69.7	7.0	1.46							
		D		25.1	74.9		1.57							
4029	2.3	A	2.7	22.7	67.4	7.2	1.51					7,860	14,140	4029. Same; 24th right heading, sample 2a, 47-inch cut.
		B	.4	23.2	69.0	7.4	1.55					8,045	14,480	
		C		23.3	69.3	7.4	1.55					8,080	14,540	
		D		25.2	74.8		1.67					8,730	15,710	
4169	3.9	A	4.2	21.8	66.1	7.87	1.59	4.72	75.92	1.28	8.62	7,505	13,510	4169. Same; run-of-mine car sample.
		B	.3	22.7	68.8	8.19	1.65	4.46	79.00	1.33	5.37	7,810	14,060	
		C		22.8	69.0	8.22	1.66	4.44	79.29	1.34	5.05	7,840	14,110	
		D		24.8	75.2		1.81	4.84	86.39	1.46	5.50	8,540	15,380	
7953	3.4	A	4.5	19.2	68.8	7.53	1.69	5.17	77.76	1.15	6.70	7,615	13,710	7953. Barnesboro, Lancashire No. 1 mine, left heading 11, 53-inch cut.
		B	1.1	19.9	71.2	7.80	1.75	4.96	80.50	1.19	3.80	7,885	14,190	
		C		20.1	72.0	7.88	1.77	4.90	81.38	1.20	2.87	7,970	14,350	
		D		21.8	78.2		1.92	5.32	88.34	1.30	3.12	8,650	15,570	
7963	2.5	A	3.1	20.6	70.0	6.3	1.14					7,915	14,250	7963. Same; right heading 13, 53½-inch bed, 50½-inch cut.
		B	.6	21.2	71.8	6.4	1.17					8,120	14,620	
		C		21.3	72.3	6.4	1.18					8,170	14,710	
		D		22.7	77.3		1.26					8,733	15,720	
7954	1.9	A	2.8	21.2	67.0	8.95	1.82	4.87	77.80	1.28	5.28	7,645	15,760	7954. St. Benedict, Victor No. 6 mine; main heading 5,850 feet from mouth, 46-inch bed, 42-inch cut.
		B	.9	21.7	58.3	9.12	1.86	4.75	79.31	1.30	3.66	7,795	14,030	
		C		21.8	69.0	9.21	1.87	4.69	80.04	1.32	2.87	7,865	14,160	
		D		24.0	76.0		2.06	5.17	88.16	1.45	3.16	8,665	15,590	
7956	1.8	A	2.6	22.1	67.8	7.5	1.71					7,775	13,990	7956. Same; left heading 7, 3½-foot bed, 38-inch cut.
		B	.8	22.5	69.1	7.6	1.74					7,915	14,250	
		C		22.7	69.6	7.7	1.76					7,980	14,370	
		D		24.6	75.4		1.91					8,645	15,560	
7964	1.5	A	2.2	23.8	65.4	8.61	1.84	4.80	78.47	1.29	4.99	7,710	13,880	7964. St. Boniface. Pardee No. 27 mine; main heading 51-inch bed, 50-inch cut.
		B	.7	24.2	66.4	8.74	1.87	4.70	79.66	1.31	3.72	7,825	14,090	
		C		24.4	66.8	8.80	1.88	4.66	80.23	1.32	3.11	7,880	14,190	
		D		26.7	73.3		2.06	5.11	87.97	1.45	3.41	8,645	15,560	
7967	1.5	A	2.3	22.1	67.3	8.3	1.82					7,710	13,880	7967. Same; 600 feet from pit mouth and 24 feet from main heading, 43-inch bed, 3½-foot cut.
		B	.8	22.5	68.3	8.4	1.85					7,830	14,090	
		C		22.7	68.9	8.4	1.86					7,890	14,200	
		D		24.8	75.2		2.03					8,620	15,510	
7968	2.3	A	3.2	21.9	67.5	7.4	.78					7,790	14,020	7968. Emeigh, Victor No. 15 mine; face of 6 left heading, 42½-inch bed.
		B	.9	22.4	69.1	7.6	.80					7,970	14,350	
		C		22.6	69.7	7.7	.81					8,040	14,470	
		D		24.5	75.5		.88					8,705	15,670	
7970	4.7	A	5.5	22.4	65.2	6.91	1.17	5.13	77.23	1.19	8.37	7,585	13,650	7970. Same; face of main heading, 45-inch bed 44-inch cut.
		B	.8	23.5	68.5	7.25	1.23	4.84	81.04	1.25	4.39	7,960	14,320	
		C		23.7	69.0	7.31	1.24	4.78	81.69	1.26	3.72	8,025	14,440	
		D		25.6	74.4		1.34	5.16	88.14	1.36	4.00	8,655	15,580	
10262	2.1	A	2.7	21.9	68.6	6.8	1.60					7,890	14,200	10262. Barnesboro, ¾ mile northeast of Delta mine; room 30, left entry 12, 4,500 feet from drift mouth, 48½-inch cut.
		B	.6	22.4	70.1	6.9	1.63					8,055	14,500	
		C		22.6	70.5	6.9	1.64					8,110	14,600	
		D		24.2	75.8		1.76					8,715	15,680	
10263	2.6	A	3.9	22.0	68.2	5.9	1.34					7,785	14,020	10263. Same; pillar on right entry 2 of main entry, 2,000 feet from drift mouth, 48½-inch cut.
		B	1.3	22.6	70.0	6.1	1.38					7,995	14,390	
		C		22.9	70.9	6.2	1.39					8,100	14,580	
		D		24.4	75.6		1.48					8,630	15,530	
10285	2.1	A	2.6	23.0	67.8	6.6	1.38					7,900	14,220	10285. Same; left entry 16 off main heading 5,500 feet from drift mouth, 58½-inch cut.
		B	.5	23.5	69.3	6.7	1.41					8,070	14,530	
		C		23.6	69.6	6.8	1.42					8,115	14,610	
		D		25.3	74.7		1.52					8,705	15,670	
10286	2.3	A	2.8	22.6	67.9	6.7	1.59					7,850	14,130	10286. Same; left entry 14 off main heading, 50¾-inch cut.
		B	.5	23.2	69.5	6.8	1.63					8,035	14,460	
		C		23.3	69.8	6.9	1.64					8,075	14,540	
		D		25.0	75.0		1.76					8,675	15,610	
10287	2.4	A	3.0	22.0	68.4	6.6	1.48					7,870	14,170	10287. Same; left entry 18 off main heading 6,500 feet from drift mouth, 52¾ inch cut.
		B	.6	22.6	70.1	6.7	1.52					8,065	14,520	
		C		22.7	70.5	6.8	1.53					8,115	14,610	
		D		24.4	75.6		1.64					8,705	15,670	
10292	2.2	A	2.9	21.4	69.2	6.46	1.52	5.00	80.53	1.19	5.30	7,875	14,180	10292. Same; composite of 10262, 10285, 10287.
		B	.7	21.9	70.8	6.61	1.55	4.87	82.34	1.22	3.41	8,055	14,490	
		C		22.1	71.3	6.65	1.56	4.81	82.91	1.23	2.84	8,110	14,590	
		D		23.6	76.4		1.67	5.15	88.81	1.32	3.05	8,685	15,630	
														UPPER KITTANNING (C') COAL.
7955	3.0	A	4.0	20.9	61.9	13.2	.89					7,100	12,780	7955. Patton, Moshannon No. 33 mine; heading 18 off main heading, 16¼-inch bed, 12¾-inch cut.
		B	1.0	21.6	63.8	13.6	.92					7,320	13,170	
		C		21.8	64.5	13.7	.93					7,395	13,310	
		D		25.3	74.7		1.08					8,570	15,430	
7959	1.9	A	2.7	23.2	65.8	8.35	1.72	4.96	78.37	1.17	5.43	7,680	13,820	7959. Same; heading 18 off main heading 2, 4½-foot bed, 50-inch cut.
		B	.8	23.6	67.1	8.51	1.75	4.84	79.89	1.19	3.82	7,825	14,090	
		C		23.8	67.6	8.58	1.77	4.79	80.56	1.20	3.10	7,890	14,210	
		D		26.1	73.9		1.94	5.24	88.12	1.31	3.39	8,635	15,540	

Analyses of coals in the Barnesboro and Patton quadrangles—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Calorific value.		Notes.
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.	
														UPPER KITTANNING (C') COAL—continued.
7961	2.6	A	3.3	22.0	63.0	11.7	3.48					7,325	13,180	7961. Same; heading 21 off main heading, 60-inch bed, 43-inch cut.
		B	.7	22.6	64.7	12.0	3.57					7,520	13,540	
		C		22.7	65.2	12.1	3.60					7,575	13,640	
		D		25.8	74.2		4.09					8,615	15,510	
7965	.4	A	.9	22.5	59.3	17.3	3.97					7,090	12,760	7965. Same; left heading 6 off level 2, 5½-foot bed, 46-inch cut.
		B	.5	22.6	59.5	17.4	3.99					7,120	12,810	
		C		22.7	59.8	17.5	4.01					7,155	12,880	
		D		27.5	72.5		4.86					8,670	15,610	
														LOWER KITTANNING (B) COAL.
3809	3.	A	3.5	18.8	71.2	6.5	2.01							3809. Expedit, Twin Rocks, near Big Bend, Nonpareil No. 1 mine, about 8 feet.
		B	.5	19.4	73.4	6.7	2.07							
		C		19.5	73.7	6.8	2.08							
		D		20.9	79.1		2.23							
3810	2.5	A	3.1	17.6	72.9	6.4	1.38							3810. Same; No. 3 mine; right heading 4.
		B	.6	18.1	74.7	6.6	1.42							
		C		18.2	75.2	6.6	1.42							
		D		19.5	80.5									
7960	2.1	A	2.9	19.5	70.9	6.67	1.76	5.04	79.78	1.26	5.49	7,855	14,140	7960. St. Benedict, Victor No. 10 mine; right heading 2, 45-inch bed, 27-inch cut.
		B	.9	19.9	72.4	6.81	1.80	4.91	81.49	1.29	3.70	8,085	14,450	
		C		20.1	73.0	6.87	1.81	4.85	82.20	1.30	2.97	8,095	14,570	
		D		21.6	78.4		1.94	5.21	88.27	1.40	3.18	8,690	15,650	
7966	2.5	A	3 2	19.3	71.1	6.4	1.38					7,905	14,230	7966. Same; near tail of heading toward No. 9 mine; 4-foot bed, 31-inch cut.
		B	.7	19.8	72.9	6.6	1.42					8,105	14,590	
		C		19.9	73.5	6.6	1.43					8,165	14,700	
		D		21.4	78.6		1.53					8,745	15,740	
7962	3.1	A	3.9	22.5	67.1	6.52	.66	5.16	79.41	1.27	6.98	7,845	14,120	7962. Patton, 1 mile north of E. C. Brown bank; 300 feet from mouth, 42-inch bed, 32-inch cut.
		B	.8	23.3	69.2	6.73	.68	4.97	81.95	1.31	4.36	8,095	14,570	
		C		23.4	69.8	6.78	.69	4.92	82.62	1.32	3.67	8,160	14,690	
		D		25.1	74.9		.74	5.28	88.63	1.42	3.93	8,755	15,750	
7969	1.3	A	2.1	24.4	66.1	7.39	2.19	5.08	79.39	1.19	4.76	7,870	14,170	7969. Clymer, Rodkey mine; face of 4th left heading, 1,400 feet from mouth, 38½-inch bed, 36½-inch cut.
		B	.8	24.8	66.9	7.49	2.22	5.01	80.43	1.21	3.64	7,975	14,360	
		C		25.0	67.5	7.55	2.24	4.95	81.06	1.21	2.99	8,035	14,470	
		D		27.0	73.0		2.42	5.35	87.68	1.31	3.24	8,695	15,650	
7971	1.6	A	2.3	25.8	66.0	5.9	1.53					7,975	14,360	7971. Same; face of main heading 39½-inch bed, 37½-inch cut.
		B	.7	26.2	67.1	6.0	1.55					8,105	14,590	
		C		26.4	67.5	6.1	1.57					8,165	14,700	
		D		28.1	71.9		1.67					8,690	15,640	
8990	2.4	A	3.3	19.0	71.7	6.0	1.50							8990. Bakerton, Sterling No. 5 mine, block entry off main entry 1,400 feet N. 50° E. from drift mouth, 23¾-inch cut.
		B	.9	19.5	73.5	6.1	1.50							
		C		19.5	74.4	6.1	1.55							
		D		21.0	79.0		1.65							
8991	2.5	A	3.3	18.0	73.0	5.7	1.05							8991. Same; right entry 7 off main entry, 2,200 feet N. 30° E. from drift mouth, 37½-inch cut.
		B	.8	18.5	74.8	5.9	1.10							
		C		18.5	75.6	5.9	1.10							
		D		20.0	80.0		1.20							
9034	2.5	A	3.2	18.5	72.4	5.87	1.27	4.84	80.43	1.27	6.32	7,955	14,320	9034. Same; composite of Nos. 8990 and 8991.
		B	.7	19.0	74.3	6.02	1.30	4.68	82.49	1.30	4.21	8,160	14,690	
		C		19.0	74.9	6.06	1.31	4.63	83.09	1.31	3.60	8,220	14,790	
		D		20.5	79.5		1.39	4.93	88.45	1.39	3.84	8,750	15,750	
8992	1.9	A	2.6	17.5	72.8	7.1	1.85							8992. Sterling No. 1 mine, left entry 3 off main entry, 4,000 feet S. 45° E. from drift mouth, 37-inch cut.
		B	.7	18.0	74.1	7.2	1.90							
		C		18.0	74.8	7.2	1.90							
		D		19.5	80.5		2.05							
8993	2.0	A	2.8	19.5	71.3	6.4	1.55							8993. Same; main entry 5,600 feet S. 6° E. from drift mouth, 38-inch cut.
		B	.8	19.5	73.1	6.6	1.60							
		C		20.0	73.4	6.6	1.60							
		D		21.0	79.0		1.70							
8994	2.2	A	2.9	17.5	73.5	6.1	1.55							8994. Same; room on left entry 3 off dip entry, 3,200 feet S. 15° W. from drift mouth, 38-inch cut.
		B	.7	18.0	75.1	6.2	1.55							
		C		18.0	75.7	6.3	1.60							
		D		19.0	81.0		1.70							
8995	2.3	A	3.3	16.5	74.6	5.6	1.10					8,010	14,420	8995. Same; pillar 2 off right entry 2 off main entry, 1,200 feet S. 15° W. from drift mouth, 38½-inch cut.
		B	1.0	16.5	76.8	5.7	1.15					8,200	14,760	
		C		17.0	77.2	5.8	1.15					8,285	14,910	
		D		18.0	82.0		1.20					8,795	15,830	
9035	2.0	A	2.9	17.0	73.4	6.74	1.69	4.68	80.12	1.16	5.61	7,945	14,310	9035. Same; composite of Nos. 8992, 8993, and 8994.
		B	1.0	17.5	74.6	6.88	1.72	4.55	81.76	1.18	3.91	8,110	14,600	
		C		18.0	75.1	6.94	1.74	4.48	82.55	1.20	3.09	8,190	14,740	
		D		19.0	81.0		1.87	4.81	88.71	1.29	3.32	8,800	15,840	
8996	3.0	A	3.8	17.0	72.1	7.1	1.85							8996. Sterling No. 6 mine, left entry 1 off main dip entry 4,200 feet S. 30° W. from drift mouth, 2 foot 11½-inch cut.
		B	.8	17.5	74.4	7.3	1.90							
		C		17.5	75.2	7.3	1.90							
		D		19.0	81.0		2.05							
8997	2.8	A	3.8	18.0	71.7	6.5	1.25							8997. Same; left entry 4, 3,800 feet S. 45° W. from drift mouth, 37½-inch cut.
		B	1.0	18.5	73.8	6.7	1.30							
		C		18.5	74.7	6.8	1.30							
		D		20.0	80.0		1.40							
8998	2.1	A	2.7	19.5	71.1	6.7	1.70					7,870	14,160	8998. Same; pillar of entries 2 and 3 off dip entry, 3,200 feet S. 45° W. from drift mouth, 37½-inch cut.
		B	.6	20.0	72.5	6.9	1.75					8,035	14,470	
		C		20.0	73.1	6.9	1.75					8,090	14,560	
		D		21.5	78.5		1.90					8,690	15,640	
9046	3.1	A	3.5	17.5	72.5	6.5	1.70							9046. Same; right entry 3 off left entry 2, 4,800 feet S. 45° E. from drift mouth, 32½-inch cut.
		B	.4	18.0	74.9	6.7	1.75							
		C		18.0	75.3	6.7	1.75							
		D		19.0	81.0		1.90							
9047	2.3	A	2.8	19.0	72.3	5.9	1.05							9047. Same; right entry 7 off left entry 2, 5,300 feet S. 60° W. from drift mouth, 34½-inch cut.
		B	.5	19.5	74.0	6.0	1.05							
		C		19.5	74.5	6.0	1.10							
		D		21.0	79.0		1.15							
9052	2.8	A	3.4	18.5	71.4	6.69	1.50	4.80	80.05	1.05	5.91	7,870	14,170	9052. Same; composite of Nos. 8996, 8997, 9046, 9047.
		B	.6	19.0	73.5	6.88	1.54	4.62	82.36	1.08	3.52	8,095	14,580	
		C		19.0	74.1	6.92	1.55	4.58	82.86	1.09	3.00	8,145	14,660	
		D		20.5	79.5		1.67	4.92	89.02	1.17	3.22	8,750	15,750	

[a] The analyses are given in four forms, marked A, B, C, and D. Analysis A represents the sample as it comes from the mine. This form is not well suited for comparison of one coal with another because the amount of moisture in the sample as it comes from the mine is largely a matter of accident, and consequently analyses of the same coal expressed in this form may vary as widely as the analyses of coal from different beds or from different fields. Analysis B represents the sample after it has been dried at a temperature a little above the normal until its weight becomes constant. This form of analysis probably presents the coal in its most stable condition and one approaching most closely its condition as it reaches the market. Therefore it is the form best adapted to the general purposes of comparison. Analysis C represents the theoretical condition of the coal after all the moisture has been eliminated. Analysis D represents the coal after all moisture and ash have been theoretically removed. This is supposed to represent the true coal substance, free from the most significant impurities. Forms C and D are obtained from the others merely by recalculation. They should not be used in comparison, for they represent theoretical substances that do not exist.

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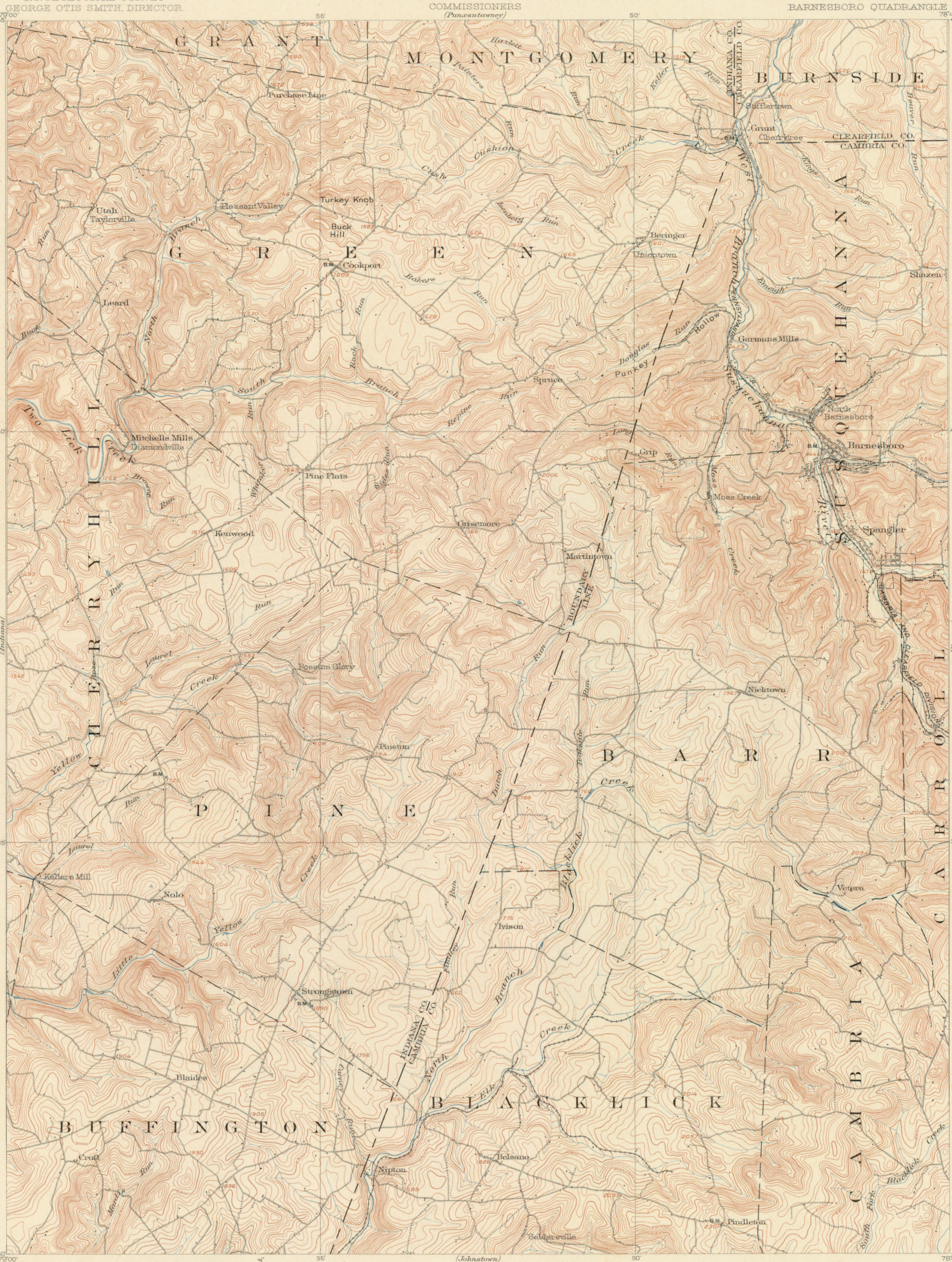
PENNSYLVANIA
BARNESBORO QUADRANGLE



LEGEND

RELIEF
printed in brown

Altitude *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

CULTURE
printed in black

Roads and buildings

Church or schoolhouse

Private or secondary road

Railroad

Reservoir or pond and dam

Coke ovens

County line

Township line

City, village, or borough line

Triangulation station

Bench mark

H.M.Wilson, Geographer in charge.
Triangulation by A.H.Thompson.
Topography by Frank Sutton, E.I.Ireland, and J.S.B. Daingerfield.
Surveyed in 1902 in cooperation with the State of Pennsylvania.

APPROXIMATE MEAN DECLINATION 1902

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

Edition of Feb. 1904, reprinted Apr. 1912.

TOPOGRAPHY

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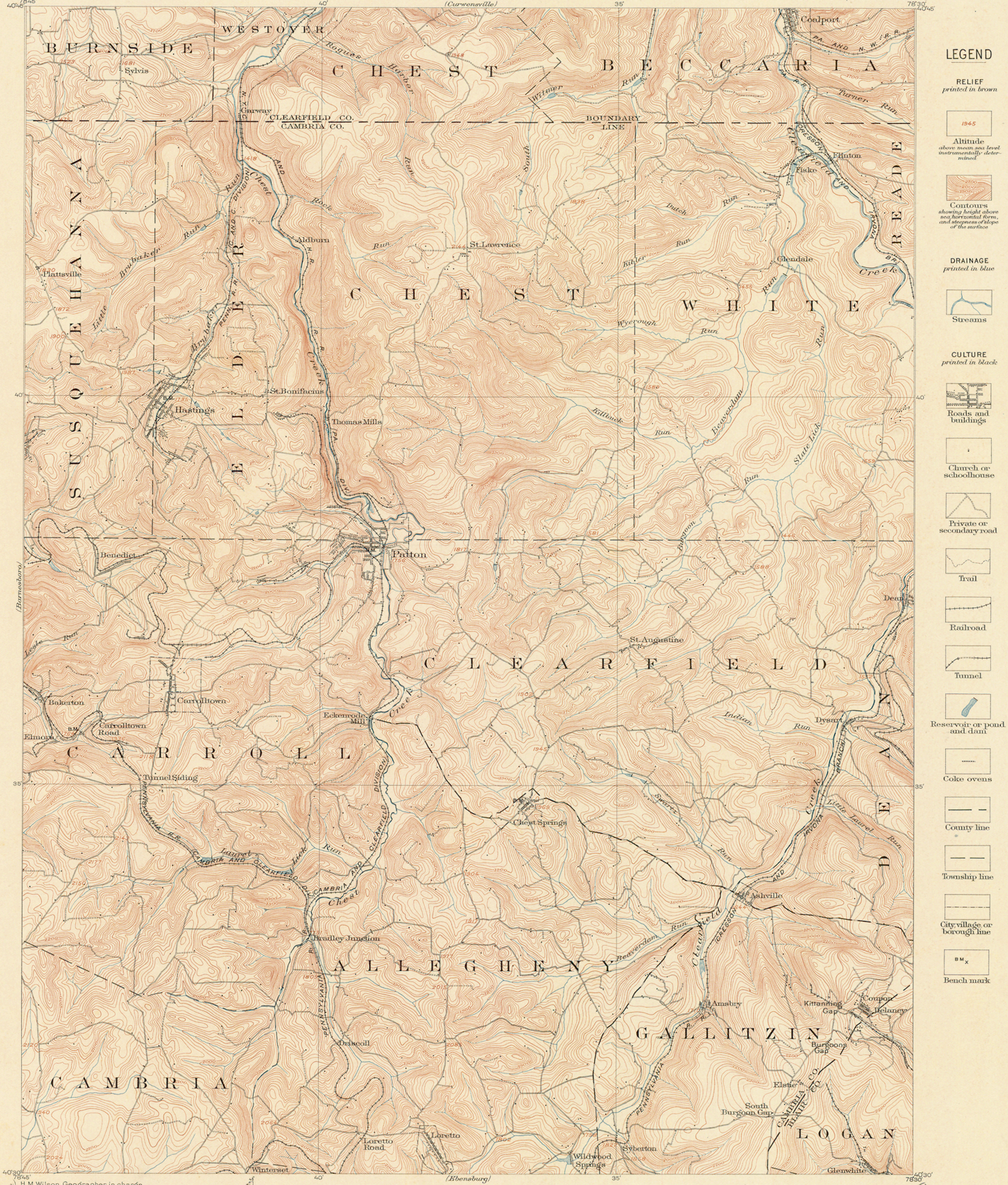
PATTON QUADRANGLE



H.M. Wilson, Geographer in charge.
Triangulation by S.S. Gannett.
Topography by Frank Sutton, A.M. Walker, and J.D. Forster.
Surveyed in 1901-2 in cooperation with the State of Pennsylvania.

APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
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AREAL GEOLOGY

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PENNSYLVANIA
BARNESBORO QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines, subaerial deposits by patterns of dots and circles)

QUATERNARY — *Recent series*

- Qal — **Alluvium** *(in flood plains of present streams)*

CARBONIFEROUS — *Pennsylvanian series*

- Ccm — **Conemaugh formation** *(shale, thin limestone, some red shale, thin coal beds locally workable, and coarse thick-bedded sandstones comprising the Morgantown, Cmt, Saltsburg, Csb, and Buffalo, Cb, members)*
- Ca — **Allegheny formation** *(chiefly light and dark gray clay shale with variable beds of coarse gray sandstone and several valuable coal beds, Upper Freeport coal at top)*
- Cpv — **Pottsville formation** *(thick-bedded sandstone with shale in the middle carrying thin coal, locally workable)*

H. M. Wilson, Geographer in charge.
Triangulation by A. H. Thompson.
Topography by Frank Sutton, E. I. Ireland, and J. S. B. Daingerfield.
Surveyed in 1902 in cooperation with the State of Pennsylvania.

APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.
Edition of May 1913.

Geology by Marius R. Campbell, Frederick G. Clapp, and Charles Butts; assisted by J. S. Burrows.
Surveyed in 1903-4 and 1909.
SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

AREAL GEOLOGY

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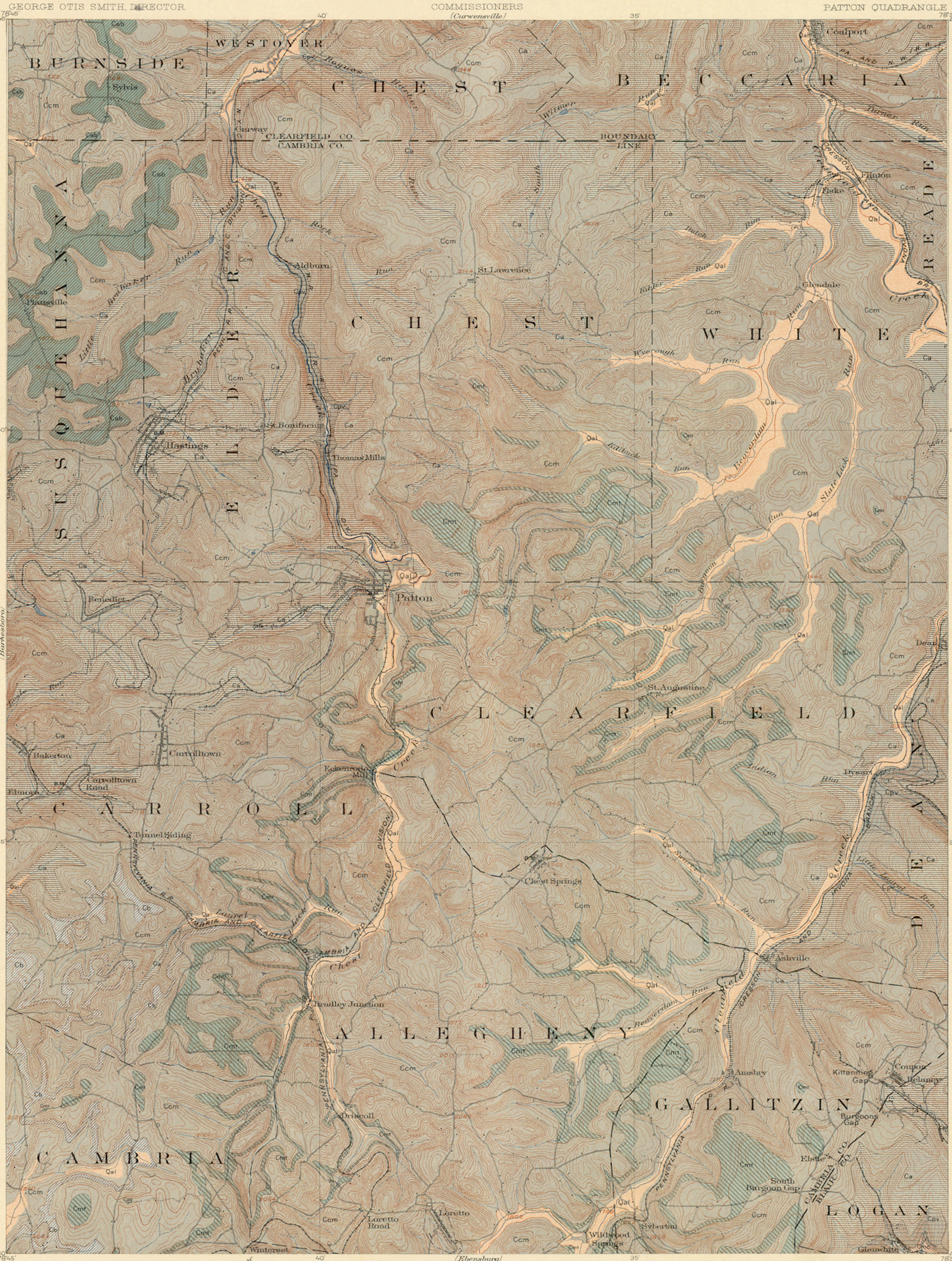
PATTON QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines, subaerial deposits by patterns of dots and circles)

QUATERNARY

Recent series

Qal — **Alluvium** *(in flood plains of present streams)*

CARBONIFEROUS

Pennsylvanian series

Cmt, Csb, Ccm, Cb — **Conemaugh formation** *(shale, thin limestone, some red shale, thin coal beds locally workable, and coarse thick-bedded sandstones comprising the Morgantown, Cmt, Saltsburg, Csb, and Buffalo, Cb, members)*

Ca — **Allegheny formation** *(chiefly light and dark gray clay shale with variable beds of coarse gray sandstone and several valuable coal beds, Upper Freeport coal at top)*

Cpv — **Pottsville formation** *(thick-bedded sandstone with shale in the middle carrying thin coal, locally workable)*

Mississippian series

Cmc — **Mauch Chunk formation** *(soft red shale in upper part, greenish to gray thick-bedded sandstone in lower part)*

H. M. Wilson, Geographer in charge.
Triangulation by S. S. Gannett.
Topography by Frank Sutton, A. M. Walker, and J. D. Forster.
Surveyed in 1901-2 in cooperation with the State of Pennsylvania.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.
Edition of May 1913.

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SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

STRUCTURE AND ECONOMIC GEOLOGY

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PENNSYLVANIA
BARNESBORO QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines, subaerial deposits by patterns of dots and circles)

QUATERNARY — *Recent series*

Qal — Alluvium *(in flood plains of present streams)*

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Cpv — Pottsville formation *(thick-bedded sandstone with shale in the middle carrying thin coal, locally workable)*

ECONOMIC AND STRUCTURE DATA

Coal outcrops *(dashed lines represent coals not known to be workable)*

uf. *Upper Freeport*
lf. *Lower Freeport*
lk. *Lower Kittanning*

Structure contours on the top of the Lower Freeport coal *(contour interval, 50 feet; datum, mean sea level)*

Shipping coal mine *(unless otherwise specified)*
Abandoned coal mine
× *Country coal bank or prospect*
⊚ *Diamond drill hole* *(only those are shown whose records are represented on columnar-section sheet)*

Note: *In addition to the coal resources, clay and shale for brick and tile occur in the Allegheny and Conemaugh formations, and building stone in the Conemaugh formation.*

NAMES OF MINES.

Location indicated on the map by numbers.

1. McKean.
2. Victor No. 29.
3. Rodkey.
4. Hines No. 5.
5. Hines No. 2.
6. Greenwich No. 5.
7. Greenwich No. 8.
8. Pioneer No. 7.
9. Penn-Mary town drift.
10. Penn-Mary No. 1.
11. Penn-Mary No. 3.
12. Penn-Mary No. 2.
13. Penn-Mary No. 5.
14. Penn-Mary No. 4.
15. Kimport.
16. Victor No. 16.
17. Victor No. 15.
18. Victor No. 17.
19. Greenwich No. 1.
20. Greenwich No. 3.
21. Greenwich No. 2.
22. Susquehanna No. 2.
23. Empire.
24. Lancashire No. 9.
25. Lancashire No. 12.
26. Lancashire No. 10.
27. Walnut No. 2.
28. Lancashire No. 3.
29. Moss Creek No. 22.
30. Moss Creek No. 21.
31. Moss Creek No. 23.
32. West Branch.
33. Spangler No. 4.
34. Spangler No. 2.
35. Alport No. 2.
36. Alport No. 1.
37. Walnut No. 4.
38. Walnut No. 1.
39. Walnut No. 3.
40. Spangler No. 1.
41. Victor No. 9.
42. Susquehanna No. 1.
43. Victor No. 4.
44. Spangler No. 25.
45. Brubaker No. 13.
46. Sterling No. 1.
47. Sterling No. 2.

H. M. Wilson, Geographer in charge.
Triangulation by A. H. Thompson.
Topography by Frank Sutton, E. I. Ireland, and J. S. B. Daingerfield.
Surveyed in 1902 in cooperation with the State of Pennsylvania.

TRUE NORTH — MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

Edition of May 1913.

Geology by Marius R. Campbell, Frederick G. Clapp, and Charles Butts; assisted by J. S. Burrows.
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PENNSYLVANIA
PATTON QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines, subaerial deposits by patterns of dots and circles)

QUATERNARY — Recent series

Qal — **Alluvium** (in flood plains of present streams)

CARBONIFEROUS — Pennsylvanian series

Ccm (Cmt, Csb, Cb) — **Conemaugh formation** (shale, thin limestone, some red shale, thin coal beds locally workable, and coarse thick-bedded sandstones comprising the Morgantown, Cmt, Saltsburg, Csb, and Buffalo, Cb, members)

Ca (uf, lf, uk, lk, br) — **Allegheny formation** (chiefly light and dark gray clay shale with variable beds of coarse gray sandstone and several valuable coal beds, Upper Freeport coal at top)

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CARBONIFEROUS — Mississippian series

Cmc — **Mauch Chunk formation** (soft red shale in upper part, greenish to gray thick-bedded sandstone in lower part)

ECONOMIC AND STRUCTURE DATA

Coal outcrops (dashed lines represent coals not known to be workable)

- uf. *Upper Freeport*
- lf. *Lower Freeport*
- uk. *Upper Kittanning*
- lk. *Lower Kittanning*
- br. *Brookville*
- mc. *Mercer*

Structure contours on the top of the Lower Freeport coal (contour interval, 50 feet, datum, mean sea level)

- *Shipping coal mine* (unless otherwise specified)
- *Abandoned coal mine*
- *Country coal bank or prospect*
- *Diamond drill hole* (only those are shown whose records are represented on columnar-section sheet)

Note: *In addition to the coal resources, clay and shale for brick and tile occur in the Allegheny and Conemaugh formations, and building stone in the Conemaugh formation.*

NAMES OF MINES.

Location indicated on the map by numbers.

1. Miller Run.
2. Red Top Nos. 1 and 2.
3. Pardee Nos. 27 and 29.
4. Hastings No. 20.
5. Rich Hill.
6. Oak Ridge.
7. Hastings No. 13.
8. Hastings No. 12.
9. Hastings No. 11.
10. Cymbria No. 2.
11. Spangler No. 3.
12. Cymbria No. 3.
13. Cymbria No. 1.
14. Eclipse.
15. Victor No. 1.
16. Victor No. 10.
17. Victor No. 6.
18. Victor No. 5.
19. Victor No. 4.
20. Victor No. 3.
21. Sterling No. 5.
22. Sterling No. 3.
23. Sterling No. 4.
24. Nanty Glo No. 2.
25. Sterling No. 6.
26. Logan No. 5.
27. Black Diamond.
28. Patton No. 1.
29. Patton No. 2.
30. Ashcroft No. 35.
31. Ashcroft No. 34.
32. Pardee No. 28.
33. Columbian No. 32.
34. Victor No. 12.
35. Pardee No. 39.
36. Pardee No. 26.
37. Patton Clay Mfg. Co.
38. Flannagan No. 31.
39. Flannagan No. 30.
40. Flannagan No. 36.
41. Moshannon No. 38.
42. Moshannon Nos. 33 and 37.
43. Mount Verde.
44. Blain Run No. 2.
45. Oakland No. 2.
46. Blain Run No. 1.
47. Oakland No. 3.
48. Blain Run.
49. Superior No. 2.
50. Alpha.
51. Oakland No. 4.
52. Beaver Dam.
53. Beaver Dam.
54. Dean No. 8.
55. Richland.
56. Jones No. 2.
57. Pennsylvania No. 16.
58. Pennsylvania No. 7.
59. Delaney No. 2.
60. Delaney No. 5.
61. Glenwhite.
62. Miller.

H. M. Wilson, Geographer in charge.
Triangulation by S. S. Gannett.
Topography by Frank Sutton, A. M. Walker, and J. D. Forster.
Surveyed in 1901-2 in cooperation with the State of Pennsylvania.

APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.
Edition of May 1913.

Geology by Marius R. Campbell, Frederick G. Clapp, and Charles Butts; assisted by J. S. Burrows.
Surveyed in 1903-4 and 1909.
SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

and still smaller ones *stages*. The age of a rock is expressed by the name of the time interval in which it was formed.

The sedimentary formations deposited during a period are grouped together into a *system*. The principal divisions of a system are called *series*. Any aggregate of formations less than a series is called a *group*.

Inasmuch as sedimentary deposits accumulate successively the younger rest on those that are older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or superposed by faulting, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossils, if present, may indicate which of two or more formations is the oldest.

Many stratified rocks contain *fossils*, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were washed into them, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that 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. Where two sedimentary formations are remote from each 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 in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is in many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not that of their metamorphism.

Symbols, colors, and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern and is labeled by a special letter symbol.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system.

The symbols consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters.

The names of the systems and of series that have been given distinctive names, in order from youngest to oldest, with the color and symbol assigned to each system, are given in the subjoined table.

Symbols and colors assigned to the rock systems.

	System.	Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent; Pleistocene	Q	Brownish yellow.
	Tertiary	Pliocene; Miocene; Oligocene; Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ꞧ	Peacock-blue.
Paleozoic	Carboniferous	Permian; Pennsylvanian; Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		Ꞓ	Brick-red.
	Algonkian		A	Brownish red.
	Archean		Æ	Gray-brown.

SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; waves cut sea cliffs and, in cooperation with currents, build up sand spits and bars. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are inseparably connected with deposition. The hooked spit shown in figure 1 is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is first built and afterward partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. Lakes or large rivers may determine local base-levels for certain regions. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the fairly even surface thus produced is called a *peneplain*. If the tract is afterward uplifted, the elevated peneplain becomes a record of the former close relation of the tract to base-level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—The map showing the areas occupied by the various formations is called an *areal geology map*. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any color or pattern and its letter symbol 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 particular formation, its name should be sought in the legend and its color and pattern noted; then 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 names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the geologic formations is termed the *economic geology map*. The formations that appear on the areal geology map are usually shown on this map by fainter color patterns and the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of each mine or quarry and is accompanied by the name of the principal mineral mined or stone quarried. If there are important mining industries or artesian basins in the area special maps to show these additional economic features are included in the folio.

Structure-section sheet.—In cliffs, canyons, shafts, and other natural and artificial cuttings the relations of different beds to one another may be seen. Any cutting that exhibits those relations is called a *section*, and the same term 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 natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface and can draw sections representing the structure to a considerable depth. Such a section is illustrated in figure 2.

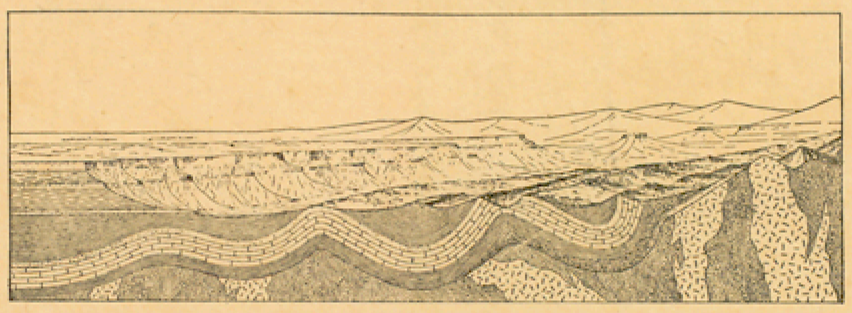

FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate patterns of lines, dots, and dashes. These patterns admit of much variation, but those shown in figure 3 are used to represent the commoner kinds of rock.

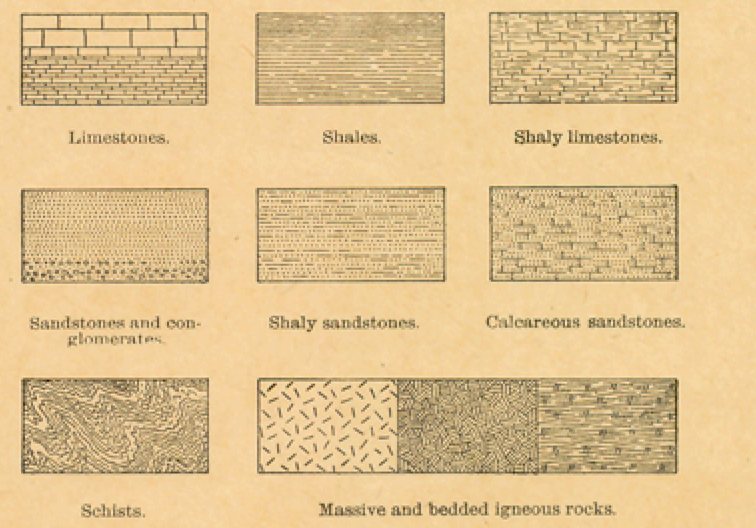

FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

The plateau shown at the left of figure 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

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. The direction of the intersection of a bed with a horizontal plane is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

In many regions the strata are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets, the fact that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in figure 4.

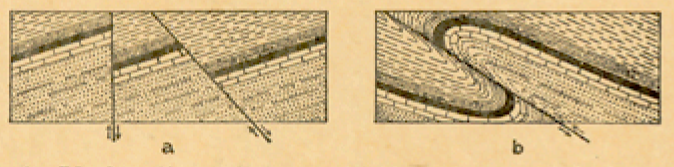

FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. 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 by well-founded inference.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of sandstones and shales, which lie in a horizontal position. These strata were laid down under water but are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been uplifted. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata that have been folded into arches and troughs. These strata were once continuous, but the crests of the arches have been removed by erosion. 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 shown at the left of the section. The overlying deposits are, from their position, evidently younger than the underlying deposits, and the bending and eroding of the older beds must have occurred between their deposition and the accumulation of the younger beds. The younger rocks are *unconformable* to the older, and the 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 folded or plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists were metamorphosed, they were disturbed by eruptive activity, and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

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

Columnar section.—The geologic maps are usually accompanied by a *columnar section*, which contains a concise description of the sedimentary formations that occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures that state the least and greatest measurements, and the average thickness of each formation is shown in the column, which is drawn to scale. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest being at the bottom, the youngest at the top.

The intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

GEORGE OTIS SMITH,
Director.

May, 1909.

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