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

GEOLOGIC ATLAS
OF THE
UNITED STATES

JOHNSTOWN FOLIO
PENNSYLVANIA

BY

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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.

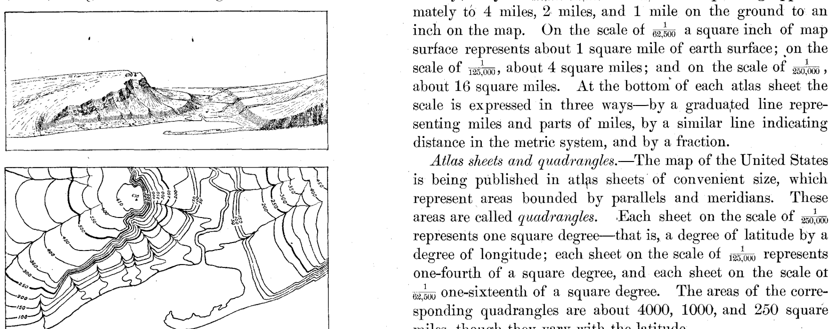

FIGURE 1.—Ideal view and corresponding contour map.

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*, 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 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		Ћ	Peacock-blue.
Paleozoic	Carboniferous	Permian; Pennsylvanian; Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		€	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.

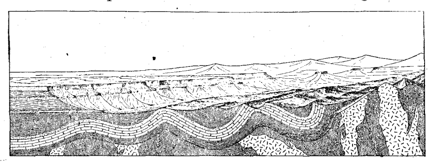

FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

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.

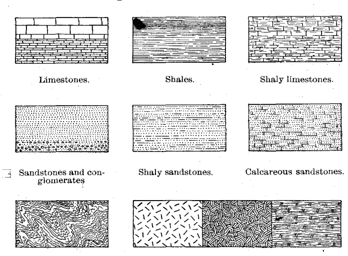

FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

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.

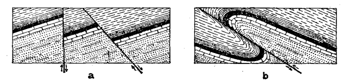

FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

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.

DESCRIPTION OF THE JOHNSTOWN QUADRANGLE.

By W. C. Phalen.

GEOGRAPHY.

INTRODUCTION.

Position and area.—By reference to the key map (fig. 1) it will be seen that the Johnstown quadrangle is in southwest-central Pennsylvania. It lies mostly in Cambria County

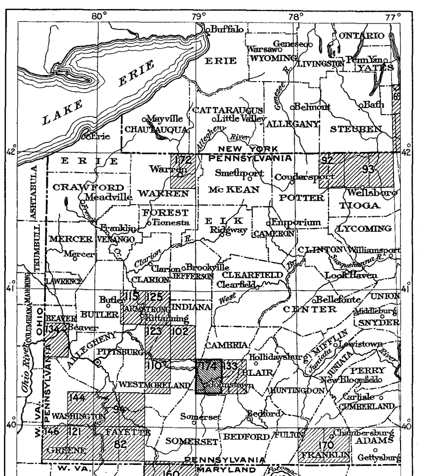

FIGURE 1.—Index map of western Pennsylvania and New York.

Darker ruled area covered by Johnstown folio. Other published folios indicated by lighter ruling, as follows: Nos. 82, Masontown-Uniontown; 92, Gaines; 93, Elkland-Tioga; 94, Brownsville-Connellsville; 102, Indiana; 110, Latrobe; 115, Kittanning; 121, Waynesburg; 123, Elders Ridge; 125, Rural Valley; 133, Ebensburg; 134, Beaver; 144, Amity; 146, Rogersville; 160, Accident-Grantsville; 169, Watkins Glen-Catatonk; 170, Mercersburg-Chambersburg; 172, Warren.

but covers also small parts of Somerset, Westmoreland, and Indiana counties. Most of it is included in the valley of Conemaugh River and its tributaries Little Conemaugh River and Stony Creek, at the confluence of which is Johnstown and its suburbs. The northern part of the area is in the valleys of Blacklick Creek and its South Branch, along which are the small but prosperous coal-mining towns Nanty Glo, Twin Rocks, Weber, Vintondale, and Wehrum.

The quadrangle extends from latitude 40° 15′ on the south to latitude 40° 30′ on the north and from longitude 78° 45′ on the east to longitude 79° 00′ on the west and embraces about 228 square miles. The exact geographic position of this area on the earth's surface has been determined from two triangulation stations within the quadrangle and three others near it. These stations have been connected by triangulation from the Maryland Heights and Sugarloaf stations of the United States Coast and Geodetic Survey, and their positions are described in a forthcoming bulletin on the mineral resources of this quadrangle. The geodetic work has been accurately checked by a carefully measured base line along the Pennsylvania Railroad in the eastern part of the Latrobe quadrangle.

Elevations.—The relief of the quadrangle—that is, the shape of its surface—is shown on the topographic map by means of contour lines in brown. These contours are based on lines of precise level run by the United States Geological Survey. The Survey has also established in this region numerous bench marks, whose elevations are referred to an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, Pa., marked "738 Pittsburg 1899," the elevation of which is now accepted as 738.384 feet above mean sea level. The initial points from which these levels were determined are numerous bench marks set along the precise-level line run by the Pennsylvania Railroad, the heights of which were fixed by adjustment made in 1903. The descriptions and elevations of these bench marks are given in Bulletin 288 of the Survey (p. 37), and also in Bulletin 447, on the mineral resources of Johnstown and vicinity, now in preparation.

GENERAL RELATIONS.

APPALACHIAN PROVINCE.

This quadrangle forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain on the east to the lowlands of the Mississippi Valley on the west, and from central Alabama on the south to eastern Canada.

With respect to topography and geologic structure, the Appalachian province may be divided into two nearly equal parts by a line which follows the Allegheny Front through Pennsylvania, Maryland, and West Virginia and the eastern escarpment of the Cumberland Plateau in Virginia, Tennessee, Georgia, and Alabama. (See fig. 2.) The rocks east

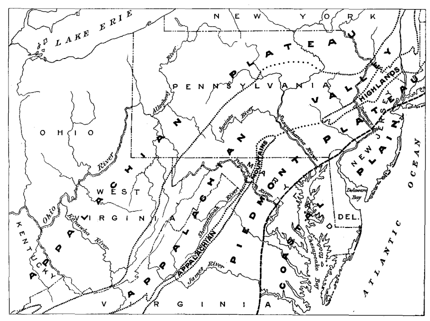

FIGURE 2.—Map of the northern part of the Appalachian province, showing its physiographic divisions and its relation to the Coastal Plain province.

of this line are greatly disturbed by faulting and folding and are in consequence locally much metamorphosed; the rocks west of this line lie nearly flat and are almost entirely unaltered, and the few folds that break the regularity of the structure are so broad and open that they produce a scarcely appreciable effect on the topography. East of the Allegheny Front, or, as it is sometimes called, especially in Pennsylvania, the Allegheny Mountain, lies the great Appalachian Valley, the surface of which is characterized by alternating ridges and valleys. The Appalachian Mountains limit the Great Valley sharply on the southeast. They are made up of many ranges, large and small, to which have been applied various local names. Farther east they merge gradually into a deeply dissected upland, the Piedmont Plateau of the Atlantic States, and still farther east, bordering the Atlantic Ocean, lies the low sandy region known as the Coastal Plain. The surface west of the Appalachian Valley is an elevated plateau, formerly called as a whole the Allegheny Plateaus, but now known as the Appalachian Plateau. The different parts of this plateau have received distinct names. The plateau character of this region can not readily be discerned in so small a part of it as the Johnstown quadrangle but may be more readily appreciated if the surface is viewed broadly in comparison with the lowlands of the Mississippi on the west and the series of alternating ridges and valleys of the Appalachian Valley on the east. The Johnstown quadrangle is situated in that division of the province which is characterized by the distinctive features of surface drainage, rocks, and geologic structure described below.

APPALACHIAN PLATEAU.

RELIEF.

The surface of the Appalachian province is composed of a number of plateaus. These represent the remnants of a broad land mass which sloped more or less uniformly from its eastern escarpment northwestward toward the lowlands of the Mississippi Valley. The plateau is therefore highest along its southeast margin. Where it emerges from beneath the Cretaceous strata in north-central Alabama it is about 500 feet above sea level. From this region it gradually increases in altitude toward the northeast into West Virginia. From this highest point, over 4000 feet above the sea, it descends to an elevation of 2200 feet in southern New York. In the southern part of the province there is also a gentle slope from north-central Alabama toward the southwest.

The character of the plateau differs greatly in different parts of the province, depending on the character of the underlying rocks, on the crustal movements which have affected them, and on the drainage consequent on both these factors. In its southern part the conditions for its preservation have been almost ideal, but toward the north the region is greatly dissected and its plateau character can not be readily made out. As viewed broadly from some elevated point, however, the summits of the highest ridges and hills rise to about the same altitude and appear to merge in the distance into a nearly horizontal line, which is approximately the surface of the old peneplain. This evenness of summits exists in most of the northern part of the plateau, where the old surface was a peneplain to which the name Schooley peneplain has been applied on account of the good preservation of its eastern part in Schooley Mountain, New Jersey.

To the west, especially in the valleys of Allegheny and Monongahela rivers, the tops of the ridges correspond with the surface of another and younger peneplain. This plateau or upland, situated at a lower level than the remnants of the Schooley peneplain, has been named the Harrisburg peneplain on account of its excellent preservation near Harrisburg, Pa. Farther south in the Appalachian province this topographic feature has been called the Highland Rim. In Kentucky and Tennessee, where this plateau is best preserved, it lies about 1000 feet above sea level and is separated from the Cumberland Plateau on the east by a more or less regular westward-facing escarpment. Its surface slopes gently westward. In Kentucky this feature has been called the Lexington plain; north of Ohio River it is more obscure and the remnants of the former mature erosion surface are difficult to determine with any exactness.

In the Monongahela and Allegheny river valleys the existence of divides at a common altitude about 100 feet lower than the Harrisburg upland points to a stage of reduction later than that of the Harrisburg, when stream valleys were widened and the intervening areas, where composed of soft rocks, were reduced to a surface that has been called the Worthington upland, from the excellent preservation of parts of it near Worthington, in the Allegheny Valley.

DRAINAGE.

The Appalachian Plateau drains almost wholly into Mississippi River, except the northwestern part, from which some streams flow into the Great Lakes and some into the Atlantic Ocean. In this northwestern part of the province the arrangement of the drainage lines has been determined by the position and movements of the ice sheets during the Pleistocene glaciation. It is supposed that all the streams north of central Kentucky flowed northward into St. Lawrence River or its tributaries before glacial time, but an advancing ice sheet acted as a barrier, closing this northern outlet and establishing the drainage systems in substantially their present form. In the southern half of the province a few of the westward-flowing streams have their sources at the summit of the Blue Ridge and flow across the Appalachian Valley as well as the plateau into the Mississippi system.

STRATIGRAPHY.

The rocks of the plateau are mostly of Carboniferous age. Devonian rocks are exposed along the northern edge and on the southeastern margin of the plateau, where the strata are sharply flexed upward, and they lie beneath the Carboniferous rocks throughout the plateau. The Carboniferous rocks are subdivided into two series—the Pennsylvanian, a coal-bearing series, and the Mississippian, which as a rule is not coal bearing. The rocks of both series consist mainly of alternating beds of shale and sandstone, but in the southwestern and southern parts of the plateau the Mississippian rocks include thick limestones. The Pennsylvanian rocks cover the greater part of the surface in the coal fields and contain practically all the coal beds. Both series are represented in the Johnstown quadrangle, the Pennsylvanian series occupying by far the greater part of its area and the Mississippian rocks appearing at the surface only along the anticlines that have been deeply eroded.

STRUCTURE.

The Appalachian Plateau is structurally a great basin or trough. The axial line of this trough extends southwestward from Pittsburg, Pa., across West Virginia to Ohio River at Huntington, W. Va. The rocks southeast of this line dip northwest and the rocks northwest of it dip southeast. The deepest part of the trough in Pennsylvania is in the southwest corner of the State, and the beds generally dip toward that point. Around the north and south ends of the trough the beds outcrop in rude semicircular or elliptical areas and dip toward the center of the trough.

Viewed thus broadly the structure is comparatively simple; in detail it is more complex. The Johnstown quadrangle is situated on the southeastern flank of this structural trough. On this limb the beds are involved in a number of parallel waves or folds having the same general trend as the major axis of the great trough itself—that is, a northeast-southwest course. Though the beds are thus waved or bent this structure does not affect the general westward dip and, in general, west of the Allegheny Front each recurring arch and trough lies lower than the one immediately east of it, so that beds which are more than 2000 feet above sea level on the Allegheny Front are below sea level in the center of the great trough. The dips along the northwest side of the trough are involved in a structural uplift known as the Cincinnati arch or anticline.

TOPOGRAPHY.

DRAINAGE.

The surface of the Johnstown quadrangle was shaped by long-continued erosion acting on rocks of differing hardness. This work has been done by streams, and so in discussing the topography the drainage may be considered first. As the Johnstown quadrangle lies near the Allegheny Front, which is the main watershed between the Atlantic Ocean and the Mississippi River system, the streams in it are not of the first magnitude. They may be divided into two systems, the Conemaugh River system and the Blacklick Creek system. These two streams unite west of the quadrangle near Blairsville and are really parts of the same drainage system. In the Johnstown quadrangle, however, they are distinct.

In relation to the geologic structure of the area, the streams may be grouped into two great classes—(1) those which flow along or near the structural axes of the region and (2) those which apparently flow regardless of the structure. The main streams, Conemaugh and Little Conemaugh rivers, Stony Creek, South Fork, and Blacklick Creek with its South Branch, belong to the latter class, though in part of their courses some of them seem to follow the structural axes. Saltlick Run, Hinckston Run, and Laurel Run are examples of streams flowing parallel with the structural axes. Little Conemaugh River and Blacklick Creek are of interest in this respect. In part of their courses they follow the structure more or less closely. Little Conemaugh River does so from a place west of Mineral Point to Johnstown, and Blacklick Creek and its South Branch from a point west of Vintondale to one nearly 5 miles southwest of Wehrum.

FIGURE 3.—Incised meander of Little Conemaugh River at the viaduct 1 mile southeast of Mineral Point, looking southwest. The river flows from the left back of the high hill in the middle ground to the right of the view.

The great bulk of the surface water of this area is carried off through Conemaugh River and its principal tributaries—Little Conemaugh River, Stony Creek (including Little Paint Creek) and South Fork. Little Conemaugh River rises in the Ebensburg quadrangle, which lies east of the Johnstown quadrangle and the greater portion of which is drained by this stream and its South Fork. The courses of Conemaugh River, Little Conemaugh River, and Stony Creek are extremely irregular, and that of the Conemaugh near the west side of the Johnstown quadrangle is marked by a gorge several miles in length, in which the lowest strata of the quadrangle and the geologic structure are well exposed.

The course of Conemaugh and Little Conemaugh rivers is independent, except as indicated above, of the present structural features and of the character of the rocks. This, as regards utility, is most fortunate, for the rivers, cutting across the major structural features, have exposed valuable coal and clay beds in such position as to render them readily workable. The resistant character of the rocks across which the streams flow denotes that the cutting process must have proceeded slowly. The gorges therefore must have originated well back in geologic time. The course of these streams dates back at least to a time when the surface of the quadrangle stood as high as the present higher knobs of Laurel Ridge. The down-cutting has proceeded with many periods of quiescence and quickening and is in progress at the present time.

The sinuous courses of Little Conemaugh River and Stony Creek are noteworthy, being almost throughout characterized by meanders. These meanders, with certain exceptions, are apparently also independent of the structure and hardness of the rocks. Their deep intrenchment is somewhat characteristic. (See fig. 3.) At some of their turns they are encroaching on the rocks and not receding. This encroachment is fairly well shown at the southwest turn of the first meander west of South Fork, and still better at the northeast turn of the two meanders next east of East Conemaugh. This character is also well shown by Stony Creek and by South Branch of Blacklick Creek at Twin Rocks.

As mentioned in another place, the streams in this area lie near the Allegheny Front—the main watershed between the Atlantic Ocean and Mississippi River systems—and so are not of the first magnitude. For the same reason the grades of the streams, especially in their upper parts, are fairly steep, but they have neither falls nor rapids of great size. The amount of water carried varies extremely with the season of the year and the local weather conditions. Water entering the streams in great quantity is carried off rapidly, with disastrous results to portions of towns lying along the flood plains. To insure an adequate and uniform water supply the larger towns, such as Johnstown, South Fork, Vintondale, and Wehrum, have been forced to construct storage reservoirs.

RELIEF.

This quadrangle, as already mentioned, lies entirely within the Appalachian Plateau and very near its eastern margin, which is but a few miles from the southeast corner of the quadrangle.

Its surface, like that of most of the plateau, is decidedly irregular. The lowest point in the area is on Conemaugh River at the western border of the quadrangle, at Conemaugh Furnace station of the Pennsylvania Railroad, where the altitude is 1134.54 feet. The hills on either side of the river a short distance to the east are between 2600 and 2700 feet high and this portion of the river valley is therefore gorgelike. In the southeast corner of the quadrangle also the highest hills are a little more than 2700 feet high.

The rest of the surface ranges in altitude between the extremes given above. In detail the surface is decidedly hilly, but most of the hill slopes are rather gentle, especially back from the main drainage channels, for a reason that will be stated later. There is very little level land in the quadrangle, almost all of it being on the lower stretches of Blacklick Creek in Indiana County and near the confluence of Stony Creek and Little Conemaugh River.

The region is characterized by two broad ridges corresponding almost exactly in position with the Ebensburg and Laurel Ridge anticlinal axes. Laurel Ridge is by far the more pronounced. It enters the quadrangle across the eastern part of the northern border, near the line between Blacklick and Cambria townships, and has a southwestward course, passing out of this quadrangle along the line between Westmoreland and Cambria counties. The crest of the ridge for the greater part of its length is formed by the massive and resistant sandstones of the Pottsville formation. The ridge is cut through by Conemaugh River and South Branch of Blacklick Creek.

The second belt of high land follows the Ebensburg or Viaduct anticline. The flats or plateau-like districts of the eastern parts of Richland, Croyle, and Cambria townships form part of this belt of high land, which is a broad, flat ridge capped mostly by the Morgantown ("Ebensburg") sandstone member of the Conemaugh formation. The greater part of this high flat land lies between altitudes of 2100 and 2200 feet. The land higher than 2300 feet is of very slight extent.

The smooth outlines of the hills in other parts of the quadrangle are noteworthy. These outlines are in many places due to dip slopes or partial dip slopes of a particular bed, generally a sandstone. These dip slopes are not local but are scattered over the entire area and illustrate well the dependence of the topography on the strata.

In previous folios treating of the western part of Pennsylvania and in the description of the Appalachian Plateau in this folio remnants of old and maturely reduced surfaces have been described. In the valleys of Allegheny and Monongahela rivers two distinct levels have been discerned, known as the Harrisburg and Worthington uplands. Remnants of these old surfaces are now present in the divides and hilltops along these rivers, and all of them stand at approximately the same elevation. These old surfaces have been traced eastward as far as Chestnut Ridge, but beyond this structural feature convincing evidence of their remnants has not been found. Remnants of peneplains may exist in the Johnstown area, but none has been recognized by the writer. One great difficulty in interpreting these old peneplains is the fact that after the old surface was well reduced it was warped, so that parts of it which formerly stood at the same altitude, or at least in the same general slope, may now bear somewhat such a relation to one another as do the basins and arches denoted by the contours on the structure sheet. For this reason it is well-nigh impossible to reconstruct the ancient surface with any degree of certainty.

It has been stated that the Johnstown quadrangle is situated in the Appalachian Plateau and that this plateau is separated from the Great Valley to the east by an escarpment known as the Allegheny Front. The Allegheny Front is not more than 10 miles from the southeast corner of the Johnstown quadrangle, and the high land in that portion of the quadrangle is really a part of it. The highest points of Laurel Ridge have about the same elevation as the hilltops near the southeast corner of the quadrangle. These areas of nearly equal elevation may be remnants of an old peneplain surface, and their correlation with the Schooley peneplain is suggested.

Butts[a] has noted the possibility that in the Ebensburg quadrangle, east of the Johnstown quadrangle, certain areas in Union Township, Bedford County, are remnants of peneplain surfaces at or near 2400 feet in altitude. At and above 2200 feet in the Johnstown quadrangle, along the belt of high land corresponding with the Ebensburg or Viaduct anticlinal axis, there are broad areas which may represent this peneplain; but it seems to the writer that another interpretation falls better into line with the facts. This explanation is as follows: In many parts of the Johnstown quadrangle the surface is characterized by outcrops of sandstones. Some of them are extremely resistant and difficult to erode. Such, for instance, are the sandstones of the Pocono and Pottsville formations. Even the Conemaugh formation, generally devoid of cliff-making sandstones, contains in the Johnstown quadrangle two notably resistant sandstone members—the Buffalo sandstone member in the northern part of the area, in the hills bordering Blacklick Creek, and the Morgantown sandstone member in the southeastern part of the area. These account for many of the more elevated parts of the quadrangle and also for many of the broad areas of comparatively level ground. The large areas of comparatively level land along the Ebensburg anticlinal axis are more satisfactorily explained as being held up by these sandstones than as remnants of an ancient base-level or peneplain.

RELATION OF TOPOGRAPHY TO CULTURE.

The relation of topography, including drainage, to human activities is admirably illustrated in many phases in the Johnstown quadrangle. Conemaugh and Little Conemaugh rivers traverse the area from east to west near the middle and Stony Creek from the southern border to Johnstown. The Conemaugh Valley has long been the most available highway between the Atlantic seaboard and the Middle West. Along this valley the first railroad and canal route was constructed, and the remnants of this old portage railroad are still visible in both the Ebensburg and the Johnstown quadrangles. A tunnel on this old route, blasted out of the solid rock of the Pottsville formation, is shown on the map between Mineral Point and East Conemaugh. When the new Pennsylvania Railroad was built it was naturally located near the old railroad but followed the bottom of the valley. Thus the development of the mineral resources of this valley had an early stimulus. The occurrence of both coal and iron in the hills near the confluence of Little Conemaugh River and Stony Creek resulted in the establishment of the iron and steel industry of Johnstown, so that the foundation of the present flourishing city was thus laid. Likewise the other main drainage channels have been followed by railroads. For example, the Baltimore and Ohio Railroad comes down Stony Creek to Johnstown; the South Fork branch of the Pennsylvania Railroad follows South Fork of Little Conemaugh River and Little Paint Creek; and the Cambria and Clearfield division of the Pennsylvania Railroad lies in this area entirely within the valley of South Branch of Blacklick Creek. The stream valleys, therefore, have furnished the most favorable locations for the railroads, and the tide of immigration that followed the railroads has naturally confined itself to these valleys. In them are located the only considerable towns in the quadrangle.

Before the advent of the railroads and the development of the coal resources incident thereto, the country was given over to farming. The loose sandy or shaly soil of the Allegheny and Conemaugh formations is well adapted to agriculture, and as large areas of this quadrangle contain these rocks at the

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[a] Butts, Charles, Ebensburg folio (No. 133), Geol. Atlas U. S., U. S. Geol. Survey, 1905, pp. 1-2.

surface, much of it is under cultivation. Where the harder rocks, such as the Pottsville, cover the surface the land is a wilderness and would be almost primeval were it not for the fact that the timber has been largely removed. Laurel Ridge, which is practically a wilderness, is an excellent example of the influence of the rocks on man's activities. The ridge is covered in large part with massive sandstone bowlders and is practically uninhabited. Where the Morgantown sandstone member covers the surface north of Summerhill the conditions are similar.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

INTRODUCTORY STATEMENT.

The surface rocks of the Johnstown quadrangle are entirely of sedimentary origin and were deposited in or by water. They consist of sandstone, shale, limestone, coal, iron ore, gravel, etc., and taken together have a total thickness of 3100 to 3200 feet. These rocks belong to the Devonian and Carboniferous systems, except the imperfectly consolidated gravel of the river terraces, which is tentatively regarded as of Pleistocene age, and the recent alluvial deposits of the flood plains. The two great geologic systems have been subdivided into numerous formations and these in turn into smaller members, according to their lithologic aspect and the fossil fauna and flora which they contain. Nearly all the rocks in this particular area belong to the Carboniferous system. The Devonian is represented along Conemaugh River, the principal drainage channel, where it crosses the axis of the Laurel Ridge anticline, and just over the border of the Ebensburg quadrangle to the east. The Devonian rocks underlie the Carboniferous surface rocks throughout the Johnstown quadrangle.

DEVONIAN SYSTEM.

Though much of the Devonian system is not exposed in the Johnstown quadrangle, brief descriptions will be given of the parts of it that do not appear above drainage level. In subsequent years deep drillings will probably reach these lower beds, and so it seems advisable to record their characteristics as obtained from the sections measured between Altoona and Bennington.

HAMILTON FORMATION.

The Hamilton is the lowest and oldest formation exposed in the Ebensburg quadrangle, east of the Johnstown area. A total of 1300 feet of beds has been measured, but the formation is known to be thicker. It is composed mainly of dark-green shale, which weathers to a dull brown or black. On weathering and on being broken up by the hammer the shale breaks obliquely to the bedding planes into pieces of very irregular shape. The formation contains also more or less olive-green or gray shale, together with dark-green sandy and micaceous shale and thin layers of fine-grained bluish sandstone. The top of the Hamilton is well marked by the Genesee shale.

GENESEE SHALE.

The Genesee shale lies conformably on the Hamilton. Owing to its black color and fissile character it is a distinctive lithologic type and hence is readily recognized as a convenient horizon marker. It contains calcareous concretions and is sparingly fossiliferous, and on the whole it is similar to the Genesee at the type locality in western New York. In Altoona 80 feet of the Genesee shale has been measured, but as the base of the shale was not seen, that does not represent the full thickness of the formation.

PORTAGE FORMATION.

The lower 100 or 200 feet of the Portage formation is composed of soft pale-brown shale, weathering to a dove color and possessing a very perfect cleavage. Upward through the formation the rocks gradually change to a pale greenish-gray sandy shale, cleaving into thin laminæ and associated with beds of coarser character and of less perfect cleavage. This sandy shale makes up the greater part of the formation. The thickness measured along the Pennsylvania Railroad is 1400 feet.

The top of the Portage is very indefinite. There is no persistent and readily recognized stratum separating it from the overlying Chemung. The rocks of the lower formation merge into those of the upper almost imperceptibly, and the boundary described in the Ebensburg folio was established in accordance with a paleontologic distinction. The formation includes all the rocks lying between the Genesee and the lowest rocks bearing Chemung fossils. Along the Pennsylvania Railroad the lowest Chemung fossils were found about 2½ miles west of the Logan Hotel, in a cut near the beginning of the curve where the track turns westward into the valley of Burgoon Run. Notwithstanding the obscurity of the boundary between the top of the Portage and the base of the Chemung, the main bodies of the two formations are well differentiated by both paleontologic and lithologic features.

CHEMUNG FORMATION.

The total thickness of the Chemung formation, as measured along the Pennsylvania Railroad west of Altoona and as calculated from the width of outcrop and dip in another place in the Ebensburg quadrangle, is between 2400 and 2500 feet. The lower 1400 feet of the formation is characterized by gray and green shale and sandy shale, with some beds of gray sandstone, generally in thin layers but locally in masses 50 feet thick. The upper 1000 feet is characteristically chocolate-colored and consists of alternating shale and sandstone beds.

CATSKILL FORMATION.

The Catskill formation comprises the lowest and oldest rocks exposed in the Johnstown quadrangle. Only 400 feet of the top of the formation is exposed where the axis of the Laurel Ridge anticline crosses the gorge of Conemaugh River west of Johnstown, and it appears at no other place in the Johnstown quadrangle. Here, as on the Allegheny Front to the east, the Catskill rocks are prevailingly red and green shales and red sandstones. A section of the upper 100 feet of this formation, measured on the eastern flank of the Laurel Ridge anticline, on the main line of the Pennsylvania Railroad, is as follows:

Section of upper part of Catskill formation.

	Feet.
Sandstone, chocolate and red	45
Shale, red	20
Sandstone, chocolate-colored	5
Shales, chocolate and vivid green	40+

The formation as a whole, measured on the Allegheny Front, is about 2000 feet thick; 80 per cent of it is made up of red shale and red or brown sandstone and 20 per cent of gray or green shale and sandstone. Red shale predominates and is generally bright red; the red sandstone usually weathers to a gray or dull-brown color and is red only on freshly broken surfaces. The sandstone is medium to fine grained and thick to thin bedded or even laminated. The formation contains but few fossils and none were found in it on Allegheny Mountain; this fact sharply distinguishes it from the underlying Chemung.

The top of the Catskill formation is exposed at the curve on the Pennsylvania Railroad where westbound trains turn into the gorge of Sugar Run. This point is in the Hollidaysburg quadrangle 1¼ miles east of Allegrippus. From this locality the Catskill can be traced to the southwest entirely across the Ebensburg quadrangle, occupying a zone varying in width from 10 to 12 miles.

CARBONIFEROUS SYSTEM.

The rocks of the Carboniferous system conformably overlie those of the Devonian system and comprise the Mississippian series below, which is not coal bearing in this area, and the Pennsylvanian or coal-bearing series above. The Mississippian series is divided into two formations, the Pocono and the Mauch Chunk, and the Pennsylvanian is represented by the Pottsville, Allegheny, Conemaugh, and Monongahela formations. It is questionable whether the Monongahela is represented in the Johnstown quadrangle.

MISSISSIPPIAN SERIES.

POCONO FORMATION.

General description. — The entire Pocono formation is exposed in the gorge of Conemaugh River between Johnstown and Conemaugh Furnace, along both flanks of the Laurel Ridge anticline. It is brought above drainage level by this anticline and covers part of the ridge both north and south of the river. The formation is not exposed along the river or railroad in this locality so as to admit of being measured in detail, but from the top of the red Catskill beds to the top of the Loyalhanna limestone member the barometer indicated an ascent of 1085 feet, which is believed to be close to the true thickness of the formation in this region. This thickness is slightly greater than that measured on the Allegheny Front, but the inclination of the beds where the measurement was made would account for the excess over the more careful determination made farther east. The upper part of the Pocono is exposed in the bed of Little Conemaugh River on both flanks of the Ebensburg anticline between South Fork and Mineral Point. The Loyalhanna limestone member is the only part of the formation there exposed; in this particular region it is about 45 feet thick.

There is no reason to suppose that the Pocono formation as exposed in the gorge of Conemaugh River west of Johnstown differs at all from the same formation as it is seen on the Allegheny Front east of Bennington. It lies conformably upon the Catskill below, and the best and perhaps the only means of differentiating it from the lower rocks is the contrast of its peculiar greenish-gray color with their deep reds. Beds of red shale, however, occur in the Pocono. As exposed along the main line of the Pennsylvania Railroad east of Bennington, it has at its base 180 feet of coarse sandstone separated into two parts by a thin layer of red shale 50 feet from the base. This sandstone is overlain by 500 to 550 feet of alternating beds of grayish-green shale and sandstone containing layers of red shale and red sandstone and some beds of clay. In other quadrangles it has been found possible to divide the remaining upper part of the Pocono by lithologic differences into three members. Beginning with the lowest, these have been named the Patton shale member, the Burgoon sandstone member, and the Loyalhanna limestone member. Overlying the 500 feet of grayish-green shale and sandstone along the Allegheny Front there is a bed of red shale 40 to 50 feet thick, having the same stratigraphic relationships as the Patton shale member in the Allegheny Valley, described in the Indiana, Latrobe, and Kittanning folios. This red shale could not be distinguished in the Johnstown quadrangle. On the Allegheny Front its top is at the railroad level 3000 feet east of Allegrippus.

Burgoon sandstone member.—Though the Burgoon sandstone member is not exposed so as to be measured in the Conemaugh River gorge, it is conspicuous owing to the quantities of small débris which it forms on the sides of the gorge. It immediately underlies the Loyalhanna limestone member, next to be described. Where it was measured on the Allegheny Front about 300 feet of the sandstone is thought to be present, with perhaps some shale portions. It consists chiefly of grayish-green sandstone with layers of sandy shale, in one of which, east of Allegrippus, a small lens of coal 8 inches thick was seen. The sandstone is a well-defined lithologic unit in the Pocono, and to it the name Burgoon was applied, from the excellent exposure in the valley of Burgoon Run above Kittanning Point.

Loyalhanna limestone member.—The Loyalhanna limestone member is exposed in three places in the Johnstown quadrangle, all in the valley of Conemaugh and Little Conemaugh rivers and all associated with structural uplifts. The easternmost exposure is at the viaduct between South Fork and Mineral Point; here, though the base was not determined with certainty, at least 43 to 45 feet of limestone is exposed. From this place it may be traced westward to Mineral Point. The next exposure downstream is at the beginning of the long, straight northwestward stretch of the river in the western part of the quadrangle, and the third is near the mouth of Findley Run, at the western edge of the area.

This member of the Pocono is sharply differentiated from the underlying members of the Pocono and from the overlying Mauch Chunk shale by its peculiar lithologic characteristics. It consists of layers in which silica predominates alternating with those in which calcareous material is in excess. The calcareous part weathers more rapidly and leaves the siliceous layers in relief. This unequal weathering in conjunction

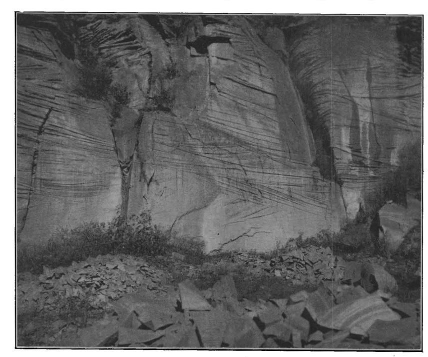

FIGURE 4.—Loyalhanna limestone member of the Pocono formation at Mineral Point, in the Little Conemaugh River gorge, showing the cross-bedded character of the rock brought out by weathering.

with the cross-bedded character of the rock gives it a highly distinctive appearance, which is well brought out in the exposure near Mineral Point. (See fig. 4.) At one place near the mouth of Findley Run the Loyalhanna limestone member is separated into two parts by a thin layer of red shale near its middle. The member is often referred to as the "Siliceous" limestone, but it is more appropriate to regard it as a calcareous sandstone, as the siliceous portion is far in excess of the calcareous. In deference to general usage, however, it will be called a limestone. The name Loyalhanna is derived from the exposure of the member along the gorge in which Loyalhanna Creek flows across Chestnut Ridge in Westmoreland County. In the reports of the Second Geological Survey of Pennsylvania it was regarded as part of the overlying Mauch Chunk, but it merges gradually into the underlying Burgoon sandstone member and is now regarded as forming the top of the Pocono formation.

MAUCH CHUNK SHALE.

General description.—The Mauch Chunk shale derives its name from Mauch Chunk, in the eastern part of Pennsylvania.

In that part of the State it is many thousands of feet thick, but in the Johnstown quadrangle its thickness is less than 200 feet. It lies conformably upon the Pocono formation and is exposed at several places in the quadrangle. Along the Pennsylvania Railroad, in the valley of Little Conemaugh River, it is exposed on the flanks of the Ebensburg (Viaduct) anticlinal axis, appearing close to the town of South Fork and in the hills along the river westward beyond Mineral Point. In this region the exposures of the Mauch Chunk are good. The formation consists of three distinct members—two shale members separated by a 45 to 50 foot body of sandstone. The combined section of the Mauch Chunk obtained here and near the southern border of the quadrangle is as follows:

Combined section of Mauch Chunk shale in vicinity of South Fork and Mineral Point, and near southern border of the quadrangle at mouth of Paint Creek.

	Ft.	in.
Shales, red	6–21	
Sandstone, heavy bedded	10	8
Shale, red	20	
Sandstone, green	3	
Shales, red and green	13–15	
Shale, green	1	
Shale, blue-green, sandy	5	4
Sandstone, green, laminated and cross-bedded	44+	
Shale, red and green, with green sandstone beds	39–40	

The thickness of the upper shale member varies but may be considered as 75 feet at the most and as about 60 feet at the least. The member contains a few sandstone beds, mostly very thin.

The intermediate sandstone member has a greenish color and is generally laminated and cross-bedded. It weathers as if it contained some calcareous material, and it may possibly represent the Greenbrier limestone of the Virginia region. Near the viaduct it measures 42 feet. Near the mouth of Paint Creek, just beyond the southern border of the quadrangle, it is more than 30 feet thick, some of it being concealed, and still farther up Stony Creek it measures 45 feet. It is probable, therefore, that its thickness ranges between 40 and 50 feet.

The lower shale member was measured near the viaduct, where 40 feet of alternating red and green shales were observed, with a few thin beds of green sandstone.

The Mauch Chunk shale is also well exposed in the valley of Stony Creek near the southern margin of the quadrangle and on the flanks of the Ebensburg (Viaduct) axis. It may be traced up Stony Creek about a mile above the mouth of Paint Creek and down to a point nearly opposite Walsall.

The Mauch Chunk is also exposed in the Conemaugh River valley west of Johnstown, where it is brought above drainage level on both flanks of the Laurel Ridge anticline. It outcrops to the north and to the south in narrow bands on both sides of the ridge. Here the formation is essentially of the same character as along the flanks of the Ebensburg anticline, but it does not afford so many opportunities for good measurement, as in most places it is nearly hidden by sandstone débris from the overlying formation. The top 50 feet of the Mauch Chunk is exposed in the valley of South Branch of Blacklick Creek about 2 miles southeast of Twin Rocks.

PENNSYLVANIAN SERIES.

POTTSVILLE FORMATION.

General description.—The Pottsville formation is the lowest of the Pennsylvanian or coal-bearing series of rocks and unconformably overlies the Mauch Chunk shale. This unconformity is best displayed along the Johnstown-Windber electric line about midway between the mouth of Paint Creek and Ingleside. It is overlain conformably by the Allegheny formation.

In this quadrangle the Pottsville consists of three members, a top and a bottom member made up of sandstone, generally very massive, and an intermediate shale member containing a coal bed, with which is associated in certain parts of the quadrangle an important bed of flint clay.

Connoquenessing sandstone member.—The lowest member of the Pottsville is known as the Connoquenessing sandstone member. It is about 100 feet thick in sections obtained near the Ebensburg anticlinal axis at the south border of the quadrangle and near the mouth of Paint Creek. As a rule it is a very massive sandstone, showing white on fresh fractures and weathering to a dull gray. It is composed essentially of quartz grains and is generally cemented by a siliceous cement. It is not everywhere firm and compact but may crumble readily when rubbed in the hand. Some of it is pure enough to be regarded as a glass sand. (See p. 14.) From a sandstone it merges in places into a grit but is rarely a true conglomerate. It is generally massively bedded and breaks out into enormous bowlders, which strew the country and render it completely unfit for cultivation.

Mercer shale member.—The intermediate shale is known as the Mercer shale member and consists of shale and clay, with which locally a coal bed is associated. The thickness and also the character of this intermediate member vary. Along Stony Creek, in the southern part of the quadrangle, it is not more than 11 feet thick and locally contains a coal bed, as, for example, a short distance south of Kring station.

Section of Mercer shale member south of Kring.

	Ft.	in.
Shale, black	5	6
Coal		9
Sandstone, dark, pyritiferous		1–2
Coal		6
Shale		2
Coal		9
Coal and bone		11
Shale, black		3–4
Coal		4
Bone		4½
Clay	1	

North of Sheridan the Mercer member is much thicker, as the following section of a part of it obtained at the quarry of Bruce H. Campbell shows:

Section of coal and shale of Mercer member at quarry of Bruce H. Campbell, north of Sheridan.

	Ft.	in.
Massive sandstone bowlders.		
Clay, red, with rounded bowlders (Pleistocene?)	5–10	
Shale	20	
Coal and bone	1	3
Clay	6	
Shale	6	

The clay and shale underlying the coal bed have been proved by three test holes to be thicker than they are stated to be in the foregoing section.

The Mercer member is imperfectly exposed in the quarry of the Conemaugh Stone Company on the main line of the Pennsylvania Railroad about 2 miles southeast of Conemaugh Furnace. The section shows clay, shale, and a thin streak of coal, aggregating nearly 12 feet, but does not include the whole thickness of the member in this locality. The section is as follows:

Section showing clay and shale of Mercer member at quarry of Conemaugh Stone Company, 2 miles southeast of Conemaugh Furnace.

	Ft.	in.
Shale, dark, with 2 inches of bone near base	3	
Fire clay	1	
Clay, sandy	1	
Clay, drab	1	
Coal or smut		½
Clay, drab	5	

Near South Fork the Mercer member is also characterized by the presence of a coal streak, but between that town and Mineral Point it is of economic importance, owing to the presence of a valuable bed of flint clay. A section obtained at a commercial mine near South Fork will convey an idea of the Mercer near this town.

Section of Mercer member, coal and clay, South Fork.

	Ft.	in.
Sandstone, heavy (Homewood).		
Clay, plastic	3½	
Coal		⅛–2
Clay, flint	4	6
Sandstone (Connoquenessing).		

The foregoing sections show that the Mercer is exceedingly various both in character and thickness, but that it is usually characterized by the presence of coal and valuable clay and shale.

Homewood sandstone member.—The upper member of the Pottsville formation, known as the Homewood sandstone member, is 65 feet thick along Stony Creek beyond the southern border of the Johnstown quadrangle, but near the mouth of Paint Creek it is slightly thicker and may be as much as 90 feet. In the area between South Fork and Mineral Point the thickness of the Homewood member is less than 65 feet and may be as little as 35 feet. Hence the complete section of the Pottsville for the Johnstown quadrangle is as follows:

Section of Pottsville formation in Johnstown quadrangle.

	Feet.
Sandstone, massive (Homewood)	35–90
Shale and clay, containing a coal bed (Mercer member)	8–13
Sandstone, massive (Connoquenessing)	95–105

The Homewood sandstone member, like the Connoquenessing, is massive and coarse grained but rarely conglomeratic. The two make heavy blocks of waste, and the country covered by this formation as a whole is generally a wilderness. This kind of country is typified by that part of Laurel Ridge crossed by the Pittsburg and Philadelphia pike. This formation covers a large part of Laurel Ridge and it also outcrops in the valley of Little Conemaugh River from a point just east of South Fork nearly to East Conemaugh. It is also above drainage level along Clapboard Run. In the southern part of the quadrangle, along Stony and Little Paint creeks, the Pottsville is also exposed, but it is confined to the valleys, and hence only the steep sides of the ravines are covered with its massive débris. The Pottsville disappears below drainage level on Stony Creek a short distance south of Kring and on Little Paint Creek near the point where the trolley line crosses the creek at the town of Scalp Level.

ALLEGHENY FORMATION.

General description.—The Allegheny formation, which conformably overlies the Pottsville, was originally known as the "Lower Productive Coal Measures." It is distinguished from the overlying formation, as may be inferred from this name, by the presence of several workable coal beds. It is the most important formation in the Johnstown quadrangle, as in it are found all the workable coal beds. The sections which follow will give an idea of its character in different parts of the area. The first section[a] was prepared by John Fulton, of Johnstown, and shows the character of the rocks east of the city, besides giving the thickness of the Allegheny formation about the city:

Section of Allegheny formation near Johnstown.[b]

	Ft.	in.
Coal, bed E [Upper Freeport, or E]	3	
Fire clay	1	
Shales	5	
Sandstones	10	
Shales	5	
Kidney ore		10
Shales	15	
Sandstone	15	
Shales	3	
Coal, bed D' [Lower Freeport, or D]	2	6
Shale, fire clay?		6
Limestone, brown, impure	3	
Iron-stained shales	17	
Micaceous gray sandstone	21	
Slates	4	
Coal, bed D [Upper Kittanning, or C']	3	6
Fire clay		9
Ferriferous limestone	5	
Fire clay, impure	7	
Slates, with iron ore	8	
Slate	8	
Black slates, with iron ore	11	
Coal, 3 inches; Slate, 1 foot; Coal, 3 inches	1	6
Thin black slates	13	
Coal, bed C? [Middle Kittanning, or C]		9
Fire clay	4	
Gray sandstone	13	
Wavy sandstone, gray	4	
Iron-stained slates	6	
Coal, bed B [Lower Kittanning, or B]	3	6
Fire clay	3	
Gray slates and shales	21	
Massive black shales	15	
Gray sandstone	5	
Massive black slate	5	
Coal (thin).		
Black slate	1	
Gray sandstone	4	
Thin gray slate	6	
Coal, bed A {Coal, 4 feet 6 inches; Slate, 6 inches; Coal, 1 foot 10 inches}	6	10
Fire clay	3	
	264	8

The thickness between the Upper Freeport and Upper Kittanning coals in the foregoing section, not including the thickness of either coal bed, is 102 feet 10 inches. This distance is not absolutely uniform from place to place, as may be seen from the following sections, but it does not vary greatly.

Section of upper part of Allegheny formation near mine of Valley Coal and Stone Company, Stony Creek.

	Ft.	in.
Coal (Upper Freeport, or E)	3	3
Shale	14	
Shale, dark, concretionary	10	
Shale, blue	25	
Sandstone, laminated	5	
Shale and sandy shale	10	
Coal, 1 foot; Bone, 1½ inches; Coal, 1 foot 7 inches; Bone, 1 inch; Coal, 3½ inches (Lower Freeport, or D)	3	1
Limestone	2	6
Shale and sandstone	8	
Shale, blue	15	
Coal (Upper Kittanning, or C')	4 to 5	9 to 5
	101	3

Section of upper part of Allegheny formation on Eighth Ward road, south of Kernville, Johnstown.

	Ft.	in.
Coal, 3 feet 8 inches; Clay, 4 inches; Coal, 3 inches (Upper Freeport, or E)	4	3
Clay	2	6
Coal		3
Shale	5	
Shale, ferruginous	10	
Sandstone, argillaceous	8	
Sandstone, concretionary	3	
Sandstone, massive	19	
Shale, black	3	
Sandstone		4
Shale, black		3
Coal, 7–8 inches; Bone, ½–1 inch; Coal, 8 inches; Shale, black, 2 inches; Coal, 2 feet 6 inches	4	1
Shale, black		6
Limestone	3	9
Shale, blue	5	
Shale, massive, drab, ferruginous	7	
Shale, sandy	8	6
Shale, bluish black	4	
Coal (Upper Kittanning, or C')	3	9
	92	2

[a] Rept. H2, Second Geol. Survey Pennsylvania, 1875, p. 97.

[b] The letters following names in brackets are those used in the latest method of lettering the Allegheny coals.

South of Kernville, where the foregoing section was measured, the interval between the Upper Freeport and Upper Kittanning coal beds is 84 feet 2 inches; near the mine of the Valley Coal and Stone Company it is 92 feet 7 inches; on Mill Creek it is 94 feet; and in a section on the Pennsylvania Railroad, half a mile east of East Conemaugh station, it is 91 feet. The last-mentioned section was completed by another extending down to and including the Lower Kittanning coal, as follows:

Section between the Upper and Lower Kittanning coals east of East Conemaugh.

	Ft.	in.
Shales, blue and gray, partly concretionary, containing in places a small coal bed	50	
Coal		10½
Shale, greenish blue	6	8
Sandstone, gray	1	9
Shale, black	1	5
Sandstone, blue, thick bedded	5	8
Interval, chiefly sandstone	25	
	91	4½

All the data in the foregoing sections considered, the distance from the Upper Freeport coal to and including the Lower Kittanning coal ranges between 185 and 195 feet and is very constant in and about Johnstown.

The interval between the Lower Kittanning coal and the top of the Pottsville is 69 feet in Fulton's section, given above, and by barometric measurement on Clapboard Run it is about 70 feet; hence the Allegheny near Johnstown is 255 to 265 feet thick.

Along the southern margin of the quadrangle, the thickness between the Upper Freeport and Lower Kittanning coals, as indicated by drill holes, ranges from 170 to 180 feet and averages about 175 feet. The lower part of the Allegheny has been measured on Stony Creek, beyond and near the southern border of the quadrangle, with the results shown in the following sections:

Section from top of Pottsville formation to Lower Kittanning coal south of Johnstown quadrangle.

	Ft.	in.
Coal (Lower Kittanning, or B).		
Clay	4	8
Sandstone, gray, laminated	9	8
Sandstone, massive	40	
Shale	2	
Coal and bone	3	7
Shale	10	
Sandstone, laminated	5	
	74	11

Section from top of Pottsville formation to Lower Kittanning coal at Scalp Level.

	Ft.	in.
Concealed to top of B coal	16	6
Shale, black	5	
Shale, sandy	10	
Shale	5	
Shale débris	20	
Coal, 10 inches; Shale, 4 inches; Bone, 6 inches; Coal, 6+ inches (Brookville or Clarion)	2	2
Concealed	10	
Top of Pottsville.		
	68	8

Thus the Allegheny may be considered 240 to 255 feet thick in and about Scalp Level, a thickness not greatly different from that near Johnstown. The distance between the Lower Kittanning and Upper Freeport coals increases to 200 feet northeastward toward Elton, so that the thickness of the Allegheny is in that direction at least 275 feet.

Just beyond the eastern border of the quadrangle, on the main line of the Pennsylvania Railroad, opposite the signal tower between Wilmore and Summerhill, the thickness of the Allegheny was obtained from a diamond-drill record.

Section of Allegheny formation near signal tower on Pennsylvania Railroad between Wilmore and Summerhill, obtained from a diamond-drill record.

	Ft.	in.
Coal with shale streaks (Upper Freeport, or E)	5	
Shale with sandstone streaks	27	1½
Sandstone		9½
Shale	1	½
Shale, black		2½
Shale		8
Sandstone with light shale streaks	3	4½
Shale	9	½
Shale with sandstone streaks	6	3½
Coal, 1 foot 11 inches; Shale, 2 inches; Coal, 1 foot 6½ inches (Lower Freeport, or D)	3	7½
Shale	2	4½
Shale and sandstone	16	5½
Sandstone	3	
Shale with sandstone streaks	7	1
Sandstone with shale layers	5	2
Shale	11	½
Coal (Upper Kittanning, or C')	2	7
Shale		10
Limestone	2	7½
Fire clay	2	
Sandstone with streaks of shale	22	2½
Sandstone	1	5½
Shale, sandy	4	6½
Sandstone	5	8
Shale	8	1½
Bone and shale		7½
Shale	1	1½
Shale with sandstone layers	14	6½
Shale and bone		3
Coal (Middle Kittanning, or C)	1	9
Fire clay	1	11
Sandstone with streaks of shale	2	10
Shale	4	11
Shale with sandstone streaks	3	2
Shale	8	10
Sandstone	1	2
Sandstone with shale streaks	4	
Shale	1	5½
Coal, 3 feet 8 inches; Shale, 3½ inches; Coal, 1 inch; Shale, 1 inch; Coal and bone, 4½ inches (Lower Kittanning, or B)	4	6
Shale	15	4½
Limestone		10
Shale with streaks of limestone	1	11
Shale, black		9½
Limestone		1½
Shale, black	7	1
Shale, light	2	1
Sandstone	9	3
Shale, sandy, with streaks of sandstone	9	6½
Shale	7	8½
Shale and bone		2½
Shale with sandstone layers	20	1
Coal (Brookville)	3	6
Shale and fire clay	3	5
Limestone	4	3
Bottom of drill hole.		
	289	7

If the lowest coal in the section is the Brookville and rests on the Pottsville, the Allegheny in this part of the quadrangle is about 282 feet thick. In this section the distance from the Upper Freeport coal to the Lower Kittanning is 203 feet. This interval diminishes notably toward South Fork, north of which, in the shaft of the Pennsylvania, Beech Creek, and Eastern Coal Company's mine at New Germany, it is only 145 feet. The Allegheny there is about 220 feet thick, if the distance from the Lower Kittanning coal to the top of the Pottsville is 75 feet, as it is near South Fork.

Along Blacklick Creek and South Branch the distance between the Lower Kittanning coal bed and the Lower Freeport or D coal is fairly uniform, varying only from 150 to 160 feet. A coal bed regarded as bed E occurs about 50 feet above the D coal, and the distance from the B coal down to the top of the Pottsville is about 80 feet; so the Allegheny in that region is 280 to 290 feet thick. The thickness of the Allegheny formation therefore ranges between 220 and 290 feet in the Johnstown quadrangle.

The more persistent and characteristic divisions of the Allegheny formation occurring in the Johnstown quadrangle are the following, the highest being named first:

Upper Freeport coal.
Upper Freeport limestone member.
Bolivar clay member.
Butler sandstone member.
Lower Freeport coal.
Lower Freeport limestone member.
Upper Kittanning coal.
Johnstown limestone member.
Coals between Upper and Lower Kittanning coals, including Middle Kittanning coal (C).
Lower Kittanning coal.
Lower Kittanning clay member.
Kittanning sandstone member.
Clarion coal.
Brookville coal.

The position of the several coal beds with reference to one another in the different parts of the quadrangle is shown in figure 5.

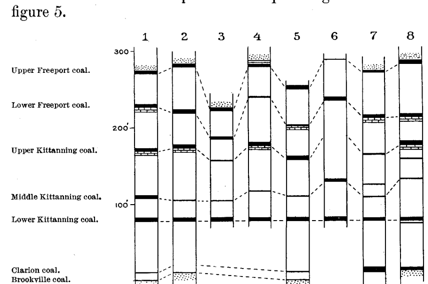

FIGURE 5.—Sections showing the position and relation of coal beds in the Allegheny formation.

1. Compiled section near Coopersdale.
2. Compiled section on Peggys and Clapboard runs.
3. Section north of South Fork.
4. Section south of South Fork.
5. Compiled section near southern border of quadrangle.
6. Section on South Branch of Blacklick Creek.
7 and 8. Two unlocated diamond-drill records in the Johnstown quadrangle.

Brookville and Clarion coals.—The lowest coal in the Allegheny formation is known as the Brookville or A coal and the next coal above it is known as the Clarion or A′ coal. The two coals appear at the roadside just opposite the pumping station of the Cambria Steel Company, west of Coopersdale. The section at that place is as shown in the next column.

The lower coal bed, consisting of two benches, is the Brookville and the higher is the Clarion. Representatives of these lower Allegheny coals also occur on Clapboard Run and near Twin Rocks.

Section containing Brookville (A) and Clarion (A′) coal beds at pumping station of Cambria Steel Company, west of Coopersdale.

	Ft.	in.
Shale, dark	10+	
Coal (Clarion, or A′)	1	0–4
Shale, black, with siliceous limestone concretions	10	
Coal, 5½ inches; Shale and bone, 4 inches; Coal, 1 foot to 1 foot 5 inches (Brookville, or A)	2	2½
Shale and bone		0–10
Top of Pottsville.		

Kittanning sandstone member.—On the Baltimore and Ohio Railroad between Foustwell and the mouth of Paint Creek, on the west flank of the Ebensburg anticline, the top of the Pottsville formation and the beds between it and the Lower Kittanning coal are well exposed. Near the water tank and culvert about a mile east of the bridge over Stony Creek the following section was measured:

Section of lower part of Allegheny formation east of Foustwell.

	Ft.	in.
Base of Lower Kittanning coal.		
Fire clay	4	8
Sandstone, laminated	9	8
Sandstone, massive (Kittanning member)	40	
Shale	2	
Coal		6
Black shale		6
Coal	2	7
Shale	10	
Sandstone, blue, laminated	5	
	74	11

The massive sandstone closely underlying the Lower Kittanning coal bed is also well exposed near Twin Rocks, in a small cut on the Pennsylvania Railroad south of the town.

Lower Kittanning clay member.—The Lower Kittanning clay is the most valuable plastic clay in the quadrangle. It generally underlies the lower bench of the Lower Kittanning coal, from which it is separated by a few inches of shale. Where the lower bench of coal is absent the clay occurs below the main coal, but separated from it by 3 to 4 inches of bone or shale. This clay is of considerable economic importance and will be considered in greater detail in the part of this folio devoted to economic geology.

Lower Kittanning coal.—The next higher coal in the Allegheny is known under various names, as the Lower Kittanning, Miller, White Ash, or B coal. It is the most persistent and valuable coal bed in the area. It lies about 180 to 200 feet below the Upper Freeport or E coal (except north of South Fork, where the distance is only 145 feet) and about 65 to 100 feet above the top of the Pottsville.

Coals between the Lower and Upper Kittanning coals.—In several of the sections south of Johnstown, 17½ to 20 feet below the base of the Upper Kittanning coal (to be described later), a very thin coal bed occurs. In most places it is less than 6 inches thick. It may be seen in the bluffs near the Citizens Coal Company's Eighth Ward mine and in the cut on the Baltimore and Ohio Railroad north of Kring. At the latter place another coal bed 7½ inches thick appears in the section 31 feet below the base of the Upper Kittanning coal. The upper of these two coal beds is mentioned in many of the drill records from the Wilmore Basin. These coals are also persistent in the section along the main line of the Pennsylvania Railroad east of East Conemaugh. Here, however, the lower coal, which is regarded as the Middle Kittanning or C bed, is 45 to 50 feet below the Upper Kittanning—farther than at Kring. Near the brick plant of A. J. Haws & Sons (Limited), near Coopersdale, the Middle Kittanning coal is 25 feet above the Lower Kittanning coal.

Johnstown limestone member.—About Johnstown the Upper Kittanning coal is underlain by a limestone that is suitable for the manufacture of cement. This limestone is best developed along Stony Creek and may be seen to advantage in the cuts on the Baltimore and Ohio Railroad north of Kring station. Here it is 6 feet thick and is separated from the coal by 8 to 12 inches of shale. Along the spur track leading from the north end of the tunnel to the Valley Coal and Stone Company's mine it is also conspicuous but slightly thinner. The cement bed is well exposed in the bluffs along Little Conemaugh River between Johnstown and East Conemaugh and still farther east and is present about South Fork.

Upper Kittanning coal.—The next higher bed of importance is the Upper Kittanning or C′ coal, known near Johnstown as the "cement coal bed." It is an important coal near Johnstown, Windber, and South Fork and is one of the persistent and valuable coals in the quadrangle. It occurs generally from 80 to 105 feet below the Upper Freeport coal, but near South Fork this interval is slightly less. Above the Upper Kittanning coal (the "cement bed") near Johnstown and to the west on Dalton Run some sections show one and some two small coals. One of these was observed 5 feet above railroad level near the residence of L. J. Prosser, north of Ten Acre Bridge, west of Johnstown, where it measured 10 inches. Sections showing this coal bed and its relations to the Upper Kittanning coal are given on the following page.

Section at mouth of Rolling Mill mine of Cambria Steel Company, Johnstown.

	Ft.	in.
Sandstone, thin bedded	3	
Coal		2–4
Sandstone, thin bedded and laminated	8	
Shale		6
Coal (Upper Kittanning or "cement" bed)	3	
Shale	1–15	
Limestone	4+	
Shale or fire clay	2–4	

Section at Reservoir dam, Dalton Run.

	Ft.	in.
Shale.		
Coal		4
Shale		10
Coal		4
Shale	3	
Coal (Upper Kittanning or "cement" bed)	4	
Shale or clay	2+	
Limestone bowlders.		

Lower Freeport limestone member.—The Lower Freeport limestone member occurs either directly below or within a few feet of the base of the Lower Freeport coal, the slight interval between them as a rule being occupied by black shale. The limestone ranges from nearly 1½ to 4 feet in thickness. The best exposures in the quadrangle occur along Stony Creek and the Baltimore and Ohio Railroad west of Moxhom and near the mine of the Valley Coal and Stone Company.

Lower Freeport coal.—The Lower Freeport or D coal is known about Johnstown as the "limestone" coal, from the limestone just described, lying close to its base. In stratigraphic position it ranges from 45 to 70 feet below the Upper Freeport coal.

Butler sandstone member.—In some places on Stony Creek a very massive sandstone lies directly above the Lower Freeport or D coal. This sandstone corresponds in position with the Butler sandstone member, also known as the "Upper Freeport" sandstone. It covers only small areas and is best exposed near the place where the trolley bridge of the Johnstown-Windber line crosses Stony Creek at Moxhom.

Bolivar clay member (?).—A flint-clay bed lying a few feet below what may possibly be the Upper Freeport coal was seen at a few places in the valley of Mardis Run near the northeastern edge of the quadrangle, but not within it. If the coal is the Upper Freeport the clay corresponds with the Bolivar clay member of the region to the southwest. Two feet of clay was seen on the outcrop and the bed may possibly be thicker.

Upper Freeport limestone member.—In the region near South Fork the Upper Freeport limestone member appears in the section. A short distance east of Ehrenfeld it is well exposed in some recent excavations made along the Pennsylvania Railroad. It ranges from 1½ to 3 feet in thickness. It is gray in color and very irregularly bedded. Its relation to the overlying Upper Freeport coal is indicated in the following section:

Section showing Upper Freeport coal and Upper Freeport limestone member at Ehrenfeld.

	Ft.	in.
Shale, blue, with alternating layers of fine-grained sandstone	20	
Sandstone (lower part of Mahoning member)	20	
Coal, 1 foot 11½ inches; Bone, 2 inches; Coal, 1 foot 8 inches } (Upper Freeport)	3	9½
Clay, lower foot containing limestone nodules	2	
Limestone, irregularly bedded (Upper Freeport member)	1½–3	
Fire clay in places	1+	
Shale	15	

Upper Freeport coal.—The roof of the Upper Freeport coal bed marks the top boundary of the Allegheny formation. It lies almost directly below the massive Mahoning sandstone member, as the foregoing section shows. It ranges in position from 220 to 290 feet above the top of the Pottsville formation, or, as it is popularly called, "the conglomerate rock." About Johnstown the coal is known as the Upper Freeport or E coal, but most commonly as the Coke Yard coal. In the South Fork district it is known as the Lemon or Four-foot coal.

CONEMAUGH FORMATION.

General description.—The Conemaugh formation includes the rocks lying below the Pittsburg coal and above the Upper Freeport coal. A partial section of these rocks was obtained from drill records and by hand-level work along the Pennsylvania Railroad in the deepest part of the Wilmore Basin. (See fig. 6.) It should be understood that the detailed section thus obtained applies only to a very small area in the Johnstown quadrangle. It is known with certainty that in places some of the sandstones are absent and others appear in the section at slightly different horizons. Such sandstones are to be regarded rather as lenses than as regular layers of regional distribution. In general, local names should be applied to such sandstone lenses and are applied to some of them when their position in the geologic column is fairly well defined.

With the section shown in figure 6 may be compared the lower part of the Conemaugh in the hills near Johnstown, as measured by John Fulton[a] and by the writer. According to these measurements, supplemented by those made to the east in the Ebensburg quadrangle, the Conemaugh formation is more than 900 feet thick just east of the Johnstown quadrangle, near the center of the Wilmore Basin. This thickness is considerably greater than that measured elsewhere in the Ebensburg quadrangle, but the figures are believed to be approximately correct, provided that the coal at the top in the Ebensburg area is the true representative of the Pittsburg coal. All other measurements of the Conemaugh in this part of Pennsylvania show a considerably less thickness. The formation is known, however, to thicken toward the east. At Steubenville, Ohio, it is less than 500 feet thick; in the Pittsburg district, about 600 feet; near Saltsburg it is about 630 feet; near Blairsville, 750 feet, showing a tendency to thicken eastward. Butts[a] gives the thickness of the Conemaugh as 770 feet in the Ebensburg quadrangle, but more complete data gathered in the Johnstown area show that this figure is too small.

[a] Rept. H2, Second Geol. Survey Pennsylvania, 1877, p. 97.

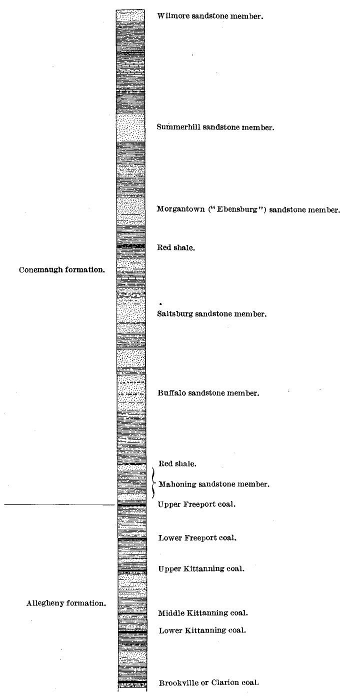

FIGURE 6.—Composite diamond-drill and surface section showing the character of the Conemaugh and Allegheny formations in the Johnstown quadrangle.

Scale, 1 inch=150 feet

From the columnar section it will be observed that the Conemaugh formation is made up essentially of shale and sandstone, with some beds of limestone. Streaks of coal are present in various parts of the section, but they are only locally of sufficient thickness and purity to be commercially important. Fire clay, of both the plastic and the flint varieties, occurs in the formation near Johnstown and Wehrum. A bed of iron ore, called in the reports of the Second Geological Survey of Pennsylvania the Johnstown iron ore, has been found in the hills near Johnstown 50 feet above the Upper Freeport coal. This ore has considerable historical importance, for its presence determined in part the beginning of the iron industry near Johnstown, which has grown to large proportions and has influenced the present vigorous development of the coal resources near the city.

Mahoning sandstone member.—The Mahoning sandstone member by general agreement includes all the rocks between the Upper Freeport and Gallitzin coal beds. It is well exposed in the hills near Johnstown and to the south along Stony Creek. At the tunnel of the Baltimore and Ohio Railroad south of Johnstown a clear section of the lower part of this member was obtained. This section, which may be considered typical for the region near Johnstown, is as follows:

Section of part of Mahoning sandstone member at Baltimore and Ohio Railroad tunnel, south of Johnstown.

	Ft.	in.
Sandstone, laminated and cross-bedded (upper division of the Mahoning member)	8	
Shale, green	4–5	
Coal, 5 inches; Shale, drab, fossiliferous, 2 feet; Coal, 6 inches } (Mahoning coal)	3	1
Fire clay, almost black		6
Limestone, blue, ferruginous, altering to iron ore (Johnstown ore)	1½–2	
Shale	30	
Sandstone, massive (lower division of the Mahoning member)	20	
Shale, massive brown	5	
Upper Freeport coal (Allegheny formation).		

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

The lower sandstone of the Mahoning member outcrops in all the hills near Johnstown. It is a very massive, decidedly coarse-grained micaceous sandstone. It ranges from 20 to 30 feet in thickness and is separated from the Upper Freeport coal by 5 to 10 feet of dark-brown shale. In the shale above this sandstone occurs a bed of flint clay which does not show in the section given above. It lies close to the top of the lower sandstone, from 50 to 80 feet above the Upper Freeport coal. The position of this flint clay is shown in the section in the hill east of Johnstown (fig. 6).

The Johnstown iron ore lies a few inches below the Mahoning coal, next to be described, and about 50 feet above the Upper Freeport coal. This ore will be considered more fully in the discussion of mineral resources.

The upper sandstone of the Mahoning member is fine grained, weathering into extremely thin slabs, and where thickest it measures 20 feet. The underlying coal, exposed in the saddle of the road above the tunnel where the section given above was measured, is the Mahoning coal. It is in two benches here. So far as known it is nowhere thick enough to be worked.

Near South Fork the base of the Conemaugh is well shown in recent cuts on the Pennsylvania Railroad near Ehrenfeld. A hand-leveled section opposite the station is as follows:

Section of lower part of Conemaugh formation at Ehrenfeld.

	Ft.	in.
Shale	15	
Shale, olive and drab, locally sandy (upper Mahoning?)	30	
Coal (Mahoning, upper bench)		4–5
Shale	8	
Shale, black		2
Shale, blue and black	1	
Coal (Mahoning, lower bench)	2	
Shale	15	
Shale, blue, with alternating layers of fine-grained sandstone	20	
Sandstone, massive (lower Mahoning member)	20	
Upper Freeport coal.		

The Mahoning coal appears in this section, as in that south of Johnstown, in two benches and at approximately the same distance above the Upper Freeport coal. The lower bench is thick enough to be worked, but so far as known no coal has ever been obtained from it. The lower sandstone of the Mahoning member is thick bedded but not so much so as in the hills near Johnstown.

The Mahoning coal is about a foot thick in the hills bordering Blacklick Creek near Wehrum. It is closely underlain by old ore benches, which give evidence of the extensive work formerly done on the Johnstown ore bed. The underlying flint clay is present north, west, and southwest of Wehrum and is to be correlated with the flint clay occurring near Johnstown in a similar position with respect to the lower sandstone of the Mahoning member. The best exposure of this flint clay observed in the quadrangle is west and southwest of Wehrum, where it occurs at many points and has in places the uncommon thickness of 7 to 8 feet. It is a typical flint clay in appearance but contains a rather high percentage of iron oxide. It will be considered further in the discussion of clays. The lower sandstone of the Mahoning member is persistent in the Blacklick Creek district and is thick bedded.

Lower red shale.—The Gallitzin coal, the next persistent stratum above the Mahoning sandstone member, is underlain by a thin bed of red shale, which is well exposed along the road leading to Pleasant Hill, northwest of Johnstown. In the records of some of the drill holes put down east of the city this shale has been called variegated.

Gallitzin coal.—Near Johnstown the Gallitzin or Brush Creek coal usually occurs from 70 to 110 feet above the Upper Freeport coal. Where there is but a single coal bed in the lower 110 feet of Conemaugh, and that is but 70 feet above the Upper Freeport coal, there is always doubt whether it should be regarded as the Gallitzin or a lower coal bed. The Gallitzin is not a commercial coal and has not been worked in any part of the quadrangle.

Buffalo sandstone member.—The name Buffalo sandstone was applied by I. C. White to a massive and apparently persistent sandstone lying above the Mahoning sandstone member along Big Buffalo and Little Buffalo creeks, Butler County, western Pennsylvania.[a] In the Ebensburg area and along the eastern border of the Johnstown quadrangle is a sandstone with a very distinctive appearance. It is composed of thick and thin flags which are very compactly bedded and are without conspicuous shale partings or layers. In texture the sandstone is medium to fine grained. It is here correlated with White's Buffalo sandstone.

Near South Fork the top of the Buffalo sandstone member is about 200 feet above the Upper Freeport coal. As nearly as can be judged from the road sections it is a single homogeneous body. It appears prominently along the Pennsylvania Railroad near Ehrenfeld, where it produces massive débris. In the shallow railroad cuts west of Summerhill it is well exposed with the characteristic appearance described above. According to the interpretation of the record of the

[a] White, I. C., Rept. Q, Second Geol. Survey Pennsylvania, 1878, pp. 87 et seq.

bore hole near Wilmore it is there at least 55 feet thick and conglomeratic.

In the hills along Blacklick Creek in the northwestern part of the quadrangle the section shows a very massive sandstone whose top is from 200 to 235 feet above the uppermost workable coal in that part of the quadrangle—that is, the Lower Freeport or D bed. Its top appears, therefore, about 185 feet above the position of the Upper Freeport or E coal. Its top is also 80 and 95 feet, respectively, above the Mahoning coal and the Johnstown ore bed. This sandstone corresponds in position to that near South Fork, just described, and it is regarded as the equivalent of the Buffalo member. It is an exceedingly massive sandstone, forming débris similar in every respect to that from the Pottsville formation. It makes a very prominent appearance in the hills directly north of Vintondale and to the west in Indiana County. Its top is locally well defined, but in many places it merges with a thin sandy shale, so that it is difficult to map with precision. Its base is as a rule badly obscured by massive débris from above. Within the Johnstown quadrangle it is not more than 50 feet thick where opportunity was afforded to judge of its thickness, but to the north, in the Barnesboro quadrangle, it is definitely known to be as much as 80 and 100 feet thick in some places.

Saltsburg sandstone member.—Around Johnstown a bed regarded as the representative of the Saltsburg sandstone member is present. No sandstone is at all conspicuous near Johnstown in the position of the Buffalo as determined around South Fork, the corresponding strata being composed largely of shale. The top of the bed near Johnstown that is regarded as the Saltsburg is about 300 feet above the Upper Freeport coal. This bed is more than 50 feet thick and is massive in the hills east of the city. It is underlain in this region by a thin bed of reddish and purplish shale.

In the southeastern part of the quadrangle the Saltsburg sandstone member is for the most part below drainage level, but several carefully kept drill records give an excellent idea of its character in that region. Its top is 300 feet above the Upper Freeport coal and it therefore corresponds in position to the sandstone near Johnstown, just described. One of the records from the southeastern part of the quadrangle shows it as about 50 feet thick, separated from the underlying Buffalo sandstone member by 30 to 40 feet of shales containing a coal bed, the equivalent of the Bakerstown bed. In another section two coals appear in the shale interval between these two sandstones, separated by 25 feet of shale and sandy shale. Red shale also appears in the interval between the two sandstone members, and a slightly calcareous bed, very thin, not more than 25 feet above the lower sandstone, may possibly represent the Upper Cambridge limestone. Both these sandstone members in places grade into sandy shales and merge imperceptibly with the beds above and below, so that it is difficult or impossible to locate their bases and tops in the records.

Higher red shale.—The next higher stratum which is persistent enough to be traced with certainty is a bed of red shale ranging up to 30 feet in thickness. This shale occurs in nearly all parts of the quadrangle, but its height above the Upper Freeport coal is not at all uniform, its top varying from approximately 300 to 400 feet above this coal. This shale may correspond to the so-called "Pittsburg red shales" of the western part of the State.

Ames limestone member.—Near the top of the shale just described and a short distance below the Harlem coal and the base of the Morgantown sandstone member, to be subsequently described, there occurs locally a thin limestone thought to be the equivalent of the Ames limestone member. This limestone may be observed in a cut along the railroad on South Fork, near the old dam site, nearly opposite the cottages. Here the limestone is about a foot thick and is separated by 11 feet of shales from the Harlem coal and the base of the Morgantown sandstone.

Harlem coal.—Above the red shale just described lies a thin coal bed, known to the drillers as the 600-foot rider, 600 feet being its usual height above the Lower Kittanning, Miller, or B coal. This coal outcrops near the old dam site on South Fork. It is possible that this coal corresponds with the Harlem or Friendsville coal of the western part of the State, but it is hazardous to attempt such close correlations over long distances.

Morgantown ("Ebensburg") sandstone member.—The next higher bed of importance in this quadrangle is a sandstone to which the name "Ebensburg" has been applied in the adjoining quadrangle.[a] In this folio it will be termed the Morgantown sandstone member. In the northern part of the quadrangle the base of this sandstone varies between 300 and 350 feet above the Upper Freeport coal. It is a well-developed sandstone in various parts of the northern third of the quadrangle, especially south of Blacklick Creek and its South Branch. Near Ebensburg, just beyond the northeast corner of the Johnstown quadrangle, it is a conspicuous member, and the town of Ebensburg has been built upon it. To the west, along the Philadelphia and Pittsburg pike, it is present, making very massive bowlders. The open topography east of Saltlick and Stewart runs is due largely to the presence of this sandstone, which here is massive, thickly covers the surface of the country, and renders most of it a barren wilderness, unsuitable for farming.

In a bore hole that was drilled near the signal tower on the Pennsylvania Railroad between Wilmore and Summerhill the base of the Morgantown sandstone member is 425 feet above the Upper Freeport coal. The Harlem (?) coal bed occurs below it, and still lower is the red shale bed. In the section measured along the Pennsylvania Railroad to the west, where the rise of the beds toward the Ebensburg (Viaduct) anticline brings them above drainage level, the sandstone measures more than 30 feet and is very massive. Farther west, near the milldam on Little Conemaugh River at Summerhill and the highway bridge across the river, the massive sandstone is prominent and the red shale appears below it. In the southeastern part of the quadrangle the bottom of this sandstone is 400 feet and its top 450 feet above the Upper Freeport coal. It is very well exposed near Elton and over much of the region southeast of the South Fork branch of the Pennsylvania Railroad. But to the north, toward the head of Clapboard Run, it becomes thin and insignificant, as do also the underlying sandstones of the Conemaugh formation. In this folio only the base of the Morgantown member is mapped and the sandstone is represented as dying out in the direction indicated. It will be seen that the interval between the base of this sandstone and the Upper Freeport coal is greater in the southeastern part of the quadrangle than in the northeastern and northern parts. The sandstones in these two regions, occurring at different positions above the Upper Freeport coal, may possibly be distinct strata, but it has been thought advisable to apply the term Morgantown sandstone member to both of them to avoid multiplication of names.

Higher beds.—The higher portion of the Conemaugh formation in the Johnstown quadrangle is made up of sandstones and shales, with several beds of limestone. Local names have been applied to some of the sandstones in the Ebensburg quadrangle in order to distinguish them, as it has been found difficult to correlate them with typical members of the upper Conemaugh in the Allegheny Valley. In a few places the limestone beds contain fossils, but the correlation of these higher limestones with those farther west by their fossil contents has never been attempted. Such correlations on a stratigraphic basis alone would have hardly any value.

To the lowest of the sandstones in the upper part of the Conemaugh formation the name Summerhill has been applied, from the town of that name in the Johnstown quadrangle. The base of the Summerhill sandstone member is 560 feet above the Upper Freeport coal. It outcrops in a ledge about 45 feet thick in a bluff east of Summerhill, also near the top of the first railroad cut east of the town. It is conspicuous in all the hills between Wilmore and Summerhill, both north and south of the Pennsylvania Railroad. It is decidedly laminated in appearance and differs in this respect very markedly from the Morgantown sandstone member below.

To the highest of the sandstones in the upper part of the Conemaugh the name Wilmore has been applied. The Wilmore sandstone member shows in the top of the first railway cut west of Wilmore, also in the neighboring hills between that town and Summerhill and in the hills along the east edge of the Johnstown quadrangle in the territory immediately north and south of the Pennsylvania Railroad. Its base is more than 700 feet above the Upper Freeport coal. Where measured along the Pennsylvania Railroad it is 17 feet thick. It is generally a thin-bedded micaceous sandstone, though in the region to the east it is in places fairly massive.

MONONGAHELA FORMATION.

The Monongahela formation is not known to be present in this quadrangle. In the Ebensburg folio, however, small areas on certain hilltops just east of the Johnstown quadrangle were mapped as belonging to it. This mapping was based on the occurrence near the hilltops in the deepest parts of the Wilmore Basin, a few miles southeast of South Fork, of a coal bed that was considered the representative of the Pittsburg bed. In the Ebensburg quadrangle this coal bed measured $2\frac{1}{2}$ feet where opened at a country bank. This coal would be more than 900 feet above the Upper Freeport coal near the eastern margin of the Johnstown quadrangle, but in the Ebensburg folio the distance is given as about 770 feet.

QUATERNARY SYSTEM.

PLEISTOCENE DEPOSITS.

Along Conemaugh and Little Conemaugh rivers and Stony Creek are deposits consisting chiefly of rounded bowlders from 2 to 3 feet in longest diameter, associated with sand and clay in small quantities. These deposits are well developed along the main line of the Pennsylvania Railroad and show in the small cuts a short distance east of Mineral Point. At the quarry of B. H. Campbell, north of Sheridan, rounded bowlders occur 100 feet above the level of the Pennsylvania Railroad. The deposit is similar in all respects to the lower one occurring near Mineral Point. Both these deposits are believed to have been produced during Pleistocene time, from their analogy to similar deposits in the Allegheny Valley, and they are tentatively regarded as belonging to the Carmichaels formation. There is nothing, however, inherent in the deposits themselves to throw any light on their age.

RECENT RIVER DEPOSITS.

The alluvium of the streams of this area is the youngest bedded deposit. It consists of fine material, chiefly sand and clay, laid down by the present streams during periods of high water, and is present in varying amount along most of the streams, though occupying, as a rule, but small areas. The most important alluvial area is that at the confluence of Little Conemaugh River and Stony Creek, on which the greater part of Johnstown and its suburbs is located. Other important areas of alluvium lie along Blacklick Creek, near the northwestern borders of the quadrangle, where they are entirely under cultivation.

STRUCTURE.

MODE OF REPRESENTING STRUCTURE.

The structure contour lines on the structure and economic geology map, which are drawn at vertical intervals of 50 feet, show the altitude of the top of the Lower Kittanning or B coal above sea level; all points on a continuous line are at the same altitude.

The top of the Lower Kittanning coal was selected as the horizon on which to base structure contours because it is the most important coal in this area commercially and the most persistent from the geologist's viewpoint. Moreover, its relations to the beds both above it and below it are well known. Where the coal is above drainage level and is worked it is an easy matter to base contours on it by obtaining the elevations of its outcrops and connecting points of equal height. Where the coal does not appear above drainage level other means have to be employed; its known distance below other beds must be used, with the assumption, of course, that the distance is constant within any such area. Similarly where the dips are so great as to carry the horizon of the coal above the hilltops its distance above known beds must be used. When such methods are employed in contouring great precision is not obtainable, for intervals between the coal and other beds are subject to variation in any region and are known to vary greatly within short distances in the Johnstown quadrangle. Furthermore, most of the elevations in this work are obtained by means of aneroid barometers, which are liable to sudden variations and give results that have to be constantly checked against spirit-level elevations. The structure contours show not only in a general way the surface formed by the Lower Kittanning coal, but less precisely the lay of the underlying and overlying beds. The limit of error may be considered to be about the same as the contour interval (50 feet), but where the beds vary much in thickness within short distances it may be more than this. From the structure contours the elevation of the top of the Lower Kittanning coal can be estimated for any point where it is below the surface, and so, by comparison with the surface contours, its depth below the surface at that point; and the approximate depth of other coals at any particular point may be readily computed from the known distance at which they lie either above or below the Lower Kittanning.

GENERAL RELATIONS.

The strata of this region are involved in a series of parallel folds having a general northeast-southwest trend. Viewed broadly, the structure in the Johnstown quadrangle is very regular, as will be seen from the structure contours, but in detail it may be decidedly irregular. The structure as worked out differs in some particulars from that described by the Second Geological Survey of Pennsylvania. Perhaps the most notable difference is in the offset of the Johnstown Basin to the east near the city of Johnstown, as shown on the structure map. In the map of the Second Survey the axis of the Johnstown syncline or basin is represented as being west of the South Fork of Bens Creek, but it has been clearly established that this axis lies farther east.

The folds have the same origin as the dislocations in the earth's crust many miles east of this area, in a zone extending along the Appalachian Mountains and Valley. Several theories have been propounded to explain the origin of these greater movements. They have been thought to be due to an effort at isostatic adjustment between eastern America and the adjacent parts of the Atlantic Basin, and to contraction of the earth, which would result in a westward thrust of the land mass against the young sediments. Whatever may have been their origin, it is positively known that their effect was most severe east of the Great Valley and gradually died out in the small folds west of the Allegheny Front, of which those in the Johnstown area are very typical examples.

[a] Ebensburg folio (No. 133), Geol. Atlas U. S., U. S. Geol. Survey, 1905, p. 5.

LOCAL DETAILS OF STRUCTURE.

General statement.—The structural features in the Johnstown quadrangle, beginning in the southeast corner and proceeding to the northwest, are the following:

1. Wilmore syncline.
2. Ebensburg or Viaduct anticline.
3. Johnstown syncline.
4. Laurel Ridge anticline.
5. Westover or Barnesboro syncline.

In the reports of the Second Geological Survey of Pennsylvania the Wilmore and Johnstown basins were designated subbasins and were considered to constitute the "first bituminous coal basin." The Viaduct anticline was called a subaxis and the Laurel Ridge anticline was designated as the "first grand axis of the bituminous coal regions."[a] D'Invilliers[b] somewhat changed the usage, as he speaks of the first and second basins, referring to the Wilmore and Johnstown basins respectively. The names given and numbered in the column above will be used in this report.

Wilmore syncline.—The Wilmore Basin is so called from the town of Wilmore, situated on the Pennsylvania Railroad a short distance east of Summerhill, in the Ebensburg quadrangle. It is a comparatively long and narrow synclinal trough parallel with and west of the Allegheny Front. The position of the axis of the basin is definitely fixed near the town of Wilmore by the opposing dips of the rocks along the old track of the Pennsylvania Railroad. As indicated on the structure map, the axis enters the Johnstown quadrangle northeast of the old reservoir site on South Fork of Little Conemaugh River and continues southeastward, passing near Elton. It leaves the quadrangle almost in a line coincident with the South Fork branch of the Pennsylvania Railroad. On the southeast side of this axis the beds dip northwest and on the northwest side the beds dip southeast. In this area all the beds along the axis dip northeast, as the axis plunges in that direction. The rise of the beds southwestward is rapid, amounting to 900 feet in 16 or 17 miles, so that the Lower Kittanning coal, which is between 800 and 900 feet above sea level, and hence far below drainage level, in the center of the basin, outcrops at an elevation of about 1700 feet at the mines about Windber.

Ebensburg (Viaduct) anticline.—The Ebensburg or Viaduct anticline is the next structural feature to the west. The axis of this anticline has a general northeast-southwest direction but swerves slightly to the southeast and again to the southwest in that part of the quadrangle south of Conemaugh and Little Conemaugh rivers. This offset, however, is not at all marked.

The Lower Kittanning coal and associated beds, deeply buried in the center of the Wilmore Basin, rise rapidly and with great regularity westward and outcrop in the valley of Little Conemaugh River at South Fork. The coal bed B from its deepest point in the Wilmore Basin rises more than 1000 feet to its highest point at the summit of the anticline. The lowest bed brought above drainage level by this rise is the one at the top of the Pocono formation, namely, the Loyalhanna limestone member, which may be seen outcropping along the summit of the arch between the viaduct and Mineral Point.

Johnstown syncline.—The Johnstown syncline is the next structural feature to the west. It comprises the area between the Ebensburg and Laurel Ridge anticlinal axes. It is really made up of two basins in this quadrangle, one in Cambria County and one in Somerset County. It has a general northeast-southwest course, but is sharply offset to the east in the vicinity of Johnstown, as may be seen by the structure map. The axis in Somerset County in this quadrangle trends in the usual northeast-southwest course. The dip of the beds on the eastern side of the basin is comparatively gentle, the fall being approximately 900 feet in 9 miles, or at the rate of 100 feet to the mile, from the summit of the Ebensburg anticline at the viaduct to the deepest part of the basin north of Little Conemaugh River. In the southern part of the quadrangle the corresponding drop is only 700 feet. On the western side of the basin the rise of the beds to the axis of the Laurel Ridge anticline is sharp, and here are found the steepest dips in the quadrangle. The rise of the beds from the axis of the basin to the apex of the Laurel Ridge anticline is, along Conemaugh River, between 2000 and 2100 feet in 9 miles. In addition to their inclination northwest and southeast toward the center of the basin, the beds north of Conemaugh and Little Conemaugh rivers rise gently to the northeast; the Johnstown axis and the Ebensburg anticlinal axis approach each other near the northeast corner of the quadrangle and continue within 2 miles of each other for a considerable distance in the Patton quadrangle, which lies northeast of the Johnstown.

Laurel Ridge anticline.—The main structural feature in the Johnstown quadrangle is the Laurel Ridge anticline, which, as already stated, was called the "first grand axis" by the Second Geological Survey. It crosses Conemaugh River about midway between Conemaugh Furnace and Coopersdale and passes to the northeast, crossing South Branch of Blacklick Creek a little more than a mile southeast of Twin Rocks. Where the axis of the fold crosses the valley of Conemaugh River the lowest beds in the quadrangle are exposed. These are the red shale and sandstone of the Catskill formation, with a total thickness of 400 feet or more above drainage level. The fold pitches sharply to the northeast, so that the Pocono formation, which caps the hills where the axis crosses Conemaugh River, is below drainage level where it crosses South Branch of Blacklick Creek near Twin Rocks, dropping in this distance at least 1000 feet. As stated in the description of the Johnstown syncline, the beds along its eastern flank rise between 2000 and 2100 feet in a distance of 9 miles. West of the anticlinal axis the beds fall to the Barnesboro or Westover Basin at about the same rate. The anticline therefore is symmetrical.

Barnesboro (Westover) syncline.—The basin west of the Laurel Ridge anticline is described as the Westover Basin in the Pennsylvania Geological Survey reports. More recently it has been called the Barnesboro Basin by members of the United States Geological Survey. The axis of the basin enters the Johnstown quadrangle near the line between Cambria and Indiana counties, passes through or very near Wehrum, and leaves the quadrangle about 4 miles south of Blacklick Creek. From the axis of this basin the beds rise gently northwestward to the axis of the Nolo anticline, which lies just beyond the northwest corner of this quadrangle.

Minor structural features.—Besides the principal folds there are many minor folds in the rocks. A small arch or anticline is exposed along Little Conemaugh River about a mile east of Conemaugh station. From this point westward to Johnstown station there are many minor fluctuations, all exposed along the main line of the Pennsylvania Railroad. Between Millville and Coopersdale there is a distinct anticline. Thus the main broad Johnstown syncline has been subjected to many minor plications. Some mining men have thought that these lesser folds about Franklin and along Clapboard Run caused the so-called "faulting" which the coal exhibits in this region. The erratic conformation of the Lower Kittanning coal may possibly be due in part to this cause, but the irregularities seen by the writer are not faults, as this term is used in the geologic sense—that is, offsetting breaks. The attitude of the coal is more probably due to peculiar conditions of sedimentation during its deposition and not at all to subsequent movement. The disturbance appears to be strictly local.

GEOLOGIC HISTORY.

INTRODUCTION.

In Pennsylvania all the rocks west of the Blue Ridge are sedimentary, as is proved by their lithologic character and by the fossil imprints, fauna, and flora contained in them. Study of these rocks shows that an interior sea existed over the whole of central and western Pennsylvania during a part of the early geologic history of that area. This sea was not a part of the Atlantic Ocean but was an interior body of water which extended from Alabama to Canada and from southeastern Pennsylvania beyond the present Mississippi Valley. The land east of this inland sea has been called Appalachia by some geologists.

Except the very latest rocks, which were formed in Pleistocene time, and the Recent alluvium, the rocks of the Johnstown quadrangle belong to the Paleozoic era. This era has been divided into periods according to the most striking variations in the species of animals which lived during that time. From earliest to latest these periods are the Cambrian, Ordovician, Silurian, Devonian, and Carboniferous. Only the Devonian and Carboniferous are represented by rocks in this quadrangle.

There is good reason to believe that before the beginning of Paleozoic time the great land mass known as Appalachia existed and that directly west of it extended a long, narrow interior sea covering part of Pennsylvania. Most of the rocks occurring at the surface in pre-Cambrian time were schists and igneous rocks, not of sedimentary origin. The wearing away of these rocks furnished the sediments that were deposited in the interior sea. These sediments now form the surface of the land area formerly covered by this sea. The surface separating the older schists and igneous rocks from the overlying sediments marks what is sometimes referred to as the basal unconformity.

When the Cambrian period began Appalachia was generally subsiding. Along the shores of the interior sea coarse sediments were deposited, consisting of gravel, sand, and sandy mud. These were followed by calcareous muds and sands. The interior sea gradually widened its boundaries and its warm and shallow waters induced a rich animal life. A new fauna came in, marking the beginning of the Ordovician period. The interior sea continued into Ordovician time. The great beds of limestone deposited during this period were succeeded by shale deposits, the transition proceeding very slowly. Such a sequence from limestones to shales might be due to a moderate uplift of the land. During this rise of the land the sea retreated westward and became a gulf that occupied an area now forming parts of Pennsylvania and other eastern States and connected with the Gulf of St. Lawrence. With the narrowing of the inland sea the water probably became muddy, with consequent disastrous effect on the animal life contained in it. New forms adapted to the change in physical conditions came in, and the new fauna has served as a means of separating the Ordovician from the Silurian rocks. During late Silurian time the waters of this gulf became shallow in its northeastern and northern parts and calcareous muds accumulated. A deepening of the waters followed, permitting the accumulation of pure limestone beds, constituting the Helderberg limestone. Near the close of Silurian time the waters of the Gulf of St. Lawrence were cut off from those to the south, and the Devonian beds were laid down in a landlocked sea. The Oriskany sandstone represents clean beach deposits along a gently sloping sea margin, and these were followed by the growth of a rich coralline fauna in the sea to the west, as shown by the rocks known as the "Corniferous" limestone.

The later beds still to be discussed are those exposed in the Ebensburg and Johnstown quadrangles.

The lowest rocks exposed in the Johnstown quadrangle are those constituting the upper 400 feet of the Catskill formation which is now generally regarded as forming part of the Devonian system, though some authorities hold the opinion that it may in the future be found to belong partly or wholly in the Mississippian series of the Carboniferous. Along the Allegheny Front, which lies not many miles east of the Johnstown quadrangle and crosses the Ebensburg quadrangle, Devonian rocks as low down in the system as the Hamilton shale are shown on the surface. The detailed sedimentary record of this quadrangle may therefore appropriately begin with the Hamilton deposition.

HAMILTON, GENESEE, PORTAGE, AND CHEMUNG DEPOSITION.

That the deposition of the Hamilton, Genesee, Portage, and Chemung formations took place in an inclosed gulf or sea has already been indicated. The character of the earliest rocks of these formations—clayey beds alternating with sandy clays—indicates long periods of comparative quiet alternating with periods of minor oscillation of the land. Such fine material was probably derived from a broad, low-lying coastal plain, perhaps similar to the present Coastal Plain of the Southern States. At any rate the character of the materials suggests that for the most part they were carried long distances and deposited in quiet surroundings, which continued into Genesee time.

As already stated, the Genesee shale conformably overlies the Hamilton formation and owing to its black color and fissile character constitutes a distinct lithologic type, easily demarked from both the underlying and the overlying beds. Viewed broadly—for beds of this kind are of broad extent—the Genesee is a fine-grained calcareous mud, usually dark brown or black from the presence of bituminous matter. Material of this character is found from Alabama to New York. The suggestion has been made that its deposition was due to accumulation in very deep water in which the vertical circulation was imperfect—such conditions as exist in the Black Sea at the present time. Some geologists, however, are disposed to regard the accumulation as having occurred in shallow waters under swampy conditions. The change from Genesee to Portage conditions must have taken place gradually, as indicated by the very gradual transition in the Portage rocks. The change from Portage to Chemung conditions likewise was gradual, so far as the physical condition of the rocks denotes its character. The facts indicate that the sea bottom during Portage and Chemung time probably was in motion, first upward and then downward, that the preponderance of movement was in the downward direction, and that the subsidence amounted to several hundred feet. The predominance of sandy shales and sandstones indicates that shallow-water conditions prevailed. The relative abundance of the fossils contained in the Chemung is of assistance in separating it from the Portage formation, as they point to a change from the physical conditions that prevailed in Portage time. It is known that a fauna from the east and one from the west invaded the sea many times in alternation.

CATSKILL DEPOSITION.

The Catskill formation is sufficiently different from the rest of the Upper Devonian to indicate that the sediments of which it is composed accumulated under conditions different from those existing during the formation of the earlier beds. The differences are as follows: (1) The Catskill is almost barren of fossils and such as occur are partly if not wholly fresh and brackish water forms. The coast during Catskill time may therefore have been shut off from the ocean so as not to permit the incursion of an abundant fauna, or sedimentation may have been so rapid as to prevent the growth of animals. (2) There is a peculiar preponderance of red sediments in the formation. The red color is due to iron oxide in a higher state of oxidation. The vivid greens associated with the reds in many places are thought to be due to ferrous iron—that is, iron in a lower con-

[a] Rept. H2, Second Geol. Survey Pennsylvania, pp. xxix, 25, 26, and 97.
[b] Summary Final Rept. Geol. Survey Pennsylvania, 1895, p. 2219.

dition of oxidation—though so far as the writer is aware this has never been definitely shown. Regarding the physical conditions necessary for the production of such red sediments there seems to be some diversity of opinion. It is possible that the only rocks that could provide the necessary iron-bearing minerals were those of the pre-Cambrian complex, which for some time had been uncovered. These may have been subject to a long period of exposure, during which rock decay proceeded much more quickly than removal. The mantle of ferruginous soil accumulated to considerable depths, simulating the conditions which are seen in the Southern States at the present time. A rapid rise in the land would have reversed the process, and the superficial ferruginous soils, clays, and gravels would have been subjected to denudation. This may have taken place in partly inclosed seas, inland lakes, or basins.

CARBONIFEROUS PERIOD.

POCONO DEPOSITION.

So far as is known the deposition of the Pocono rocks followed, without any break, that of the Catskill. The transition from Devonian to Carboniferous conditions was gradual, and rocks typical of the Catskill recur from place to place in the Pocono. The typical Pocono rocks differ from the Catskill in being greenish gray instead of red. They suggest rapid erosion of the land, such as would give scant time for oxidation. They are feldspathic and micaceous, indicating removal at a rate so rapid that the disintegrated feldspathic rocks had no time to break down to quartz sand and clay. They suggest also deposition in shallow water, and, like the Catskill rocks, they were formed in fresh water, as is proved by the presence in them of fossil plants associated with considerable coal beds in Virginia and West Virginia.

Toward the close of Pocono time occurred the accumulation of its Loyalhanna limestone member. The cross-bedded character of this member shows that it is of clastic origin and was deposited along a shore line or in a position where the particles could be worked over by rapidly changing currents.

MAUCH CHUNK DEPOSITION.

Pocono deposition was followed by a recurrence of Catskill conditions, and the red beds of the Mauch Chunk shale, which in this part of Pennsylvania are physically almost identical with the Catskill beds, were deposited. The beds of the Mauch Chunk shale are characterized by the presence of ripple marks, and the associated sandstones are in many places cross-bedded—for instance, the middle sandstone member of this formation in the Johnstown quadrangle. In the eastern part of Pennsylvania near the type locality the Mauch Chunk is 2000 feet thick, but it thins southwestward and westward and is less than 200 feet thick in the Johnstown area; still farther west it gradually merges into limestone in the Mississippi Valley. The red beds, therefore, are limited to the northeastern part of the Appalachian Gulf, indicating a gradual subsidence in this part of the gulf. The formation suggests land elevated, eroded, and redeposited in the Carboniferous gulf. The Mauch Chunk is barren of fossils and of coal.

Up to the close of Mauch Chunk time, so far as known, deposition went on continuously without any appreciable break in the sedimentary record. At or near the close of the Mauch Chunk deposition, or, more accurately, before the beginning of Pottsville deposition, a break occurred, revealed by the unconformity between the Mauch Chunk and Pottsville, already referred to. This unconformity points to an uplift of the sea floor above sea level over a large part of western Pennsylvania, including the Johnstown quadrangle. While the Mauch Chunk beds were above sea level Pottsville conditions began in the eastern part of Pennsylvania. The erosion of the Mauch Chunk proceeded, subsidence occurred again, and Pottsville sediments began to accumulate over the area near the Allegheny Front. It has been suggested that the uplift causing the emergence of the Mauch Chunk beds above sea level may have occurred at the same time as an uplift which took place east of the Blue Ridge and which led to the discharge of the coarse sand and gravel of the Pottsville rocks into the anthracite basin of eastern Pennsylvania.

POTTSVILLE DEPOSITION.

A very decided change in physical conditions must have occurred after the deposition of the red muds of the Mauch Chunk. It is believed that subsidence must have taken place rapidly in the northeast and along the southeastern margin of the Paleozoic gulf, possibly accompanied by a warping and deepening of the shallow Mauch Chunk sea. At the same time mountain building took place to the east, by which the streams were rejuvenated and brought in immense quantities of the coarse material characteristic of the Pottsville formation. This coarser material, composed of clear quartz, had not been directly eroded from the land, like the material of the Pocono sediments, but had been worked and reworked, possibly along coastal plains which existed during Mauch Chunk time. During the subsidence there were periods of relative stability in which the conditions were favorable for a luxuriant growth of vegetation, which gave rise to coal beds. The Pottsville is of further interest, inasmuch as during Pottsville time those peculiar conditions began which resulted in the deposition of the coal of Pennsylvania and adjoining States.

The Pottsville formation, which followed the Mauch Chunk, is a remarkably coarse grained sandstone almost throughout its thickness, not only in the Johnstown quadrangle but over nearly the entire State of Pennsylvania and in adjoining States. In the southern anthracite field and the West Virginia coal field this formation is very much thicker than in the western part of Pennsylvania. It was formerly supposed that the difference was due to unequal deposition—in other words, that the considerable thickness of coarse sediments in the eastern part of the State and in West Virginia was deposited in no longer time than the few hundred feet of Pottsville in the western part of Pennsylvania. Recent studies by David White,[a] however, have shown that this is not true, but that while the earlier Pottsville beds were being deposited in the anthracite coal fields much of the western part of the State, including the Johnstown quadrangle, was above water and subject to denudation; hence no rocks of corresponding early Pottsville age were laid down in that region. This statement is proved by the fact that the thick sections along the eastern border of the Appalachian coal region contain floras older than those in the lowest beds of the thin northwestern sections. Furthermore, the characteristic floras of the thin sections occur in their natural order in only the upper part of the thick sections; in other words, the lower Pottsville beds were not deposited in the bituminous region of Pennsylvania and Ohio. Later, during Sharon time, the Appalachian gulf by a transgression westward covered the northwestern part of Pennsylvania and deposited the Sharon shale and conglomerate members of the Pottsville. During this time, as is inferred from the thinness of the Pottsville sediments in the small northeastern bituminous basins of Pennsylvania and their thickness near the Allegheny Front, both west and east of it, a low barrier existed in the region of the Allegheny Front, including the Johnstown quadrangle, and extended nearly as far westward as Pittsburg. After the Sharon members were deposited the central barrier disappeared in an area lying between the northwest and northeast arms of the Pottsville sea, the region near the Allegheny Front was submerged, and the Connoquenessing sandstone member, the Mercer shale member, and the Homewood sandstone member were deposited on the eroded Mauch Chunk and Pocono surfaces. In the Johnstown quadrangle the erosion had not removed the lowest 200 feet of the Mauch Chunk when the pre-Connoquenessing submergence occurred.

ALLEGHENY DEPOSITION.

The resemblance of the sediments in the lower part of the Allegheny to those of the Pottsville formation in the Johnstown quadrangle indicates that the physical conditions which existed during the Pottsville deposition extended into Allegheny time until the deposition of the Lower Kittanning coal. Certainly the Allegheny sediments up to and including the Kittanning sandstone member seem to be essentially like the Pottsville beds over a large part of the quadrangle where the lower Allegheny beds are exposed. With the deposition of the Lower Kittanning and the subsequent Allegheny beds conditions were changed somewhat; the peculiar physical conditions necessary to the production of the coal beds frequently recurred. This is the most notable fact to be deduced from a study of the Allegheny sections. Accompanying the coal beds are shales, sandstones, and limestones in irregular succession. These vary in extent, in thickness, and in composition, and this variation in connection with their irregularity of succession indicates unstable conditions of the sea bottom relative to the land during the intervals between the periods when the coal beds were formed.

It is now generally agreed that the coal beds are of vegetable origin, and it seems most probable that they represent vast marshes of a peculiar type, though whether the coal-forming plants grew in fresh water, brackish water, or salt water is not certain. The remains of the marsh vegetation, as well as of associated tree trunks, leaves, etc., fell and were protected from oxidation by a thin covering of water. These great marshes were subject to incursions from the sea, at least locally, for beds containing marine fossils are associated with the coals or are present in the coal-bearing formations. The fact that the coals very commonly contain clay partings or consist of several benches, separated by bone or clayey material, indicates that even during the deposition of the coal bed there was relative movement, by which the land subsided so that water came in bearing fine or coarse sediments. In some places the inrush of sediments was rapid and deposition of sand closely accompanied or followed the erosion of part of the material that formed the coal bed; this is thought to have been the history, for example, of the Lower Kittanning coal near Clapboard Run. Intimately connected beds of sandstone and coal are, however, rare, at least in this region. In most places the inwash of silts and clays must have proceeded quietly, for in no other way could extensive accumulations of the finest muds be formed in layers so thin.

The intimate association of ferruginous limestone and coal is of interest. Limestone underlies the Upper Kittanning and the Lower and Upper Freeport coals in different parts of the quadrangle. The association is common also in other parts of the Appalachian coal field. The deposition of a limestone bed is accompanied by the liberation of carbon dioxide, which is thus added to the amount already present in the atmosphere. This fact may have had something to do with the succeeding rich vegetable growth, but it is doubtful whether it induced such a growth over any considerable area. Certainly such a hypothesis can not be invoked to account for the bulk of the coal beds.

CONEMAUGH DEPOSITION.

The material of the Conemaugh formation does not differ greatly from that deposited in Allegheny time. The coal beds deposited in the Conemaugh epoch were not so numerous as those in the Allegheny and not so thick and important. There were at intervals in Conemaugh time, moreover, conditions under which red beds were deposited, but as a whole the Conemaugh is made up essentially of rocks of the same types that characterize the Allegheny, namely, sandstones, shales, limestones, and some coal beds. It seems reasonable to suppose, therefore, that the Conemaugh conditions were essentially the same as during Allegheny time. The land was under water, possibly fresh water most of the time but occasionally salt water, as salt-water fossils are found associated with the roof shales of the Upper Freeport bed and in the Ames limestone member in the region to the west.

MONONGAHELA DEPOSITION.

There is no reason to suppose that during the deposition of the Monongahela the physical geography in western Pennsylvania and adjoining States was much different from that which prevailed during Allegheny and Conemaugh time. The Conemaugh formation was separated from the underlying and overlying formations because it contains few workable coal beds, and for the same reason it was designated the "Lower Barren Coal Measures." But the presence in it of coal beds and the essential likeness of its sediments to those in the underlying formation indicate a continuation of earlier physical conditions up to the beginning of Monongahela deposition. The line beween the Monongahela formation and the underlying Conemaugh is marked by the famous Pittsburg coal bed. The beds of the Monongahela are lithologically like those in the two underlying formations, especially like the Allegheny, for the Monongahela includes many important coal beds. During Monongahela time the peculiar conditions necessary for the accumulation of coal beds reached their culmination. As previously stated, it is doubtful if any true Monongahela beds are present in the Johnstown quadrangle.

DUNKARD DEPOSITION.

The Dunkard group does not occur in the Johnstown quadrangle. It is of interest in the present discussion, however, as it represents a continuation of the conditions described as existing during the deposition of the Allegheny, Conemaugh, and Monongahela formations. Like them, it is coal bearing, but during the Dunkard epoch the peculiar conditions necessary to the formation of coal beds gradually waned and finally died out altogether.

THE APPALACHIAN REVOLUTION.

Up to the close of the Carboniferous the interior Paleozoic gulf had received sediments brought into it from the surrounding land. The sedimentation must have been accompanied by a relative subsidence of the sea bottom to accommodate the many thousands of feet of sediments deposited on it. That this subsidence was by no means continuous is attested by the character of the sediments and the presence of unconformities. At the close of the Carboniferous period these beds emerged from the sea, and so far as known they have been above water level ever since in western Pennsylvania.

After the emergence of the land, and quite likely also while Carboniferous sediments were still being deposited, diastrophic movements occurred. Their effects are shown in a small way by the folds which extend across the Johnstown quadrangle. These folds are probably genetically connected with a series of folds and breaks in the earth's crust many miles east of this area, in a zone extending along the Appalachian Valley and Mountains. The westward thrust of the land mass due to the contraction of the earth may have influenced their development. Whatever may have been their origin, it is known that the effect was most severe in the east and gradually diminished westward. Along the east side of the Great Valley the rocks were faulted and folded and greatly metamorphosed, so that in many places the original character of the sediments has been entirely obliterated. In the Great Appalachian Valley

[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 751-930; Bull. Geol. Soc. America, vol. 15, 1904, pp. 267-282.

the rocks are also greatly faulted and folded, but they are not highly metamorphosed. The effects of the movement died out in small folds west of the Allegheny Front, where the Johnstown quadrangle is located.

SUBSEQUENT GEOLOGIC HISTORY.

Since the emergence of the land degradation of the surface has been in progress, and it was going on during deformation. At several stages the land was worn down to a nearly level surface, and the summit of Laurel Ridge and the highest points along the Allegheny Front in the southeastern part of the Johnstown quadrangle are thought to represent the remains of one of these old and thoroughly reduced surfaces, the Schooley peneplain. This peneplain was formed before or during Cretaceous time, for Cretaceous deposits occur on it in New Jersey. There is no evidence, so far as the writer is aware, of other old reduced surfaces within the Johnstown quadrangle.

That the region is now in process of uplift seems evident from the presence of phenomena associated with rejuvenation. The gorgelike character of many of the river valleys and the continued intrenching of the meanders are examples of such phenomena.

ECONOMIC GEOLOGY.

The mineral resources of the Johnstown quadrangle are coal, flint and plastic clay, shales, limestone, cement material, building stone, glass sand, and iron ore.

COAL.

In the following descriptions no attempt will be made to present very detailed information. Only general facts regarding the important coals of the quadrangle will be given. For details as well as for consideration of the unimportant coals of the area the reader is referred to a forthcoming bulletin of the United States Geological Survey (No. 447), treating of the mineral resources of the Johnstown quadrangle.

CHEMISTRY AND USES OF THE COALS.

The coals of the Johnstown quadrangle belong to the soft, lustrous semibituminous variety. They are best adapted for steaming and domestic purposes, but some of them also make coke of an excellent grade. They are classed as smokeless coals, owing to their small content of volatile hydrocarbons. They contain uniformly a high proportion of carbon and small amounts of volatile matter and moisture. Their ash and sulphur contents vary but in general are high in comparison with those of other Appalachian coals—for instance, the coals of West Virginia and eastern Kentucky. Some analyses of samples collected according to present Survey methods are listed below:

Analyses of coal samples from Johnstown quadrangle, Pennsylvania.

[All analyses given in this folio, unless otherwise stated, were made at the fuel-testing plant of the United States Geological Survey at St. Louis, Mo.; F. M. Stanton, chemist.]

	Upper Freeport (E).			Lower Freeport (D).	Upper Kittanning (C′).					
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Sample as received:										
Moisture	2.65	2.82	3.04	4.73	2.81	1.67	2.60	1.94	2.93	3.51
Volatile matter	14.86	15.61	16.27	13.78	15.07	18.52	14.10	15.81	13.47	17.16
Fixed carbon	72.38	70.32	73.47	72.27	72.64	69.14	72.05	70.77	74.06	69.04
Ash	10.11	11.25	7.22	9.22	9.48	10.67	11.25	11.48	9.54	10.29
Sulphur	2.06	2.42	2.18	1.09	1.92	3.46	2.79	3.73	1.88	2.01
Loss of moisture on air drying	2.00	2.10	2.50	4.00	2.20	1.00	2.00	1.20	2.20	2.30
Air-dried sample:										
Moisture	.66	.74	.55	.76	.62	.68	.61	.75	.75	1.24
Volatile matter	15.16	15.94	16.69	14.35	15.41	18.71	14.39	16.00	13.77	17.56
Fixed carbon	73.86	71.83	75.35	75.28	74.28	69.84	73.52	71.63	75.73	70.67
Ash	10.32	11.49	7.41	9.61	9.69	10.77	11.48	11.62	9.75	10.53
Sulphur	2.10	2.47	2.24	1.14	1.96	3.49	2.85	3.78	1.92	2.06

	Lower Kittanning (B).									
	K.	L.	M.	N.	O.	P.	Q.	R.	S.	T.
Sample as received:										
Prox. Moisture	2.70	2.03	2.81	1.78	2.21	2.24	2.63	2.79	3.12	3.07
Prox. Volatile matter	15.64	14.47	14.66	15.19	14.32	15.70	17.85	17.76	17.89	17.64
Prox. Fixed carbon	74.03	75.31	75.75	73.25	78.16	78.37	73.24	73.20	70.85	72.85
Prox. Ash	7.63	8.19	6.78	9.78	5.31	3.69	6.28	6.25	8.14	6.44
Ult. Sulphur	1.93	2.26	1.33	4.50	.47	.77	1.49	1.88	2.74	1.38
Ult. Hydrogen	......	4.14	......	4.16	......	......	......	......	......	......
Ult. Carbon	......	79.97	......	77.10	......	......	......	......	......	......
Ult. Nitrogen	......	1.26	......	1.41	......	......	......	......	......	......
Ult. Oxygen	......	4.18	......	3.05	......	......	......	......	......	......
Calorific value:										
Calories	......	7,823	......	7,612	......	......	......	......	......	......
British thermal units	......	14,081	......	13,702	......	......	......	......	......	......
Loss of moisture on air drying	1.80	1.40	1.90	1.10	1.60	1.60	2.00	2.10	2.50	2.50
Air-dried sample:										
Prox. Moisture	.91	.64	.93	.69	.62	.65	.64	.71	.64	.58
Prox. Volatile matter	15.93	14.67	14.94	15.36	14.55	15.95	18.21	18.14	18.35	18.09
Prox. Fixed carbon	75.39	76.38	77.22	74.06	79.43	79.65	74.74	74.77	72.67	74.72
Prox. Ash	7.77	8.31	6.91	9.89	5.40	3.75	6.41	6.38	8.34	6.61
Ult. Sulphur	1.97	2.29	1.36	4.55	.48	.78	1.52	1.92	2.81	1.42
Ult. Hydrogen	......	4.04	......	4.08	......	......	......	......	......	......
Ult. Carbon	......	81.10	......	77.95	......	......	......	......	......	......
Ult. Nitrogen	......	1.27	......	1.43	......	......	......	......	......	......
Ult. Oxygen	......	2.99	......	2.10	......	......	......	......	......	......
Calorific value:										
Calories	......	7,934	......	7,697	......	......	......	......	......	......
British thermal units	......	14,281	......	13,854	......	......	......	......	......	......

A. Conemaugh.
B. Johnstown.
C. South Fork.
D. Stony Creek, near trolley bridge between Moxhom and Ferndale, south of Johnstown.
E. South Fork.
F. Franklin.
G. Dale.
H. Johnstown.
I. Moxhom.
J. Solomons Run, southeast of Johnstown.
K. Franklin.
L. Johnstown.
M. Near Walsall.
N. Stony Creek, Somerset County, south of quadrangle.
O. South Fork.
P. South Fork.
Q. Nanty Glo.
R. Nanty Glo.
S. Vintondale.
T. Twin Rocks.

Analyses of coal samples from Johnstown quadrangle, Pennsylvania—Continued.

	Lower Kittanning (B).								Brookville. (A).
	U.	V.	W.	X.	Y.	Z.	AA.	BB.	CC.
Sample as received:									
Prox. Moisture	2.80	3.45	2.59	3.49	3.09	2.31	1.10	0.59	2.35
Prox. Volatile matter	17.30	18.82	18.91	16.12	16.66	13.99	15.80	16.61	14.30
Prox. Fixed carbon	73.28	71.18	70.33	74.68	74.79	76.69	75.69	76.76	71.40
Prox. Ash	6.62	6.55	8.17	5.71	5.46	7.01	7.41	6.04	11.95
Ult. Sulphur	2.46	2.01	4.04	.95	1.18	1.19	1.49	.91	3.30
Ult. Hydrogen	......	......	......	......	......	......	......	......	4.22
Ult. Carbon	......	......	......	......	......	......	......	......	75.16
Ult. Nitrogen	......	......	......	......	......	......	......	......	1.13
Ult. Oxygen	......	......	......	......	......	......	......	......	4.24
Calorific value:									
Calories	......	......	......	......	......	......	......	......	7,382
British thermal units:	......	......	......	......	......	......	......	......	13,288
Loss of moisture on air drying	2.00	3.00	2.00	2.80	2.20	1.60	......	......	1.80
Air-dried sample:									
Prox. Moisture	.82	.46	.60	.71	.91	.72	......	......	.56
Prox. Volatile matter	17.65	19.40	19.30	16.58	17.03	14.22	......	......	14.56
Prox. Fixed carbon	74.77	73.38	71.77	76.83	76.47	77.94	......	......	72.71
Prox. Ash	6.76	6.76	8.33	5.88	5.59	7.12	......	......	12.17
Ult. Sulphur	2.51	2.07	4.12	.98	1.21	1.21	......	......	3.36
Ult. Hydrogen	......	......	......	......	......	......	......	......	4.09
Ult. Carbon	......	......	......	......	......	......	......	......	76.53
Ult. Nitrogen	......	......	......	......	......	......	......	......	1.15
Ult. Oxygen	......	......	......	......	......	......	......	......	2.71
Calorific value:									
Calories	......	......	......	......	......	......	......	......	7,517
British thermal units	......	......	......	......	......	......	......	......	13,532

U. Near Weber station, Blacklick Creek.
V. Twin Rocks.
W. Wehrum.
X. Ehrenfeld.[a]
Y. Ehrenfeld.[a]
Z. Scalp Level.
AA. Windber.[b]
BB. Windber.[b]
CC. South Fork.

[a] J. S. Burrows, collector. See Bull. U. S. Geol. Survey No. 290, 1906, p. 179.
[b] Analyses of sample of carload shipped by operators to St. Louis. See Bull. U. S. Geol. Survey No. 261, 1905, p. 51.

LOWER ALLEGHENY COALS (CLARION AND BROOKVILLE).

DISTRIBUTION AND PHYSICAL CHARACTER.

Johnstown.—The lowest coals of any importance in the Johnstown quadrangle are the Brookville (A) and Clarion (A′) coals. These are exposed near Johnstown. West of Coopersdale the top of the Pottsville formation appears above the road level just west of the brick plant of A. J. Haws & Sons (Limited). Just above the top of the massive Homewood sandstone member of the Pottsville two small coal beds are exposed, separated by about 10 feet of dark shale. The section measured at this place has been given elsewhere. (See p. 5.) The coal beds are each less than 1½ feet thick. The lower and upper probably correspond with the Brookville (A) and Clarion (A′) coals of the Allegheny Valley. At least one of these coals, regarded as the Brookville, is exposed on Clapboard Run but is badly broken up by partings, as the following sections show. (See also section 2, fig. 7.)

Sections of the Brookville coal on Clapboard Run.

	Ft.	in.
Bony coal	1	8
Bone		1
Coal	1	8

	Ft.	in.
Bone or shale		9
Coal		3
Bone		½
Coal		6
Bone or shale		1
Coal	1	7

These two sections if carefully observed look very similar, showing an upper bench 19 to 21 inches thick and a lower bench 19 to 20 inches thick. Both these benches are so badly broken up by partings as to have no commercial value.

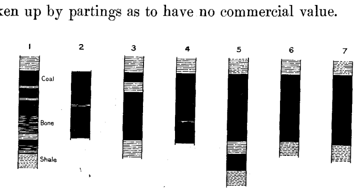

FIGURE 7.—Sections of the Mercer coal (1 and 2), Brookville coal (3 and 4), and Lower Kittanning coal (5 to 7).

1. Baltimore and Ohio Railroad cut north of Ingleside, near Kring.
2. Clapboard Run.
3. Baltimore and Ohio Railroad near southern edge of quadrangle.
4. J. H. Wickes mine, South Fork.
5. A. J. Haws & Sons (Limited), Coopersdale.
6. Citizens Coal Company, Green Hill mine.
7. Ingleside Coal Company. Walsall.

South of Moxhom, on Stony Creek, the horizon of these lower coals is brought above drainage level, but information as to the coals in this locality is so meager that it is uncertain whether they will generally be found workable.

South Fork.—A coal bed 60 to 70 feet lower than the Lower Kittanning coal has been opened near South Fork and Mineral Point. This bed, it is believed, corresponds to the Brookville or A coal. Most of the openings are "fallen shut," but the coal is mined at one bank at South Fork to supply the local brick company. This coal is better known locally as the Six-foot coal or Dirty A, but where seen it measured only 3½ feet, as indicated in section 4, figure 7.

Blacklick Creek.—Along Blacklick Creek and South Branch outcrop coals which are below the main Blacklick Creek bed, correlated with the Lower Kittanning coal. In the railroad cut near Twin Rocks at least one representative of these lower coals appears, but it is so badly broken up as to have no commercial value. Attempts to work this coal have resulted in failure. This lower coal is regarded as one of the group lying directly above the top of the Pottsville formation.

CHEMICAL CHARACTER.

An analysis was made of the Brookville coal collected from a mine in operation at South Fork. The composition of the coal is indicated by analysis CC in the table above. From the high ash and sulphur content the coal well deserves the name Dirty A, which is popularly applied to it. In other respects it is similar to other coals of the area, being relatively high in fixed carbon and low in volatile matter.

LOWER KITTANNING COAL.

DISTRIBUTION AND PHYSICAL PROPERTIES.

Johnstown.—Immediately about Johnstown the Lower Kittanning coal is below drainage level and the mines working it are slopes and shafts. The rise of the beds brings the coal above drainage level east of the city, and it is worked by drifts at Franklin and East Conemaugh and on Clapboard Run. It appears above drainage level for a short distance on Solomons Run. It is also above drainage level west of the city and is worked at Coopersdale, near Morrellville, and on St. Clair and Laurel runs. It has been opened on Stony Creek south of Kring.

This coal is valuable in all parts of the quadrangle, and the developments on it are important and extensive, as may be seen from the structure and economic geology map. A few of the representative sections of it near Johnstown are shown in figure 7.

The workable coal is present in a single bench ranging mainly from 3 to 3½ feet in thickness, though locally it reaches 4 feet. Below the main bench and separated from it by a few inches of shale and bone there is commonly a lower bench from 3 inches to a foot thick. This lower coal is usually not worked. Below the lower bench, or in its absence below the main bench, there is uniformly a thick bed of fire clay. In nearly all the coal mines about Johnstown the under clay is mined in addition to the coal, though of course not nearly on the same scale. The roof of the coal is hard and firm and gives no trouble whatever. There are few or no clay veins. The floor is irregular, and numerous rolls are reported, which in many places cut out the coal. These irregularities have led to much expensive dead work near Franklin and have caused the abandonment of large operations along Clapboard Run.

South Fork.—The Lower Kittanning coal lies about 160 feet below the Upper Freeport coal at the town of South Fork. It is the most extensively worked coal near the town, sustaining at present no less than thirteen large and active operations. These workings are mainly about the town but include also two small mines near Mineral Point. All the mines are located near the main line of the Pennsylvania Railroad. The coal makes its appearance above drainage level in the town and is exposed in the valley of Little Conemaugh River for most of the distance westward to Johnstown.

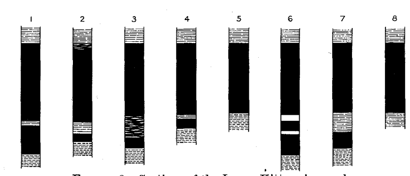

FIGURE 8.—Sections of the Lower Kittanning coal.

1. Stineman Coal and Coke Company, No. 2.
2. South Fork Coal Mining Company, No. 1.
3. Pennsylvania, Beech Creek, and Eastern Coal Company, No. 14, Nanty Glo.
4. Lincoln Coal Company, Nanty Glo.
5. Cardiff Coal Company, 5 miles north of Nanty Glo.
6. Commercial Coal Mining Company, No. 3, 1½ miles east of Twin Rocks.
7. Berwind-White Coal Mining Company, Eureka No. 37.
8. Near Walsall.

This coal has much the same section near South Fork as near Johnstown. (See fig. 8.) Its main bench averages nearly 4 feet and in some places is 5 feet thick, with no partings. The double structure, which is fairly persistent in the Johnstown district, is even more distinct about South Fork. Some of the mines, however, show it only here and there. In other physical aspects this coal resembles the Miller bed about Johnstown. The roof of dense shale or sandstone, the general absence of draw slate or clay veins, and the irregular floor are all common to the bed in both districts. The top few inches is usually bony and has to be discarded. In appearance the coal is lustrous and much of it is iridescent. Its columnar cleavage is one of its more characteristic features.

Blacklick Creek.—There has been some question as to the identity of the only coal mined along Blacklick Creek and South Branch on an extensive scale. It has been regarded by some as the equivalent of the Upper Kittanning coal of the region about Johnstown, and by others as the equivalent of the Lower Kittanning or Miller coal. The writer takes the latter view, for reasons already given in this folio. Certainly the bed as mined along Blacklick Creek and South Branch strongly resembles in its main physical features the coal in the districts to the south, as may be seen from the sections in figure 8.

The coal is made up of a main bench 3½ to 4 feet thick. Below this there may be one or two thinner benches, but in places both lower benches are absent. The second lower bench was not observed about South Fork or Johnstown but is rather persistent along Blacklick Creek. Below the lowermost bench occurs a good body of clay, not exploited in this district. The roof of the coal is very firm shale or sandstone. This fact and the irregularity of the floor, the general absence of clay layers, and the fact that it is nongaseous are points in which it is similar to the Lower Kittanning bed in the Conemaugh Valley. The coal is bright and lustrous, with a marked tendency to columnar cleavage. Analyses of this coal are given in the table above.

Windber.—The Lower Kittanning coal is worked on a large scale in all the hills about Windber, and the large operations conducted by the Berwind-White Coal Mining Company have drawn to the town between 4000 and 5000 people. The coal outcrops well down in the hills about the town, so that the operations can be conducted from the outcrop by drifts. Of the large mines now working only two are situated in the Johnstown quadrangle, namely, Eureka Nos. 37 and 40, but the character of the coal at these mines and as seen at some of the country banks to the northwest near Walsall may be regarded as typical of the coal in this district. (See sections in fig. 8.)

Little need be said regarding the physical character of the coal about Windber. The sections in figure 8 are typical as to the thickness of the main bench. The under coal is generally present and in some of the mines is remarkably uniform. There is also present a small rider, averaging 3 to 4 inches in thickness and lying 3½ to 4 feet above the main bench. In other respects the coal resembles the Lower Kittanning coal along Conemaugh and Little Conemaugh rivers.

Conemaugh Furnace.—Along the west edge of the quadrangle, in the valley of Conemaugh River, the lower part of the Allegheny formation is brought down to drainage level by the steep dips along the western flanks of the Laurel Ridge anticline. There are two commercial mines on the Lower Kittanning coal in this district, one operated by the Nineveh Coal Company and the other by the Johnstown Coal Company. The coal at these two mines is strictly comparable in every way with the corresponding coal as mined farther east near Johnstown and South Fork. It averages about 3½ feet in thickness and has the characteristic under coal and a valuable under clay that has not been worked. Its roof is strong and there are the usual rolls in the floor. (See sections in fig. 9.)

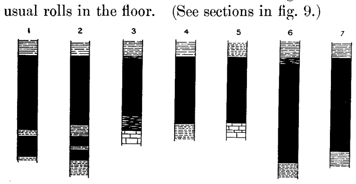

FIGURE 9.—Sections of the Lower Kittanning coal (1 and 2) and Upper Kittanning coal (3 to 7).

1. Johnstown Coal Company, north of Conemaugh River.
2. Nineveh Coal Company, near Conemaugh Furnace.
3. Robert A. Giles.
4. Abandoned bank, southern part of South Fork.
5. Somerset and Cambria Coal Company's opening, Baltimore and Ohio Railroad south of quadrangle.
6. West of Ingleside.
7. East of Walsall.

CHEMICAL PROPERTIES.

The analyses of the Lower Kittanning coal given above show that its fixed carbon ranges from 70 per cent in the sample collected at Wehrum to 78 per cent in a sample collected at South Fork. Its volatile matter ranges from 14 to 19 per cent. The moisture is low, only a few analyses showing more than 3 per cent. The ash and sulphur exhibit considerable variation, as might naturally be expected in view of the wide extent of the territory from which the samples were collected. The samples from South Fork have the lowest content in both sulphur and ash and show the excellent character of the Lower Kittanning bed in this part of the Wilmore Basin. As a steam coal it ranks among the very best coals of western Pennsylvania, the coal mined about South Fork probably equaling any other steam coal in this part of the State. As bearing on this point the table in the next column has been prepared, showing the position of the Lower Kittanning among the first 120 coals tested at the fuel-testing plant of the United States Geological Survey at St. Louis, Mo.[a]

The results of tests on the Ehrenfeld samples (Lower Kittanning), although showing a range of 9.75 to 10.42 pounds of water evaporated per pound of dry coal used, are yet, when averaged, among the very best obtained at the testing plant. Each sample submitted to the steaming test was analyzed, and the analyses in the table are averages of all that were made, as are the figures representing the efficiency of the coals as steam producers. It is of interest to note that the Ehrenfeld coal contains the largest percentage of fixed carbon and the lowest amount of volatile matter of all the samples. For the details of the conditions of these steaming tests the reader is referred to Bulletins 261 and 290.

Chemical composition and steaming values of typical Appalachian coals.

Location.	Number of tests made.	Average chemical composition.					Average pounds of water evaporated from and at 212° F. per pound of dry coal.
		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	
Page, Fayette County, W. Va.	2	4.06	30.35	61.54	4.05	0.90	10.545
Do	1	2.85	30.13	64.78	2.24	1.06	10.52
McDonald, Fayette County, W. Va.	2	2.75	20.59	70.05	6.61	.98	10.36
Big Black Mountain, Harlan County, Ky	2	5.06	34.77	56.31	3.86	.56	10.26
Rush Run, Fayette County, W. Va.	2	2.12	21.91	70.73	5.24	.67	10.195
Ehrenfeld, Cambria County, Pa.	5	2.38	16.53	74.47	6.62	.95	10.186
Winifrede, Kanawha County, W. Va	4	3.79	35.33	55.76	5.12	1.11	10.16
Acme, Kanawha County, W. Va.	4	2.93	32.66	57.64	6.77	1.23	10.115
Powellton, Fayette County, W. Va	1	3.42	31.11	59.47	6.00	.82	10.09
Near Bretz, Preston County, W. Va	3	4.20	28.05	60.86	6.89	1.28	10.07

This coal is coked, but it does not rank so high as a coking coal as it does as a steam producer. A test was made on a sample of this coal with the following results:[a]

Coking test of Lower Kittanning coal from Ehrenfeld, Pa.

[Coal finely crushed. Duration of test, 51 hours.]

Coal charged	pounds	10,000
Coke produced	do	5,223
Breeze produced	do	1,600
Coke produced	per cent	52.23
Breeze produced	do	16.00
		68.23

The coke was dull gray in color and was soft and dense. It was broken into large and small chunks, had a heavy black butt, and was hard to burn.

Analyses of coal and coke from Ehrenfeld, Pa.

	Coal.	Coke.
Moisture	3.32	0.91
Volatile matter	15.56	2.16
Fixed carbon	74.29	88.99
Ash	6.83	7.94
Sulphur	1.12	.91

The yield of coke from this test is comparatively high, but the poor quality of the coke shows that this coal does not belong among the best coking coals of western Pennsylvania and West Virginia. The coal mined at Franklin (analysis K, p. 10) is coked by the Cambria Steel Company in by-product ovens for use in the company's plant near Johnstown and gives satisfactory results, but before the coal is coked it is washed and the cost of the coke is thereby increased. Even with this additional item of cost, it is found cheaper to coke this coal on the ground than to buy coke of better quality from the Connellsville region. Tests have been made by the Cambria Steel Company with the coal mined from this bed about Ehrenfeld, and the resulting coke proved well adapted to metallurgical purposes. The yield also was satisfactory. The coal mined at Nanty Glo from this bed has been tested in beehive ovens at Gallitzin. It produced coke of good structure but of a rather dull appearance. As was to be expected, an insufficient amount of sulphur was volatilized. At Bennington this coal, like the Upper Freeport, shows a higher content of volatile matter than it does about South Fork and Johnstown. The Lackawanna Coal and Coke Company has experimented with it about Wehrum, but the washeries are now shut down and the results of the coking tests were not learned. The Vinton Colliery Company has recently completed a large by-product plant at Vintondale, and much of the coal mined from colliery No. 6 during 1907 was coked.

Besides the steaming and coking tests briefly mentioned above, many other tests have been made on the Lower Kittanning coal of the Johnstown quadrangle. These include producer-gas, washing, float-and-sink, briquetting, and cupola tests. The details connected with these tests and their results are given at length in the forthcoming bulletin on the mineral resources of the quadrangle and will not be considered here.

MIDDLE KITTANNING COAL.

As a rule the Middle Kittanning coal is not workable in this district, though it is very persistent and hence serves as an additional check on the identity of the beds above and below. It has been opened at Coopersdale, where it is about 25 feet above the Lower Kittanning coal at the brick plant of A. J. Haws & Sons (Limited) and shows a thickness of 30 inches, with more concealed. It is also of workable thickness at the head of Solomons Run. Though it is locally workable about Johnstown it can not be classed among the future commercial coals of the Johnstown district.

A little more than 100 feet below the Lower Freeport or D bed and about 50 feet above the Lower Kittanning coal occurs a coal which is fairly persistent along Blacklick Creek and South Branch. It has been called the Middle Kittanning simply because it is the first bed above the Lower Kittanning coal. It has been seen about Nanty Glo, Twin Rocks, and Vintondale; at Vintondale a section showed 33 inches of coal with a thin parting of shale near its base.

UPPER KITTANNING COAL.

DISTRIBUTION AND PHYSICAL PROPERTIES.

Johnstown.—The Upper Kittanning coal, also called the "cement" coal, outcrops at a height above drainage level that is convenient for exploitation at practically all points about Johnstown. West of the city the operations of the Cambria Steel Company in the Rolling Mill mine have been pushed westward in Upper Yoder Township beyond Mill Creek, and the coal has showed no indication of becoming too thin to work. Where observed along Bens Creek in Somerset County it is also of workable thickness. The westward dips toward the Johnstown Basin carry this bed below drainage level less than a mile east of the Baltimore and Ohio Railroad tunnel south of Moxhom.

This coal is the most extensively exploited of all the beds in this district. It is worked on a commercial scale from Franklin as far west as Coopersdale and to the south beyond Moxhom. Many small operations are conducted along Solomons and Sams runs. The mines in operation about Johnstown are noted on the accompanying economic map. One of these mines—the Rolling Mill mine of the Cambria Steel Company—is the largest in the area and one of the largest in the State, having a daily output of about 3000 tons.

The thickness of this coal may be seen from the sections in figure 10. The bed varies somewhat in thickness about Johnstown but contains on an average between 3 and 3½ feet of coal. It rarely exceeds 4 feet, and at a few mines less than 3 feet has been measured. South of the city it is thicker, and along Stony Creek, on the Baltimore and Ohio Railroad, the sections show on an average about 5 feet of coal. This thick coal continues southward to the Windber district. There is generally a thin bony streak at the top of this bed that is discarded in mining, and locally a few inches of bone at the bottom; but the rest of the bed is good clean coal, generally of uniform quality throughout. In a few mines the upper foot is reported to be soft and the lower foot harder than the average. The roof of the coal is very dense shale or sandy shale and sandstone and gives no trouble whatever. The floor is generally a few inches of firm shale, closely underlain by the bed of limestone that has been mentioned as suitable for making cement. The coal is remarkably uniform and few rolls are reported. Clay veins are, however, rather numerous and occasionally considerable annoyance is caused by gas, necessitating the use of safety lamps.

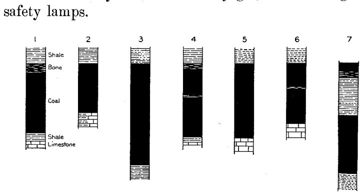

FIGURE 10.—Sections of the Upper Kittanning coal.

1. Cambria Steel Company's Rolling Mill mine.
2. E. W. Fuge, Cambria.
3. Valley Coal and Stone Company's mine.
4. Sunnyside Coal Company, between Dale and Moxhom.
5. Mertz & Miller, Walnut Grove.
6. Caddy mine.
7. William McAuliff, Bens Creek, near confluence of North and South forks.

South Fork.—The coal known as the "cement" bed about South Fork probably corresponds to the Upper Kittanning or "cement" bed of Johnstown. It has been opened by H. C. Stineman and O. M. Stineman west of the town and by Charles Hutzel and R. A. Giles in the town itself. The coal ranges from 3 to 3½ feet in thickness, generally without any partings, and has a hard shale roof, which gives no trouble. A few inches below the coal lies 3 feet or more of limestone. The third and fourth sections in figure 9 show the character of the coal in and near South Fork. The coal is bright, lustrous, and of good quality; though the single analysis E shows it to be on a par with the Upper Kittanning bed in the Johnstown Basin, its general reputation is not so good.

Windber.—The Upper Kittanning coal near Windber lies practically midway between the Upper Freeport and Lower Kittanning beds. This is one of the valuable coals near Windber, and though not yet worked commercially it promises to rival in importance the Lower Kittanning or Miller bed. As stated with reference to this coal in the Johnstown Basin, on Stony Creek south of Moxhom it is thicker. The uncommon thickness of 5 to 6 feet prevails generally north of Windber, as shown in figure 9. The coal where measured shows a clear face 4½ to 6 feet thick, with a firm shale roof. To judge from the appearance of the coal, its quality is equal to that of the coal mined from this bed about Johnstown.

CHEMICAL PROPERTIES.

The Upper Kittanning coal has a high standing near Johnstown, South Fork, and Windber. As a steaming coal it is probably equal, if not superior, to any other coal in the Johnstown Basin, and the recent demand for it in the market has

[a] Bull. U. S. Geol. Survey Nos. 261, 1905, and 290, 1906.

[a] Bull. U. S. Geol. Survey No. 290, 1906, p. 181.

been greater than the supply. The six analyses given above, lettered E to J, show a high-carbon coal with correspondingly low volatile matter. The moisture is low, but the ash and sulphur are rather high. The coal mined from this bed at Franklin mine No. 1 of the Cambria Steel Company is washed and coked at the Franklin plant. It makes a coke of good grade, but owing to its low volatile matter it is not considered so well adapted for beehive ovens as some of the richer gas coals of the districts farther west. When the cost of shipping coke from the region about Connellsville and Pittsburg is considered it is found cheaper to wash and coke this coal on the ground than to obtain coke from that region.

LOWER FREEPORT COAL.

DISTRIBUTION AND PHYSICAL PROPERTIES.

Johnstown.—The Lower Freeport coal is known as the "limestone" coal about Johnstown. It has been prospected at many points about the city and its suburbs but is not mined at present. The most promising outcrops were observed along Stony Creek from the vicinity of the Valley Coal and Stone Company's mine northward to Roxbury.

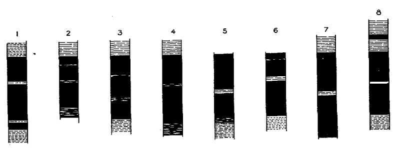

FIGURE 11.—Sections of the Lower Freeport coal (1 to 5) and Upper Freeport coal (6 to 8).

1. Natural exposure south of Kernville.
2. Dale.
3. Mardis Run, off northwest corner of quadrangle.
4. Road south of Twin Rocks.
5. Ivory Hill Coal Mining Company, Nanty Glo.
6. O M. Stineman, No. 3.
7. Pennsylvania, Beech Creek, and Eastern Coal Company's colliery No. 8.
8. South Fork Coal Mining Company, No. 2.

In this region the first two sections in figure 11 were measured. From these sections it is evident that the coal occurs in three distinct benches, separated by thin shale and bone partings. The upper bench averages about a foot thick and the middle bench about 2 feet. Possibly in the commercial development of this bed only these two benches will be worked, and the underlying coal and bone will serve as a floor. It may be said, therefore, that from 2½ to 3 feet of good coal is present. Immediately over the coal is generally a few inches of bone and black shale, overlain by either sandy shale or massive sandstone.

Blacklick Creek.—Along Blacklick Creek and South Branch a coal bed of workable thickness is present about 150 feet above the Lower Kittanning coal. The interval between these two coals is exceptionally uniform. It has been measured at Nanty Glo and Vintondale and is reported by the engineer of the collieries situated at Twin Rocks to be the same at that place. At Wehrum certain of the diamond-drill records show a coal at about the same interval above the Lower Kittanning bed. A few sections of this upper bed, which is presumably the Lower Freeport or D coal, are given in figure 11.

The bed has generally two benches, separated by a small bone parting, and the coal is altogether from 3 to 3½ feet thick. The presence of the parting has been a drawback to operations on this bed, but in the future the coal will probably be worked. If proper care is exercised in separating the thin bony parting it should be readily marketed.

Windber.—The Lower Freeport is fairly persistent in the hills north of Windber, but little is known about it except from data furnished by drillings. Some of the records from points northeast of Windber show it to be 3 feet thick in places, but others show less promising sections. This coal may possibly be valuable in the future near Windber, but the data obtained are insufficient to afford a basis for a positive opinion.

CHEMICAL PROPERTIES.

In the sample of the Lower Freeport coal collected near Johnstown, the analysis of which is given in the foregoing table, the clay partings were not included, as these will be discarded when the coal is worked on a commercial scale. The percentage of carbon is high and comparable with the percentage in other coals in the district. The moisture is not representative, as the material was procured near the outcrop. The ash runs rather high, but not above the average of the coals of the quadrangle. The coal from this bed is not considered good in the region about Johnstown, but the analysis of the sample collected near Stony Creek indicates that in this locality, where the coal is persistent and of workable thickness, it may be of some commercial importance.

UPPER FREEPORT COAL.

PHYSICAL PROPERTIES.

Johnstown.—To obtain an idea of the thickness of the Upper Freeport coal near Johnstown the sections in figure 12 should be studied. These are average sections and show a main bench 3 to 3½ feet thick, with a lower bench of half an inch to 6 inches, separated by a bone and shale parting 1 to 6 inches thick. The lower bench is not invariably present and in places it it is bony in character. Only the main bench is worked and the bone and shale below it may be regarded as a floor. As a rule no partings were noted in the main bench in this district. It thus differs markedly from the equivalent bed about South Fork. The maximum thickness does not exceed 4 feet; the minimum is about 2 feet and is caused by rolls, but these are extremely rare and the coal is notably uniform. There are few or no clay layers. The roof is generally shaly but is firm, and little or no typical draw slate was reported. At one or two abandoned banks gas was reported, and also in some of the older workings in one of the larger mines; it is nonexplosive and may be carbon dioxide.

South Fork.—The highest workable coal near South Fork is the Upper Freeport. It has been opened by the Pennsylvania, Beech Creek, and Eastern Coal Company at Ehrenfeld and by the South Fork Coal Company and H. C. Stineman near South Fork. Its physical character may be seen from sections 6 to 8 in figure 11 and from the sections shown in figure 12.

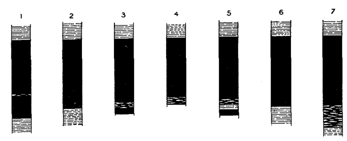

FIGURE 12.—Sections of the Upper Freeport coal.

1. Louis Eppley, Hinckston Run above Rosedale.
2. Charles Umbarger, head of Solomons Run.
3. William Davis, Frankstown road.
4. Country bank, Sams Run just above opening of Highland Coal and Coke Company's mine.
5. Ferndale Coal Company.
6. Natural exposure along trolley line opposite Valley Coal and Stone Company's mine.
7. South portal of Baltimore and Ohio Railroad tunnel south of Johnstown.

The bed consists of two benches or in places of three, of which only the two lower are workable, and in this respect it differs essentially from the same coal near Johnstown. About Ehrenfeld only two benches were observed. The upper of the workable benches ranges in thickness from 1 foot to 2 feet and the lower from 1½ to 2 feet. The bone or shale parting between the two main benches ranges from one-half inch to 2 inches. It is very persistent in this district and is also generally present in this bed along the southeast margin of the Wilmore Basin.

Windber.—The Upper Freeport coal outcrops in all the hills surrounding Windber. It lies about 170 to 180 feet above the Lower Kittanning coal in the hills near No. 37 mine, and this interval continues fairly uniform as far east as Elton, where drillings show it to be about 175 feet. Still farther northeast, toward South Fork of Little Conemaugh River, the interval increases to 200 feet. Little definite information regarding this coal was obtainable in this district, as no openings were found. It is persistent, however, and may be of workable thickness.

CHEMICAL PROPERTIES.

The Upper Freeport coal is used as a domestic and steam fuel about Johnstown and South Fork, supplying also some of the brick plants at the former city. The coal from this bed is used almost exclusively for steaming purposes. It gives satisfactory results, particularly when used for generating steam in locomotives. It is not used for coking purposes in this region, but at Cresson, Gallitzin, and Bennington it is coked with satisfactory results in beehive ovens. In the by-product ovens of the Cambria Steel Company at Franklin, near Johnstown, it was found to be unsuitable, owing to expansion, which quickly ruined the ovens and made it very difficult to force out the charge after it was coked. The analyses of this coal, as given in the table on page 10, show it to be a high-carbon coal with very low moisture. The ash is high, especially in the first two samples collected in the Johnstown Basin. Its sulphur content, ranging from 2 to 2½ per cent, is also rather high.

CLAY AND SHALE.

INTRODUCTION.

The clay materials of the quadrangle include flint clays, plastic clays (including some fire clays), and shales.

Under the heading "Stratigraphy" the formations of the quadrangle have been described in detail, including the beds in which the workable or potentially workable shale and clay beds are found. Reference should be made to these preliminary descriptions for explanation of many of the names that are here applied to the beds containing the clays and employed in describing them. For the distribution of the clay beds which are regarded as of economic importance, the reader is referred to the structure and economic geology map in this folio.

FLINT CLAYS.

FLINT CLAY IN THE MERCER SHALE MEMBER.

The most important flint clay in the Johnstown quadrangle is that occurring in the Mercer member in the hills about South Fork, where it is associated with plastic clay. It has been worked at points south of the Pennsylvania Railroad from South Fork westward beyond Mineral Point, and also at a few places north of the railroad. The clay is present in the hills along Little Conemaugh River in an area extending as far west as a point about 1 mile east of Conemaugh station. The outcrop is continuous, except where the local dips and changes in direction carry it below drainage level. The flinty phase may not be present everywhere between Mineral Point and East Conemaugh. For example, the clay observed at this horizon in the tunnel of the old Portage Railroad is not particularly flinty. From Mineral Point to South Fork, however, the flinty character is persistent.

This flint clay is now worked by the Garfield Fire Clay Company near the viaduct and by J. H. Wickes and the South Fork Fire Brick Company west of South Fork. The following section was measured at Mr. Wickes's mine:

Section of fire clay at J. H. Wickes's mine, South Fork.

	Ft.	in.
Heavy sandstone roof.		
Plastic clay	3	6
Coal		⅛–2
Flint clay	4	6
Sandstone.		

A sample of the flint clay collected at the Wickes mine was analyzed by A. J. Phillips at the testing laboratory of the United States Geological Survey at St. Louis, with the following results:

Ultimate and rational analyses of flint clay from the Mercer shale member near South Fork.

Ultimate analysis:	
Silica (SiO_2)	44.30
Alumina (Al_2O_3)	38.31
Ferric oxide (Fe_2O_3)	1.40
Manganese oxide (MnO)	.10
Lime (CaO)	.82
Magnesia (MgO)	.59
Sulphuric anhydride (SO_3)	Trace.
Ferrous oxide (FeO)	.71
Alkalies (Na_2O)	.22
Alkalies (K_2O)	.17
Water at 100° C.	.75
Ignition loss	12.77
	100.14
Rational analysis:	
Free alumina	3.88
Clay substance	93.26
Feldspathic substance	2.86
	100.00

The analysis indicates a clay of high grade, containing more than 97 per cent of clay substance and free alumina. The amount of feldspathic fusible material is very small. The clay is smooth, hard, and compact and is light to dark gray in color. It burns to a straw-yellow.

The clay mined at South Fork is in part shipped to Johnstown and in part mixed with the plastic clay found below the Lower Kittanning coal and worked up at the local brick plant. Some of the products of this flint clay have been tested as to their refractory character at the plant of the Cambria Steel Company at Johnstown and have proved highly satisfactory.

FLINT CLAY ON MARDIS RUN.

A flint clay occurring a few feet below what is regarded as the Lower Freeport coal was seen at a few places in the valley of Mardis Run, near the northwestern border of the quadrangle. Two feet of clay was observed at one point on the outcrop, and the bed may possibly be thicker. The clay is too remote from railways to be of commercial value at the present time.

FLINT CLAY NEAR WEHRUM AND JOHNSTOWN.

The highest flint clay in the quadrangle occurs in the Conemaugh formation and ranges from 50 to 100 feet above the Upper Freeport coal. It usually occurs very close to the Mahoning coal in the hills immediately about Johnstown, and its distance above the Upper Freeport coal is therefore nearer 50 to 75 feet than 100 feet. A flint clay in a similar position with reference to the top of the Allegheny formation was seen in the Blacklick Creek district near Wehrum. This clay, which at many points is as much as 7 feet thick, is correlated with the flint clay near Johnstown, just mentioned.

Flint clay occurs persistently at but one horizon in the Johnstown district. This horizon is at or just above the lower sandstone of the Mahoning member, and in the hills surrounding the city it is 50 to 70 feet above the Upper Freeport or Coke Yard coal. Though fairly well distributed in favorable locations for easy exploitation, this clay is, so far as known, worked only by the Johnstown Pressed Brick Company at its plant on a hill east of the city. A section of the rocks in the hill (see p. 13) will show the position of this clay and its relation to the underlying coal, which is at the top of the Allegheny formation.

Fragments of flint clay have been seen in several localities near Johnstown. On the road ascending Shingle Run, in Dale borough, east of Johnstown, more than 2 feet of flint clay associated with shale was measured 60 feet above the bloom of the Upper Freeport coal. An old prospect hole on this flint clay was seen on the road leading to Grandview Cemetery. Here the clay was about 65 feet above the Upper Freeport coal, had a light straw color, and appeared to be of good quality. On the Ferndale-Johnstown road, a short distance north of the Eighth Ward mine of the Citizens Coal Company, an abundance of flinty clay débris occurs above the road near the top of the massive Mahoning sandstone member. In the hill above the Baltimore and Ohio Railroad tunnel east of Island Park, on the new county road, some flint clay was observed about 40 feet above the Upper Freeport coal and near the top of the lower sandstone of the Mahoning member. Northwest of Johnstown, in the hills bordering Laurel Run and its branches on the east, a short distance east of the old coke yard from which the Upper Freeport gets its local name, this flint clay is exposed, indicating a probable continuity of the bed as far west as the valley of Laurel Run. Here again the flint clay is about 50 feet above the Upper Freeport coal. Northwest of Johnstown, on the road ascending Pleasant Hill from the valley of Conemaugh River, a flint clay occurs about 110 feet above the Upper Freeport coal and 10 feet below a smaller bed of coal. This smaller bed of coal may possibly be higher stratigraphically than the seam 70 feet above the Upper Freeport at the Baltimore and Ohio tunnel near Island Park. If so, the flint clay of Pleasant Hill is higher than that previously described and there are two flint-clay horizons in the 100 feet at the base of the Conemaugh formation. At the southern border of the quadrangle in Somerset County, in the hills bordering Stony Creek, the same flint clay has been observed.

Section of lower part of Conemaugh formation in hill east of Johnstown.

	Ft.	In.
Concealed, and sandstone from top of hill	91	
Shale	10	
Black shale	5	
Brick-red shale	40	
Concealed, but probably shale	25	
Dull-olive shale, weathering reddish[a]	25	
Olive to red shales	5	
Dark olive green shale, slightly gritty, with iron oxide and manganese oxide on the bedding planes[a]	13-15	
Laminated sandstone	15	
Shale	30	
Concealed, but with a sandstone in its upper part	42	
Flint clay[a]	?	
Shale	?	
Ferruginous shale	10	
Green concretionary shale	10	
Irregularly bedded shale	5	
Sandy shale	8	
Massive sandstone (Mahoning member)	25	
Concealed	12	
Coal } Upper Freeport or Coke Yard coal	3	6
Bone }		5

Should the clay after careful prospecting prove to be present in sufficient quantity and of such quality as to justify its exploitation at the localities described above, it could be marketed, as most of these localities are conveniently situated with respect to transportation. Deposits of this clay too far removed from market and railroads to have commercial value have also been observed on the headwaters of Mill Creek and Dalton Run.

It should be added that the occurrences noted above are largely roadside outcrops, at which it is impossible to determine the exact thickness and nature of the clays. Only careful prospecting can determine these points, but the fact that one of the flint clays is being exploited at one place is significant.

The flint clay in the Blacklick Creek district occurs at two horizons. The higher flint clay is found in the lower part of the Conemaugh formation, above what is thought to be the equivalent of the upper sandstone of the Mahoning member and a few feet below a small coal bed, possibly the Gallitzin coal. This flint clay has been observed in many places north, west, and south of Wehrum, but the rise of the beds toward the east gradually increases its distance from the valley and from railroads and finally results in its disappearance from the hills. West of Wehrum, however, it occurs at many points both north and south of Blacklick Creek, in places having the common thickness of 7 to 8 feet. It is a typical flint clay in appearance, though its content of iron oxide seems to be very high. A sample collected from a roadside exposure west of Dilltown gave the following analysis:

Partial analysis of flint clay from a natural exposure west of Dilltown.

[E. C. Sullivan, analyst.]

Silica (SiO_2)	50.3
Alumina (Al_2O_3)	21.3
Ferric oxide (Fe_2O_3)[b]	10.4
Magnesia (MgO)	.61
Lime (CaO)	.39
Soda (Na_2O)	.18
Potash (K_2O)	1.14
Titanium oxide (TiO_2)	.90
Loss on ignition	12.00
	97.22

The percentage of fluxing materials, principally iron oxide, indicated in this analysis is so high as to prohibit the practical use of the clay.

[a] Beds worked for brick material.

[b] Total iron calculated as Fe_2O_3.

Johnstown.

PLASTIC CLAYS.

PLASTIC CLAY NEAR JOHNSTOWN.

The lowest plastic clays near Johnstown occur in the Mercer shale member of the Pottsville formation. The clay is not exposed immediately about the city. In the hills lying east of Stony Creek south of Kring, on the Baltimore and Ohio Railroad, this member has been prospected and some clay and shale have been found, but they have never been worked. At one exposure of the Mercer south of the quadrangle, on the west flank of the Ebensburg anticlinal axis, more than 11 feet of clays and shales were measured. Flint clay was not observed in connection with the Mercer at any of the old prospect pits.

The most valuable clay in the Allegheny formation is that underlying the Lower Kittanning or Miller coal. Many of the mines working this coal around Johnstown produce also considerable amounts of the clay. The clay bed in this district ranges from less than 3 to about 6 feet in thickness, but locally it may be even thicker. It generally underlies the lower bench of the Lower Kittanning coal, from which it is separated by a few inches of shale; in the absence of the lower bench it occurs below the main coal itself and is separated from it by about 3 to 4 inches of bone or shale. It is a light-drab clay, not very hard, of irregular fracture, and greasy to the touch, and slakes on exposure to the weather. Its composition is indicated by the following analyses:

Analyses of clay underlying the Lower Kittanning coal seam.

	1.	2.	3.	4.
Silica (SiO_2)	65.90	66.40	53.10	68.82
Alumina (Al_2O_3)	20.30	19.80	27.80	20.85
Ferric oxide (Fe_2O_3)	[a]1.60	[a]1.68	[a]3.08	2.79
Magnesia (MgO)	.66	.61	.60	.23
Lime (CaO)	.09	.10	.22	.82
Soda (Na_2O)	.34	.30	.48	
Potash (K_2O)	2.98	3.24	3.58	
Titanium oxide (TiO_2)	1.20	1.00	1.20	
Manganese oxide (MnO)				.66
Loss on ignition	6.50	6.40	10.20	5.83
	99.57	99.53	100.26	100.00

[a] Total iron calculated as Fe_2O_3.

1. Citizens Coal Company's Green Hill mine, Johnstown; E. C. Sullivan, analyst.
2. A. J. Haws & Sons' (Limited) mine, near the stone bridge, Johnstown; E. C. Sullivan, analyst.
3. Seward Coal Company's mine, Seward, Westmoreland County, Pa.; E. C. Sullivan, analyst.
4. Clay underlying the Lower Kittanning seam at Johnstown; T. T. Morrell, analyst, Rept. H2, Second Geol. Survey Pennsylvania, p. 148.

This clay is worked by W. J. Williams at Kernville, near Johnstown. Below the coal at the Kernville mine there is a shale layer of varying thickness, about 2 to 6 inches in places, below which is from 3 to 5 feet of plastic clay. The clay is mined and used at one of the local brickyards. At the Green Hill mine of the Citizens Coal Company the average thickness of the underlying clay is 5 feet. This also is shipped to a local brick plant. The clay underlying the Lower Kittanning coal is also mined by A. J. Haws & Sons (Limited) at their shaft near the famous stone bridge in Johnstown and to the west at Coopersdale. In the shaft workings the clay averages nearly 3 feet thick; that is, so much of it is worked. At Coopersdale it averages 3½ feet in thickness but locally reaches 5 feet. It was observed in the mine that where the clay was thickest the coal appeared in a single bench, with its lower 4 or 5 inches bony. At both the Haws mines the Lower Kittanning coal is mined with the clay and is used as the fuel to burn the brick at the brick plants situated at the mine mouths. The clay is also mined by Robertson & Griffith on St. Clair Run in connection with the overlying coal.

Nearly all the product of the Johnstown clay mines is used at local brick plants, where it is mixed with flint clay from the Mercer shale member, shipped chiefly from South Fork and Dean station. It forms a suitable bond in this mixture, which is used in the manufacture of high-grade refractory products and bricks for blast-furnace and open-hearth work, and in making sleeves, nozzles, tuyères, and other articles exposed to high temperatures. In the most refractory products nothing but flint clay is used.

A clay bed underlies the Johnstown limestone member, which lies near or just below the base of the Upper Kittanning or "cement" coal. This clay has been worked near Johnstown, but it is not now exploited. It is referred to in the report on this district by F. Platt and W. G. Platt[a] as having been developed by Mr. Haws, of Johnstown. The clay was analyzed by T. T. Morrell,[a] with the following results:

Analysis of clay occurring below the Johnstown limestone member.

Silica (SiO_2)	71.98
Alumina (Al_2O_3)	26.29
Ferric oxide (Fe_2O_3)	2.21
Magnesia (MgO)	.44
Manganese dioxide (MnO_2)	.32
	101.24

[a] Rept. H2, Second Geol. Survey Pennsylvania, 1875, p. 148.

PLASTIC CLAY NEAR SOUTH FORK.

The plastic clay associated with the Lower Kittanning coal is usually workable near South Fork, at some places having a thickness of 6 to 8 feet but averaging about 3 to 4 feet of workable clay of good grade. A brief note on the character of this clay in the Johnstown district, with analyses, is given above. There is every reason to suppose that in the South Fork district it is of the same quality as the clay mined about Johnstown. Most of the clay product of the mines about South Fork is mined in connection with the coal and is used almost entirely at the local brick plant.

PLASTIC CLAY ON BLACKLICK CREEK.

The coal that is being extensively worked in the valley of Blacklick Creek is regarded as the equivalent of the Lower Kittanning, Miller, or B bed of the Johnstown and South Fork districts. In the Blacklick Creek district, as well as along Conemaugh River, this coal is underlain by a promising clay bed. This clay is not exploited at present, and no certain measurement of its thickness was obtained. At many of the mines 2 feet or more of good clay was seen, comparable, in appearance at least, with that in the Johnstown district.

SHALE.

SHALE NEAR JOHNSTOWN.

The lowest promising shale zone near Johnstown is associated with the Mercer coal. The prospect pits on the Baltimore and Ohio Railroad south of Kring station show the presence of dark shale at this horizon. North of Sheridan the Mercer member is thick, and the shale is worked in connection with the overlying Pleistocene clays at the quarry of Bruce H. Campbell. The shale bed worked is 20 feet thick, dark brown to drab in color, somewhat sandy, and concretionary. This shale is mixed with the overlying clay, and the mixture is used in making a buff or red building brick, the color depending on the proportions of shale and clay used. The beds worked at this quarry rise abruptly toward the west at a rate that within a short distance carries the horizon of the Mercer and its shale over the tops of the hills.

A sample of shale was collected from this quarry. The sample was taken from the entire width of the exposure and then mixed with the overlying clay in the proportion of two parts of shale to one of clay. The sample was analyzed by P. H. Bates, of the structural-materials laboratory of the Survey at St. Louis, with the following results:

Analysis of shale and clay from Mercer shale member, B. H. Campbell quarry north of Sheridan.

Ultimate analysis:	
Silica (SiO_2)	62.86
Alumina (Al_2O_3)	18.85
Ferric oxide (Fe_2O_3)	5.19
Manganese oxide (MnO)	.37
Lime (CaO)	1.42
Magnesia (MgO)	.98
Sulphuric anhydride (SO_3)	.11
Alkalies { Na_2O	.06
Alkalies { K_2O	2.59
Water at 100° C	2.27
Ignition loss	5.45
	100.15
Rational analysis:	
Free silica	27.70
Clay substance	56.41
Feldspathic substance	15.89
	100.00

The most important shale beds about Johnstown are within the lower 300 feet of the Conemaugh formation. Some of these are worked in the hill along the Frankstown road east of the city. From a horizon about 50 feet above the top of the Upper Freeport coal to the top of the hill numerous promising beds of shale are exposed. Most of the shale beds lying between 165 and 210 feet above the Upper Freeport or Coke Yard coal are being worked by the Johnstown Pressed Brick Company into a building brick of good grade, of both the buff and red varieties. The fuel used in burning the brick is obtained from the Upper Freeport coal, which the company works in the same hill. The shales are ground so as to pass through a 12-mesh sieve, or to a size to make them "ball." From the grinder the material is hoisted by a bucket-belt conveyor to the sieve, thence going through a hopper to the pans, after which it is pressed into brick, the dry-press process being used.

The composition of the shale employed is indicated by the analyses on page 14. The shale was first air dried, and the air-dried shale was then fused by the usual method.

In Prospect Hill, north of Johnstown, the Cambria Steel Company has quarried shales lying about 80 to 100 feet above the Upper Freeport coal and has utilized them in connection with the overlying surface clay in the manufacture of red building brick of good quality. The brick plant of the company is at Cambria.

The geologic structure close to Johnstown is such that the beds lie fairly flat and the lower few hundred feet of the Conemaugh formation is exposed. Sections obtained in the hills around the city and along the Pennsylvania Railroad to the west indicate that the lower part of this formation is of prevailingly shaly character, similar to that of beds seen in the hill to the east. It is therefore probable that a great deal of brickmaking material exists in these hills which has never been tested. Though all this shale may not be of as high grade as that worked by the Johnstown Pressed Brick Company, some of it probably is and much of it may be suitable for paving brick, sewer pipe, fireproofing of various sorts, and other rough material. All the shale in the hills about the city and to the west is fairly accessible to railroads, and cheap fuel is assured by the presence of valuable coal beds 300 feet or more below.

Analyses of shale from lower part of Conemaugh formation east of Johnstown.

	1.	2.
Ultimate analysis:		
Silica (SiO_2)	51.32	64.29
Alumina (Al_2O_3)	24.39	17.95
Ferric oxide (Fe_2O_3)	6.94	5.74
Manganese oxide (MnO)	.14	Trace.
Lime (CaO)	.70	.46
Magnesia (MgO)	1.73	1.30
Sulphuric anhydride (SO_3)	Trace.	Trace.
Ferrous oxide (FeO)	1.43	1.64
Alkalies { Na_2O	.23	.35
Alkalies { K_2O	1.09	1.80
Water at 100° C	.92	.95
Ignition loss	11.32	5.44
	100.21	99.92
Rational analysis:		
Free silica	10.09	28.54
Clay substance	81.51	57.85
Feldspathic substance	8.40	13.61
	100.00	100.00

1. Sample collected from upper shale bed; see section, page 13. Analysis made at the structural-materials laboratory of the United States Geological Survey at St. Louis; A. J. Phillips, analyst.
2. Sample collected from lower shale bed; see section, page 13. Analysis made at the structural-materials laboratory of the United States Geological Survey at St. Louis; P. H. Bates, analyst.

SHALE NEAR SOUTH FORK.

The shales in the South Fork district are not known to have been utilized. In the two large cuts west of Wilmore, on the main line of the Pennsylvania Railroad, shale beds are exposed that vary in position from 400 to 675 feet above the Upper Freeport coal. These beds contain many promising shales, which are found in the surrounding hills, conveniently situated with respect to railroads. Their appearance indicates that they may be adapted to the manufacture of paving brick and other materials that require only an inferior grade of clay or shale. To determine their fitness for any purpose, however, practical tests must be made. In a recent cut opposite Ehrenfeld station, along the new county road, a bed of shale 50 to 60 feet thick, lying 60 feet above the Upper Freeport coal, also appears to be promising.

LIMESTONE AND CEMENT MATERIALS.

Of the limestones in the Johnstown quadrangle, only those of the Allegheny formation are important. They are three in number—the Johnstown limestone member, the Lower Freeport limestone member, and the Upper Freeport limestone member.

JOHNSTOWN LIMESTONE MEMBER.

The limestone occurring below the Upper Kittanning or "cement" coal is commonly known as the "Johnstown cement bed." It is best developed along Stony Creek and may be seen to advantage on the Baltimore and Ohio Railroad north of Kring station. It is here 6 feet thick and is separated from the coal by about 8 to 12 inches of shale. Along the spur track leading from the north end of the Baltimore and Ohio tunnel to the mine of the Valley Coal and Stone Company it is also conspicuous, but slightly thinner. The bed is nearly 8½ feet thick near Conemaugh station and nearly 5 feet thick in the section along the Pennsylvania Railroad to the west near Johnstown station. To the east on Little Conemaugh River it is exposed just at the northwest apex of the first big meander. It must be thick in all the intermediate territory. Its outcrop along Stony Creek near the Rolling Mill mine of the Cambria Steel Company is also conspicuous. Northwest of Johnstown near the old Cambria furnace and at the east base of Laurel Hill it outcrops and shows just above the waters of Laurel Run. Here it is a bluish limestone with some streaks of calcite. It is present but not very thick near South Fork, and is also reported near Scalp Level, just across the quadrangle border.

LOWER FREEPORT LIMESTONE MEMBER.

The Lower Freeport limestone member occurs either directly below or within a foot of the base of the Lower Freeport coal, the separating beds as a rule being black shale. It varies from 1½ to nearly 4 feet in thickness, and the best exposures seen in the quadrangle occur along Stony Creek and the Baltimore and Ohio Railroad between Moxhom and the mine of the Valley Coal and Stone Company. This limestone has never been used in any way.

UPPER FREEPORT LIMESTONE MEMBER.

The Upper Freeport limestone member appears in the section only near South Fork and Ehrenfeld. A short distance east of Ehrenfeld station it is exposed in some recent excavations along the main line of the Pennsylvania Railroad, where it ranges from 1½ to 3 feet in thickness. It is a gray limestone, and at Ehrenfeld it is very irregularly bedded. It lies a short distance below the Upper Freeport coal, from which it is separated by about 2 feet of clay containing limestone nodules in its lower half. So far as known, this particular limestone has never been used in this quadrangle.

LIMESTONE OF THE CONEMAUGH FORMATION.

The limestones of the Conemaugh formation are of no importance whatever commercially and have never been used except on a small scale for fertilizing.

BUILDING STONE, PAVING BLOCKS, AND CONCRETE MATERIALS.

The only rock suitable for building stone in the Johnstown quadrangle is sandstone; of this rock there is locally a great abundance. As a rule this building stone will not bear the cost of very distant shipment. As a local building stone it has proved of great value in the construction of culverts, bridges, etc., along the Pennsylvania Railroad and of a few dwellings. The gate at the entrance to Grandview cemetery, Johnstown, is an example of the application of the local rock for construction.

The sandstones of the Conemaugh formation have been used in certain parts of the quadrangle in the construction of dwellings. In the northeastern part of the quadrangle the Ebensburg sandstone member has been so used with very satisfactory results. In the hills about Johnstown the Mahoning sandstone member is exceedingly massive in places and is capable of furnishing dimension stone of sizes suitable for the foundations of houses and for culverts, bridges, chimneys, etc. A great deal of this sandstone has been quarried from the outcrops, especially in the hills east of the city, and used for these purposes.

The Pottsville formation is made up almost entirely of sandstone. This sandstone has been quarried along the main line of the Pennsylvania Railroad and used in construction and in the manufacture of concrete. The Conemaugh Stone Company formerly quarried sandstone for use in construction along the Pennsylvania Railroad from its quarry on the south side of Conemaugh River a few miles southeast of Conemaugh Furnace. This formation outcrops along the Pennsylvania Railroad also near South Fork and Mineral Point and east of Johnstown and on the Baltimore and Ohio Railroad near Paint Creek and farther south. The sandstone in most of these localities is a pure coarse-grained or gritty rock, usually weathering to a gray or a gray-white, so that the weathered rock has a pleasing appearance. After cutting it seasons rapidly and firmly and withstands the eroding action of the elements, so that it has great value as a building stone.

West of Coopersdale the sandstone of the Pottsville formation is quarried and crushed for use in the manufacture of concrete. The quarry is owned by A. B. Cooper. It is located a few hundred feet above the tracks of the Pennsylvania Railroad on the north side of the river. The sandstone is a very pure one, decidedly coarse grained to gritty in texture. It is blasted out without much regard to the size or shape of the product, as the fragments are required to be as small as possible. The larger pieces are broken up and the stone is removed to the mill, which is located on the railroad, by means of small cars moving on an inclined plane and controlled by a stationary engine at its foot. The sandstone after removal to the mill is crushed by two crushers having capacities of 100 and 300 tons per day of ten hours. After removal from the crushers it is conveyed to a wet pan, in which it is further reduced in size, and thence it is passed through screens of the proper size. From the screens it is taken by a bucket conveyor directly to the cars.

Another rock which is used in the manufacture of concrete is the Loyalhanna limestone member, at the top of the Pocono formation. It is about 45 feet thick in the Johnstown quadrangle. It is not a true limestone but rather a sandy limestone. It weathers in a peculiar and characteristic way. This siliceous limestone is quarried and split into paving blocks, which give satisfaction. The crushed material is also used for ballast in railroad beds. For both uses it is well adapted, as the calcareous portion of the rock on solution and recrystallization tends to bind the fragments solidly together and yet leaves sufficient space between them to allow the free circulation of water.

The siliceous limestone exposed near the viaduct between Mineral Point and South Fork has also been quarried for paving blocks.

GLASS SAND.

The question has been raised whether the pure sandstone occurring in the Pottsville formation in the Johnstown quadrangle might not be used in the manufacture of glass, especially bottle glass. Sand or crushed sandstone, as is well known, is the chief constituent of glass, constituting from 52 to 65 per cent of the mass of the original mixture, or from 60 to 75 per cent of the finished product. To the sand is due the absence of color (according to its purity), the transparency, brilliancy, and hardness of glass. For the finest flintware, such as optical and cut glass, only the purest sand can be employed. For plate and window glass, which are commonly pale green, absolute purity is not essential, but generally the sand should not carry more than 0.2 per cent of iron oxide. Green and amber glass for bottles, jars, and rough structural work can be made from sand relatively high in impurities, but an excess of iron is to be avoided by careful selection. Washing may be necessary to remove the iron, and perhaps also magnetic separation. Clay in the raw material is objectionable, as it clouds the glass, but it may be removed in part by washing. Magnesia is troublesome because it makes the batch difficult to fuse. If a sandstone is used as the source of glass sand it should be one that is easily crushed.

The sandstone derived from the Pottsville formation is in its original form a massive rock, in some places friable but in many places not so. The less friable parts of this rock are, however, readily crushed. In many parts of the quadrangle this sandstone fills all the requirements of a glass sand suitable for the manufacture of bottles, jars, and rough structural material; where the amount of oxide of iron is excessive it may be corrected by the addition of small amounts of manganese dioxide or other decolorizing agents. The following analysis of a sample of friable sandstone from the Pottsville formation shows the character of the sandstone on the west flank of Laurel Ridge not far from Seward, and it is quite probable that sandstone of equal purity may be collected at other points where the Pottsville outcrops in this quadrangle.

Analysis of glass sand from Pottsville formation on west flank of Laurel Ridge, near Seward.

[Analyst, A. J. Phillips, at the testing laboratory of the United States Geological Survey at St. Louis, Mo.]

Silica (SiO_2)	97.54
Alumina (Al_2O_3)	.81
Ferric oxide (Fe_2O_3)	.09
Lime (CaO)	1.04
Magnesia (MgO)	.06
Alkalies { Na_2O	.02
Alkalies { K_2O	.16
Water at 100° C	.03
Ignition loss	.49
	100.24

The amount of impurities is notably small. The percentage of iron oxide falls well below the limits prescribed for bottles, jars, and rough structural material. The amount of clayey material is very small, and so is the amount of magnesia. The sandstone of the Pottsville formation is not likely to present any serious obstacle to being ground to the requisite fineness, say to pass through a 20 to 50 mesh sieve. In prospecting for glass sand, only the clearest and whitest sand should be selected, and before exploitation complete quantitative analyses and furnace tests of representative samples should be made.

IRON ORE.

IMPORTANCE.

But one bed of iron ore in the Johnstown quadrangle deserves mention, and that is now only of historic interest. Such interest is great, however, for the close relationship between the ore and the underlying coal beds in the hills near Johnstown was perhaps the main factor in determining the location of the present great plant of the Cambria Steel Company. With the appearance of the cheap Lake ores on the market the Johnstown iron ore ceased to be of importance. At the present time it is not worked and but very little first-hand information is to be obtained regarding it.

EXTENT.

The Johnstown ore bed is in the center of the Johnstown Basin. Its eastern outcrop appears a short distance west of Conemaugh station, where it occupies a position well up on the hillside above the railroad. Thence it descends slowly, approaching water level at Hinckston Run, and beyond the synclinal axis it again rises toward the Laurel Ridge anticlinal axis and outcrops on the eastern flank of Laurel Ridge. In the hills along the south bank of the Little Conemaugh it has never been found, although repeated search has been made for it. Its horizon has been determined many times and its vertical distance above the Upper Freeport or Coke Yard coal has been accurately measured. At Johnstown this interval is about 50 feet. This iron-ore bed is known to exist on Mill Creek southwest of Johnstown and it was benched there for many years, until 1875, by Doctor Schoenberger, the ore furnishing the material on which two small furnaces were run. The same ore was mined near and smelted at the old Cambria furnace near the base of Laurel Hill.

CHARACTER OF THE ORE.

The ore bed at the opening of the Cambria Company's mine on the west bank of Hinckston Run was divided into two bands by a stratum of fire clay or shale, which ranged from an inch to a foot in thickness and which crumbled when exposed to the weather, losing its water slowly and changing in color. The upper bench was much richer in iron than the lower, the latter being calcareous; but both benches contained sufficient lime to flux, and the ore and coke were introduced into the furnace without limestone. The ore contained on an average about 30 per cent of metallic iron when carefully treated in the furnace, but sometimes fell below this figure and occasionally rose above it. The character of the ore is expressed by the following analysis furnished by T. T. Morrell:[a]

Analysis of Johnstown iron ore.

Silica	4.885
Alumina	1.552
Carbonate of iron	52.330
Sesquioxide of iron	15.230
Carbonate of lime	15.285
Carbonate of magnesia	9.390
Phosphoric acid	.530
Sulphur	..850
Water.	
Metallic iron, 35.930.	

[a] Rept. H2, Second Geol. Survey Pennsylvania, 1875, p. 118.

WATER RESOURCES.

The Johnstown quadrangle is a well-watered region. Most of the towns derive their water from the headwaters of the smaller creeks flowing into the main drainage channels—Stony Creek, Conemaugh and Little Conemaugh rivers, and Blacklick Creek with its North and South branches. These streams are fed by multitudes of springs as well as by the ordinary rainfall. This water is stored in reservoirs to insure a constant and adequate supply. The water is excellent, because the slopes from which most of it comes, though of small extent, are in general well wooded and comparatively free from habitation. The city of Johnstown obtains its water chiefly from three storage reservoirs, two on Mill Creek and one on Dalton Run. South Fork obtains its supply from a storage reservoir on Sandy Run. The town of Wehrum procures water from a reservoir on Rummel Run, and it is understood that the town of Vintondale also has a reservoir on a stream to the southeast. The town of Windber and associated mining villages, lying in part within the Johnstown quadrangle, are supplied partly from a storage reservoir on Little Paint Creek. For industrial purposes the Cambria Steel Company has constructed a large reservoir on Hinckston Run. During most of the year the flow of the streams is fairly adequate, but in the dry season of the autumn the supply is likely to run low. During the summer of 1906 the streams all maintained a good flow of water.

Away from the railroads the inhabitants of the region depend mostly on wells. Many of these wells have been driven as far down as coal beds, which are almost universally in water-bearing zones. The water obtained from such beds is commonly sulphurous and generally considered very wholesome. Springs are very abundant but do not appear to be large. They generally issue from coal beds or just above impervious clay beds. Though the volume in most such springs is not large, in purity the water can not be excelled. Many of the drill holes put down in this area have tapped water-bearing beds, but almost all the drillings have been made in search of coal beds and little or no attention has been paid to the water-bearing strata. These usually have been either sandstone beds or coal beds. Such a hole was drilled near the confluence of North Fork and South Fork of Bens Creek in Somerset County near Mishler. The locality is known as Sulphur Springs. The water probably issues from the Upper Kittanning coal bed, as the drill hole is understood to be very shallow.

December, 1909.

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PENNSYLVANIA
JOHNSTOWN QUADRANGLE

LEGEND

RELIEF
printed in brown

Figures
showing heights above mean sea level instrumentally determined

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

DRAINAGE
printed in blue

Streams

Reservoirs and ponds

CULTURE
printed in black

Roads and buildings

Churches and school houses

Private and secondary roads

Railroads

Electric railroads

Tunnels

Bridges

Dams

County lines

Township lines

City, village, and borough lines

Triangulation stations

Bench marks

H.M. Wilson, Geographer.
Frank Sutton and R.D. Cummin, in charge of section.
Topography by R.D. Cummin and A.C. Roberts. Assistant, B.B. Alexander.
Control by S.S. Gannett and H.B. Paige.
Surveyed in 1901 - 1904.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1904.

Scale $\frac{1}{62500}$

Miles
Kilometers

Contour interval 20 feet.
Datum is mean sea level.

Edition of Nov. 1907, reprinted Nov. 1909.

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

AREAL GEOLOGY

STATE OF PENNSYLVANIA
GEORGE W. MCNEES, RICHARD R. HICE, ANDREW S. MCCREATH
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PENNSYLVANIA
JOHNSTOWN QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

Qal — Alluvium *(only the larger areas shown)*

CARBONIFEROUS

Pennsylvanian

Ccm (Cs, Cmt, Csb, Cb) — Conemaugh formation *(shale with several thin coal beds, limestones, fire clay, some red shale, and heavy-bedded sandstones comprising the Summerhill, Cs, Morgantown ("Ebensburg"), Cm, Saltsburg, Csb, and Buffalo, Cb, members)*

Ca — Allegheny formation *(chiefly gray and dark shale, with local beds of heavy sandstone and several workable coal beds)*

Cpv — Pottsville formation *(heavy-bedded sandstone with shale bed containing locally a thin coal bed and flint clay)*

Mississippian

Cmc — Mauch Chunk shale *(red and green shale with a thick bed of gray sandstone)*

Cpo — Pocono formation *(grayish green sandy shale and sandstone with several beds of red shale)*

DEVONIAN

Dck — Catskill formation *(red shale and reddish and green sandstones)*

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MAGNETIC NORTH
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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 1910.

Geology by W. C. Phalen,
assisted by Lawrence Martin,
under the supervision of G. H. Ashley.
Surveyed in 1906.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

STRUCTURE AND ECONOMIC GEOLOGY

STATE OF PENNSYLVANIA
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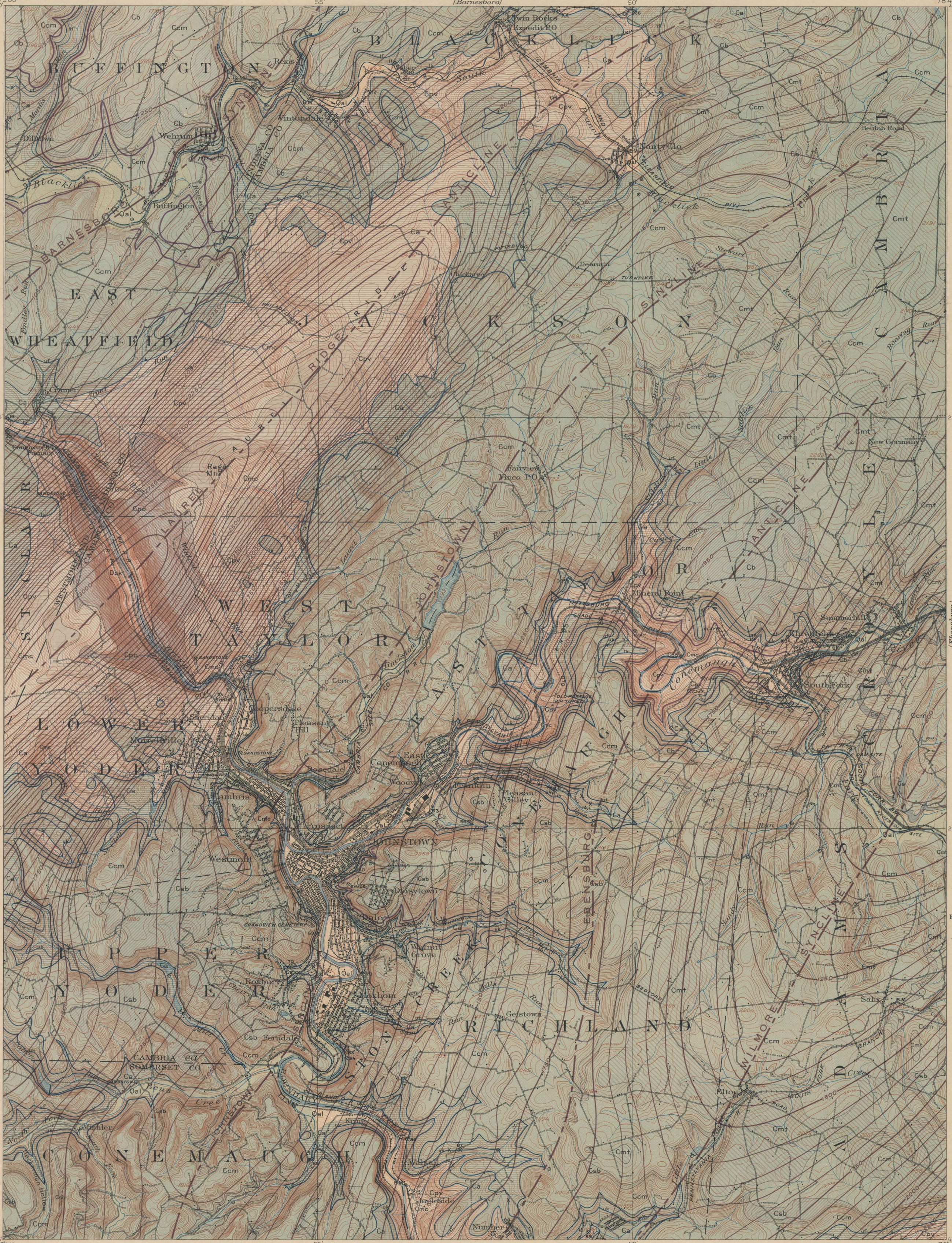
PENNSYLVANIA
JOHNSTOWN QUADRANGLE

LIST OF MINES.

Location indicated on the map by numbers.

1. Pennsylvania, Beech Creek, and Eastern No. 14.
2. Nant-y-Glo.
3. Ivory Hill.
4. Ivory Hill (slope).
5. Lincoln.
6. Cardiff.
7. Blacklick No. 2.
8. Big Bend (Nonpareil No. 1).
9. Commercial No. 3.
10. Commercial No. 4.
11. Vinton No. 5.
12. Vinton No. 3.
13. Vinton No. 6.
14. Vinton No. 2.
15. Vinton No. 1.
16. Rager.
17. Lackawanna No. 4 (shaft).
18. Dill.
19. Johnstown (Cramer).
20. Nineveh.
21. Pennsylvania, Beech Creek, and Eastern No. 8.
22. Pennsylvania, Beech Creek, and Eastern Nos. 3 and 5.
23. Giles.
24. South Fork No. 2.
25. South Fork No. 1.
26. Hutzel.
27. Stineman C. M. Co. No. 1.
28. Stineman C. and C. Co. No. 4.
29. O. M. Stineman No. 3½
30. O. M. Stineman No. 3.
31. H. C. Stineman No. 5.
32. H. C. Stineman No. 6.
33. Stineman C. and C. Co. No. 2.
34. Priscilla.
35. Argyle No. 1.
36. Argyle No. 2.
37. Argyle No. 3.
38. Page-Reighard (Juniper).
39. Gillan.
40. Valley Smokeless No. 3 (Radnor).
41. Adams.
42. Hawes (Coopersdale).
43. Williams (Morrellville).
44. Robertson & Griffith.
45. Prosser (slope).
46. Samuel Fuge.
47. E. W. Fuge.
48. Hawes (shaft).
49. Cambria Steel Co., Rolling Mill mine.
50. Epply.
51. Cambria Steel Co. (Conemaugh slope).
52. Keystone (Conemaugh).
53. Mitchell.
54. Custer.
55. Umbarger.
56. Cambria Steel Co. (Franklin No. 1).
57. Cambria Steel Co. (Franklin No. 2).
58. Griffith.
59. Cover.
60. Davis.
61. Johnstown Press Brick Co.
62. Suppes No. 1.
63. Citizens C. Co. (Green Hill slope).
64. Williams (Kernville).
65. Livergood.
66. Suppes (Dale).
67. Citizens C. Co. (Dale).
68. Caddy.
69. Citizens C. Co. (Eighth Ward).
70. Davis (Grubtown).
71. Schaeffer.
72. Jacoby.
73. Fyock.
74. Wertz & Miller.
75. Litsinger.
76. Heidingsfelder.
77. Berkebile.
78. Llewellyn.
79. Sunnyside.
80. Ferndale.
81. Caufield.
82. Highland.
83. Valley C. and S. Co. No. 1.
84. Valley C. and S. Co. No. 2.
85. Kelso.
86. Ingleside.
87. Orris.
88. Berwind-White (Eureka No. 37).
89. Berwind-White (Eureka No. 40).



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DEVONIAN

Dck — Catskill formation *(red shale and reddish and green sandstones)*

ECONOMIC AND STRUCTURE DATA

Coal outcrops and area underlain by coal
uf, *Upper Freeport*
lf, *Lower Freeport*
uk, *Upper Kittanning*
lk, *Lower Kittanning*

Outcrop of workable clay beds *(in places a valuable fire clay)*

Structure contours *(showing elevation and lay of Lower Kittanning coal bed. Contour interval is 50 feet; datum is mean sea level)*

⚒ *Coal mines* *unless otherwise specified*
⚒ CLAY *Fire clay mines*
x *Country coal banks and abandoned mines*
⊙ *Diamond drill holes*

Economic data: *Coal occurs in the Allegheny, Conemaugh, and Pottsville formations; flint clays in the Pottsville and Conemaugh; clay and shale for brick, terra cotta, and tile in the Mauch Chunk, Pottsville, Allegheny, and Conemaugh; limestone and cement materials in the Allegheny; building stone and paving blocks in all except the Catskill and Mauch Chunk formations; sand and gravel in stream alluvium; glass sand in the Pottsville; iron ore near the base of the Conemaugh.*

List of mines on the left margin.

H. M. Wilson, Geographer.
Frank Sutton and R. D. Cummin, in charge of section.
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TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1904.

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.
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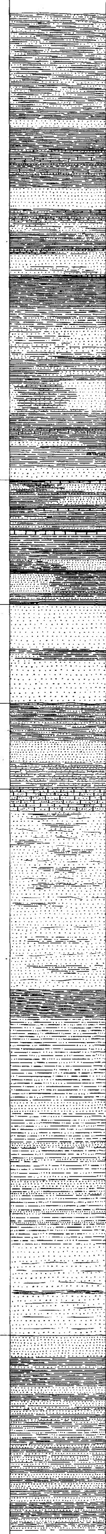
COLUMNAR SECTION

GENERALIZED SECTION OF THE ROCKS EXPOSED IN THE JOHNSTOWN QUADRANGLE.

SCALE: 1 INCH = 200 FEET.



System.	Series.	Formation.	Symbol.	Columnar Section.	Thickness in Feet.	Members.	General Character of Rocks.	General Character of Topography and Soil.
CARBONIFEROUS	PENNSYLVANIAN	Conemaugh formation	Ccm		850–960±	Wilmore sandstone. Summerhill sandstone. Morgantown ("Ebensburg") sandstone. Ames limestone. Harlem (?) coal. Red shale. Saltsburg sandstone. Bakerstown coal. Buffalo sandstone. Gallitzin coal. Upper sandstone. } Mahoning coal. } Mahoning sandstone. Flint clay. } Lower sandstone. }	Shale and heavy sandstones, with a few beds of coal, locally workable, thin limestones, and an occasional bed of red shale. The sandstones are not persistent but are lenticular, being very massive in some localities and pinching out entirely and being replaced by shales in others. The limestones also are lenticular.	Rolling country cut here and there by deep valleys. Surface is generally smooth, free from rock, and in large part cultivated. The sandstone outcrops form uncultivated rocky regions.
		Allegheny formation.	Ca		220–290	Upper Freeport coal and limestone. Butler sandstone. Lower Freeport coal and limestone. Upper Kittanning coal. Johnstown limestone (cement bed). Middle Kittanning coal. Lower Kittanning coal and clay Kittanning sandstone. Brookville and Clarion coals.	Chiefly gray and dark shale, with local beds of heavy sandstone. This is the coal bearing formation of the quadrangle and contains at least five coals that are workable in different parts of the area.	Slopes and valleys of the larger rivers and streams. Surface smooth, with few sandstone breaks.
		Pottsville formation.	Cpv		175–250	Homewood sandstone. Mercer shale. Connoquenessing sandstone.	Characterized by two heavy sandstones, separated by a comparatively thin shale. Contains a valuable bed of flint clay and an unimportant coal.	Ridges and steep valley slopes, with rocky uncultivated surfaces.
		UNCONFORMITY						
	MISSISSIPPIAN	Mauch Chunk shale.	Cmc		175–200		Red and green shale, with a 40-foot red and green sandstone member near the middle.	Chiefly stream valleys with smooth surface; red soil, susceptible of cultivation.
		Pocono formation.	Cpo		1000–1100	Loyalhanna limestone. Burgoon sandstone. Patton shale.	Grayish-green sandy shale and sandstone, with several bands of red shale.	Rocky slopes and bottoms of stream gorges where it is exposed.
DEVONIAN		Catskill formation.	Dck		400+		Red shale and reddish to green sandstones.	Bottom and lower slopes of the Conemaugh River gorge.

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