DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

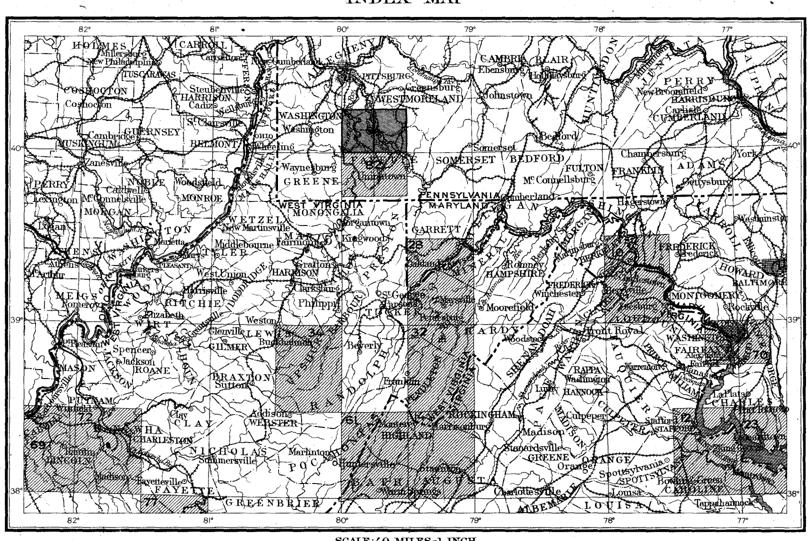
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS OF THE UNITED STATES

BROWNSVILLE-CONNELLSVILLE FOLIO

PENNSYLVANIA

INDEX MAP



SCALE: 40 MILES-1 INCH

AREA OF THE BROWNSVILLE-CONNELLSVILLE FOLIO

AREA OF OTHER PUBLISHED FOLIOS

CONTENTS

FIELD EDITION

BROWNSVILLE-CONNELLSVILLE FOLIO
NO. 94

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

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

1903

EXPLANATION.

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

THE TOPOGRAPHIC MAP.

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

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

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

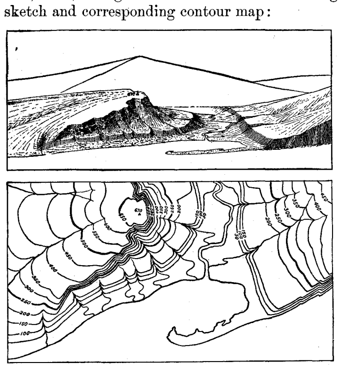


Fig. 1.—Ideal sketch and corresponding contour map.

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

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

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

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

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

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

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

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

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

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

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

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

THE GEOLOGIC MAP.

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

KINDS OF ROCKS.

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

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

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

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

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

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

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

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

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

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

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

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

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

AGES OF ROCKS.

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

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

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

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

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

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

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

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

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

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

a letter-symbol composed of the period letter combined with small letters standing for the formation name. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

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

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

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

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

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

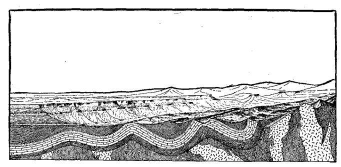


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

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

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

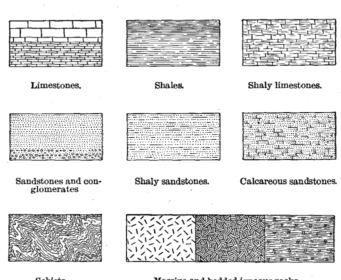


Fig. 3.—Symbols used to represent different kinds of rock.

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

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

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts slipped past one another. Such breaks are termed *faults*.

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

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

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

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

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

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

Columnar section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thicknesses of the formations, and the order of accumulation of successive deposits.

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

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

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

CHARLES D. WALCOTT,
Director.

Revised January, 1902.

DESCRIPTION OF THE BROWNSVILLE AND CONNELLSVILLE QUADRANGLES.

By Marius R. Campbell.

GEOGRAPHY.

GENERAL RELATIONS.

Position and area.—By reference to the key map on the cover of the folio it will be seen that these are adjacent quadrangles in the southwestern part of Pennsylvania, including parts of the counties of Fayette, Washington, Allegheny, and Westmoreland. They extend from latitude 40° on the south to 40° 15′ on the north, and from longitude 79° 30′ on the east to 80° on the west. Each covers one-sixteenth of a square degree of the earth's surface, and together they contain 457 square miles.

The latitude and longitude of the boundaries of the quadrangles have been determined from stations located on some of the most prominent hilltops of the region. These stations have been connected by triangulation with astronomical stations at Washington, Cumberland, Grafton, and Pittsburg, and the accuracy of the work has been checked by a carefully measured base line on the Pennsylvania Railroad north of Latrobe.

TRIANGULATION POINTS.

All surveys for the maps of this folio are based on nine triangulation stations located within the boundaries of the quadrangles, and four other stations in close proximity to this territory. The locations of the stations within the quadrangles are shown on the topographic map by small triangles, but the following sketch (fig. 1) shows the relative positions of all these points. The stations are

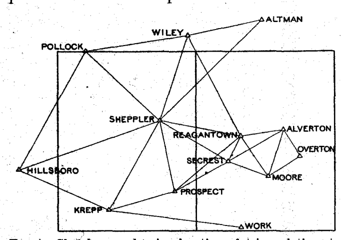


FIG. 1.—Sketch map showing location of triangulation stations on which the survey of the Brownsville and Connellsville quadrangles is based.

marked by stone posts 8 by 8 inches in cross section. In the center of the top of each post is cemented a bronze tablet marked "U. S. Geological Survey–Pennsylvania." For the convenience of engineers who may wish to secure accurate control over their surface surveys the following list of stations is given. Full details regarding the angles by which their positions have been determined can be obtained on application to the Director of the United States Geological Survey at Washington.

OVERTON, WESTMORELAND COUNTY.

About 15 feet northeast of the summit of a hill 2 miles northeast of Scottdale and one-fourth mile west of the Painter coke ovens, on land owned by the McClure Coke Company. Latitude, 40° 06′ 07.88″. Longitude, 79° 33′ 48.87″.

ALVERTON, WESTMORELAND COUNTY.

On the summit of the hill on which is located the Alverton cemetery, about 30 feet west of the westerly fence line of the cemetery. Latitude, 40° 08′ 28.25″. Longitude, 79° 35′ 35.68″.

MOORE, FAYETTE COUNTY.

On a hill locally known as Moore's Hill, 2 miles southwest of Scottdale, on the road between Scottdale and Dawson, on land owned by the H. C. Frick Coke Company. Latitude, 40° 04′ 29.12″. Longitude, 79° 37′ 08.83″.

WORK, FAYETTE COUNTY.

On land owned by John Work, about 5 miles west of Connellsville and 9 miles north of Uniontown. A row of locust trees crosses the top of the hill along a north-south fence. Reference mark, a nail driven at the foot of a locust tree 25½ feet distant, magnetic bearing of which is N. 30° E. Latitude, 40° 00′ 09.20″. Longitude, 79° 40′ 06.44″.

SECREST, WESTMORELAND COUNTY.

In the center of a cultivated field on a high summit of a long wooded ridge, locally known as Fort Hill, on land owned by W. M. Secrest, who lives about one-half mile northeast of the station and about 2½ miles east of Layton post-office. Latitude, 40° 05′ 48.90″. Longitude, 79° 41′ 31.20″.

REAGANTOWN, WESTMORELAND COUNTY.

On the summit of a hill, in a cleared field, 100 feet east of a tree, one-half mile south of the State road and about 2 miles west of Reagantown; about one-fourth mile northeast of a blacksmith shop on the road from Coal Hollow to the State road. Latitude, 40° 07′ 57.87″. Longitude, 79° 40′ 11.80″.

PROSPECT, FAYETTE COUNTY.

About 1¾ miles southeast of Redstone and 7 miles northeast of Brownsville, on a flat, bald hill having a large apple tree on the summit. The land is owned by the heirs of Thomas Murphy, and is occupied by J. C. Murphy, of Redstone. Latitude, 40° 03′ 15.98″. Longitude, 79° 47′ 19.34″.

KREPP, WASHINGTON COUNTY.

About 1½ miles northwest of Brownsville, on a prominent and well-known bald knob owned by Jacob Nickson. Latitude, 40° 01′ 44 55″. Longitude, 79° 54′ 25.69″.

SHEPPLER, WESTMORELAND COUNTY.

About 4 miles southeast of Bellevernon and 5 miles east of Charleroi, on a high, cultivated hill owned by John Sheppler. Latitude, 40° 09′ 12.22″. Longitude, 79° 48′ 54.10″.

HILLSBORO, WASHINGTON COUNTY.

In a rocky pasture, about 1000 feet north of Hillsboro church, about half way between Brownsville and Washington, along the National Pike, on land owned by Mrs. E. S. Tonebaugh, who lives at a crossing about 1500 feet southeast of the station. Latitude, 40° 05′ 17.67″. Longitude, 80° 04′ 15.81″.

POLLOCK, WASHINGTON COUNTY.

On Pollock's Hill, about 2 miles west of West Elizabeth, on the road to Finleyville, 400 feet west of a rough board shanty on the highest point of a bare hill owned by Mr. McClure. Latitude, 40° 15′ 08.99″. Longitude, 79° 57′ 06.26″.

WILEY, WESTMORELAND COUNTY.

About 5 miles north of West Newton and 6 miles southwest of Irwin, on a high ridge on a farm belonging to Emily G. Wiley, of Yohoghany, whose house is about one-fourth mile south of the signal. Latitude, 40° 16′ 22.57″. Longitude, 79° 45′ 49.85″.

ALTMAN, WESTMORELAND COUNTY.

About 5 miles southwest of Greensburg and 1 mile south of Old Grapeville, on a flat, cleared hill with a fringe of timber on the northern side, on land owned by John C. Altman. Latitude, 40° 17′ 47.65″. Longitude, 79° 37′ 22.85″.

RELATION TO APPALACHIAN PROVINCE.

In their physiographic and geologic relations these quadrangles form a part of the Appalachian province, which extends from the Atlantic Coastal Plain on the east to the Mississippi lowland on the west, and from central Alabama to beyond the northern boundary of the United States.

SUBDIVISIONS OF APPALACHIAN PROVINCE.

With respect to topography and the attitude of the rocks, the Appalachian province may be divided into two nearly equal parts by a line which follows the Allegheny Front throughout Pennsylvania, Maryland, and West Virginia, and the eastern escarpment of the Cumberland Plateau across Virginia, Tennessee, Georgia, and Alabama.

East of this line the rocks are greatly disturbed by faults and folds, and in many places they are so metamorphosed that their original characters can be determined with difficulty. West of the dividing line the rocks are entirely unaltered; they lie nearly flat, and the few folds which break the regularity of the structure are so broad and open that they produce scarcely an appreciable effect.

The general topographic features are well illustrated by fig. 93, Illustration sheet, which is a relief map of the northern part of the province. From this it will be seen that east of the Allegheny Front the surface consists of alternating ridges and valleys, as shown in the Greater Appalachian Valley, and of a slightly dissected upland like the Piedmont Plain of eastern North Carolina and Virginia. West of the dividing line the surface is composed of more or less elevated plateaus, which are broken by a few ridges where minor folds have affected the rocks, and which are greatly dissected where they have been raised high above drainage level. In contradistinction from the lowlands on the west and the regularly alternating ridges and valleys on the east, it has been called by Powell the Allegheny Plateaus.

ALLEGHENY PLATEAUS.

This region is characterized by distinctive types of geologic structure, of surface features, and of drainage arrangement.

Geologic structure.—The structure of the Allegheny Plateaus is comparatively simple. The strata lie nearly flat, and their regularity is broken only by small faults and low, broad folds which usually have little effect upon the general structural features of the region.

The most pronounced fold is a low, broad arch known as the Cincinnati anticline. The main axis of this fold enters the Allegheny Plateaus from the direction of Chicago, but a minor fold from the western end of Lake Erie joins the major axis near the type locality. From Cincinnati the anticline passes due south to Lexington, Ky., and there curves to the southwest, parallel with the Appalachian Valley, as far as Nashville, Tenn. Its maximum development is in the vicinity of Lexington, where the Trenton limestone is exposed at the surface at an altitude of 1000 feet above sea level; but in Tennessee it again swells into a dome-like structure which is represented topographically by the Central Basin of Tennessee.

This anticline separates the Allegheny Plateaus into two structural basins, which are best known by the coal fields that they contain. The western basin extends far beyond the limit of the province and contains the eastern interior coal field of Illinois, Indiana, and Kentucky. The eastern basin lies entirely within the limits of the Allegheny Plateaus and is generally known as the Appalachian coal field. By reference to the map, fig. 94, Illustration sheet, it will be seen that the Brownsville and Connellsville quadrangles are situated near the northern extremity of this basin. A somewhat detailed description is therefore necessary to a thorough appreciation of the geology and topography of these quadrangles.

Since the Appalachian coal field is a structural basin or trough, the strata around its margin generally dip toward the center of the field. This is particularly noticeable on the two sides, the rocks on the northwestern side dipping gently but regularly to the southeast and those of the southeastern side dipping more strongly to the northwest. In Pennsylvania and West Virginia the regularity of the dip on the southeastern limb of the trough is interrupted by parallel folds which gave rise to anticlinal ridges and synclinal valleys. These undulations are similar to the great folds east of the Allegheny Front, except that they are developed on a very much smaller scale and have not been broken by faults as have many of the great folds farther east. Across the northern extremity of the basin, where the rocks are nearly flat, the minor folds are numerous, extending at least halfway across Pennsylvania near its northern boundary. In the southern part of the State there are only six pronounced anticlines, and two of these disappear near the West Virginia line. Further south the number is reduced, until on the Kanawha River the regular westward dip is interrupted by only one or two small folds.

Drainage.—The drainage of the Allegheny Plateaus is almost entirely into the Mississippi River; but the northeastern end of the region drains either into the Great Lakes on the north-west or through the Susquehanna, Delaware, and Hudson rivers into the Atlantic Ocean on the southeast.

The arrangement of the drainage lines in the northern part of the province is largely due to the advance of the ice-sheet during the Glacial epoch. Before that time it is supposed that all the streams north of central Kentucky flowed to the north and discharged their waters through the St. Lawrence system. The encroachment of the great ice sheet closed this northern outlet, and new drainage lines were established along the present courses of the streams.

In the southern half of the province the westward-flowing streams have their sources on the summit of the Blue Ridge and flow to the west across the Greater Appalachian Valley as well as the Allegheny Plateaus.

Surface relief.—The surface of this division of the province is composed, as its name implies, of a number of plateaus of different altitude and extent. The most important lies along the southeastern margin of the division and extends nearly the whole length of the province. This plateau is very old, and its surface is so greatly dissected that its plateau character is not always apparent. It emerges from beneath the Cretaceous cover in central Alabama at a height of 500 feet above sea level. From this altitude it ascends to 700 feet at Chattanooga, 2400 feet at Cumberland Gap, 3500 feet at New River, and probably 4000 feet at its culminating point in central West Virginia. From this point it descends to about 2600 feet on the southern line of Pennsylvania and to 2300 or 2400 feet in the central part of the State. North of this point the plateau increases in width, including most of the northern counties of Pennsylvania and the southern counties of New York, and ranges in altitude from 2000 to 2400 feet.

The surface of this plateau varies greatly in different parts of the province, depending upon the character of the underlying rocks, the general drainage conditions of the region, and the crustal movements which have affected its altitude. In the southern part conditions have been very favorable to the preservation of the plateau, and large areas of its even surface are still visible in Lookout and Sand mountains and in the Cumberland Plateau. North of Tennessee the cap of hard sandstone which protects the Cumberland Plateau is lacking, and the surface is completely dissected, showing only rounded hilltops as the possible representatives of its once even surface. In northern West Virginia a few remnants of the original surface of the high plateau are preserved where conditions are especially favorable, but generally the surface is so deeply eroded that it is difficult to realize that it was once approximately flat and extended over most of the Appalachian region. In the northern part of Pennsylvania conditions are similar to those just described, and considerable areas, protected by the massive sandstones of the Pottsville formation, are still intact.

Throughout most of the province there are knobs and ridges that rise to a greater height than the surface of this plateau, but usually they may be distinguished by the fact that they stand above the general level of the surrounding hills.

The surface of the plateau slopes to the west, but it is generally separated from the next lower plateau by a more or less regular westward-facing escarpment. This feature is most pronounced in Tennessee, where it has a height of 1000 feet, and separates the Cumberland Plateau on the east from the Highland Plateau on the west. Its height diminishes toward the north, falling to 500 feet in central Kentucky; and north of Ohio River it is so indistinctly developed that it is doubtful whether it has been recognized. In southern Pennsylvania it becomes more pronounced where the hard rocks of Chestnut Ridge rise abruptly above the plain formed on the soft rocks of the Monongahela Valley, but the surface of the upper plateau is so greatly dissected that it can be recognized with difficulty. Toward the central part of the State the plateau surfaces approach each other, and the escarpment is merged in a mass of irregular hills which seem to represent all that is left of the higher plateau.

The second plateau surface is best developed as a distinct feature in Tennessee and Kentucky. In the former State it is known as the Highland Plateau, and in the latter as the Lexington Plain. Its surface slopes gently to the west, but along its eastern margin throughout these States it holds a constant altitude of 1000 feet above sea level. North of Ohio River it is less perfectly developed, but presumably it constitutes most of the surface of Ohio, eastern Indiana, western Pennsylvania, and southern New York. Throughout most of this territory the plateau was developed on harder rocks than in Kentucky and Tennessee, and the result is that the surface is less regular and the position of the base-level of that epoch is difficult to determine. It seems to rise eastward from an altitude of 700 or 800 feet in Indiana to 1000 feet in central Ohio, 1200 to 1300 feet in southwestern Pennsylvania, and 1600 to 1800 feet throughout the northern part of the State and the southern part of New York.

This lower plateau is diversified in its surface, though less so than the higher. In Kentucky and Tennessee it is preserved over large areas as a nearly featureless plain, but in other States it was less perfectly developed and has suffered greatly from dissection since it was elevated to its present position.

West of this intermediate zone there is a third plain which is developed only in the great central basin of Tennessee and in the western portion of Kentucky and Indiana.

SURFACE FEATURES.

These quadrangles lie within the Allegheny Plateaus, and their topography is, in a measure, of the plateau type, but with modifications depending upon local conditions. Since the surface features are due to subaerial erosion, the streams are the principal agents by which the present topographic features have been produced; therefore a knowledge of the drainage of the territory is important.

DRAINAGE.

The Brownsville and Connellsville quadrangles are particularly well drained; they are crossed by Monongahela and Youghiogheny rivers, the two principal streams of southwestern Pennsylvania. Besides these main drainage lines there are several large creeks which play a prominent part in carrying off the surplus waters of this region. The most important of these streams is Sewickley Creek, which drains the northern part of the Connellsville quadrangle and unites with the Youghiogheny a short distance below West Newton. Jacobs Creek is also a large tributary of the same stream. It drains the middle part of the Connellsville quadrangle, and from Scottdale to the river it pursues a course parallel with and only a short distance north of Youghiogheny River. The alignment of this stream is peculiar. Above Scottdale it coincides with the belt of soft rocks which marks the location of the Connellsville basin. Instead of following this outcrop to the river along what appears to be its natural route, the stream turns abruptly to the west and crosses the Fayette anticline through a sharp gorge which has a depth near the center of the arch of about 500 feet. The surface over the crest of this arch is formed of a very massive sandstone, which seemingly was a decided barrier in the path of the stream.

Geologists have indulged in considerable speculation regarding the effect of such folds upon the drainage lines. Many have regarded them as accountable for most of the irregularity in the present drainage systems. Jacobs Creek, however, shows no such influence, since it leaves the outcrop of relatively soft rocks and cuts directly across the anticline at the point where it is most strongly developed and where it is marked by heavy beds of massive sandstone. The creek certainly established this course at a time when the surface had not been eroded to anything like its present position. At that time higher beds, approximately of the same degree of hardness as those on the Fayette anticline, were probably present in the Connellsville basin, and, consequently, the course of Jacobs Creek was then not abnormal. Since that time it has simply intrenched itself as the land has risen and as the general erosion of the region has uncovered the hard beds which now appear to form such a barrier in its pathway.

Redstone Creek is also one of the important streams of this region. Its source is near Uniontown, and it unites with Monongahela River a mile below Brownsville. Only a small part of its drainage basin is within this territory, but from an economic standpoint its valley is of considerable importance, since it affords a route for a railway and so gives easy access to the Pittsburg coal, in the southeastern corner of the Brownsville quadrangle.

There are a number of small streams on the west side of Monongahela River which are of local importance, since the Pittsburg coal is exposed in outcrop along them for some distance from the river. The most important of them is Pigeon Creek, which enters the river at Monongahela. Its valley is not cut deep enough to expose the Pittsburg coal except near the river, but it has been utilized for railroad construction, and shaft mines are developing along its course.

In the commercial development of the Pittsburg coal the valleys cut by Monongahela and Youghiogheny rivers are of the utmost importance, since the coal is generally exposed along them at a little distance above water level. These valleys are, therefore, generally selected for the location of mines, and consequently many towns have been built within them and railways have been constructed for the transportation of the products of the mines. In this respect Monongahela River is of much more importance than Youghiogheny River. It was not navigable at low stages of water, but by means of a series of locks and dams steamboats and coal barges can make the passage from Morgantown, W. Va., to Pittsburg at any season of the year except when prevented by ice. The construction of the dams was begun at Pittsburg, by private enterprise, about 1840, and by 1854 had been extended to dams Nos. 5 and 6 near the southern boundary of the Brownsville quadrangle. Since that time the Government has assumed control, and the system has been extended by the construction of dams Nos. 7, 8, and 9, which secure slackwater navigation to Morgantown.

The altitude of the surface of the water in the various pools is as follows:

Altitudes of water surface of Monongahela River between Pittsburg and Morgantown.

	Feet above tide.
Pool of Davis Island dam, Pittsburg	703.00
Pool No. 1	707.40
Pool No. 2	715.10
Pool No. 3	723.10
Pool No. 4	733.48
Pool No. 5	746.41
Pool No. 6	760.15
Pool No. 7	769.99
Pool No. 8	780.80
Pool No. 9	793.40

SURFACE RELIEF.

On the basis of its topography this territory is naturally divided into two parts by a line along the western base of Chestnut Ridge. East of this line is the so-called mountain region of western Pennsylvania. It consists in the main of long, narrow ridges separated by rather wide valleys in which at many localities the topography is nearly as broken as that of the adjacent ridges.

A very small part of the mountainous belt lies in the southeastern corner of the Connellsville quadrangle. In fact the corner of the quadrangle is nearly on the summit of the first or westernmost ridge of the mountainous territory. This ridge extends for a long distance both north and south of Connellsville, but south of the Youghiogheny River it is usually known by the name of Laurel Ridge. In this territory it is generally spoken of as Chestnut Ridge. The application of two names is really appropriate although somewhat confusing, for the anticlinal fold which forms the ridge south of Youghiogheny River is distinct from the fold which forms Chestnut Ridge. At their junction the two folds merge, and as a topographic feature, the ridge is practically continuous.

From the small area of the mountainous belt in the Connellsville quadrangle it is impossible to determine the physiographic history of the region, but from studies conducted in the Uniontown quadrangle and in territory farther south it seems probable that a peneplain was produced in this part of the State during Cretaceous time, and that its surface is marked approximately by the common level attained by most of the high ridges of the region. The great length of time which has elapsed since it was formed has given opportunity for its almost complete dissection, and therefore it is probable that its once fairly even surface has completely disappeared. This is the surface which is supposed to constitute most, if not all, of the highest plateau of this division of the province. Since its formation it has been elevated unequally, the maximum movement occurring in the middle part of West Virginia. From that maximum of nearly 4000 feet the surface descends to probably 2500 or 2600 feet near the southern line of Pennsylvania, and it seems probable that its northward extension marks approximately the summit of Chestnut Ridge in this region. This plateau surface slopes to the west as well as to the north, and it is probable that east of this region it rises from its position on the summit of Chestnut Ridge so as to include most of the high ridges between this point and the Allegheny Front.

In the description of the topography of the Uniontown quadrangle it is stated that a substage in the reduction of this plateau seems to be recognizable in the Ligonier Valley at an altitude of 2000 feet. No trace of this feature was seen in the Connellsville quadrangle, the hard sandstones composing the ridge not being affected by such substages in the erosion of the country, but it is possible that the topography east of Chestnut Ridge may show similar features.

The low country south of Youghiogheny River, as viewed from the summit of Laurel Ridge, appears like a nearly featureless plain. Slight irregularities in detail may be noted, but the summits of the hills fall into line with remarkable uniformity. In such a view the valleys are lost from sight, and the surface has the same appearance that it had before these valleys were cut. When examined in detail the surface is found to be far from regular; in almost all parts of the region decidedly hilly. From the contoured maps of the Uniontown and Masontown quadrangles it will be observed that the altitude of these hills ranges generally from 1200 to 1300 feet above sea level. Along the major streams the summits rise but little over 1200 feet above tide. In the Brownsville and Connellsville quadrangles the regularity of this upland surface is interrupted to a considerable extent by the development of a low ridge along the Fayette anticline west of Scottdale. This ridge is due to the greater development of the arch in this locality, and to the beds of heavy sandstone that cap the fold.

With the exception of this low ridge the surface of the territory may be said to range from 1200 to 1300 feet above tide. The regularity in altitude of the upland surface is remarkable, since in only a few localities does it correspond with the bedding of the rocks. It cuts across anticline and syncline alike, except where it encounters particularly hard beds, as in the Fayette anticline, or beds softer than the average, as at the margins of the Connellsville basin. These slight inequalities show that the even surface is the result of subaerial rather than marine erosion and that its development was not carried to such an extent as to lose all of the modifying effects of geologic structure.

It may be regarded as a peneplain the original surface of which now probably ranges in altitude from 1200 to 1300 feet. It is somewhat more perfectly developed in the Masontown quadrangle, and its altitude in that area is thought to be about 1250 feet. It seems to rise somewhat toward the north, and in the territory described its general altitude may be close to 1300 feet.

Its geologic age has not been definitely determined, but observations made in other parts of the province indicate that it was produced in early Tertiary time, probably during the Eocene period.

In the Masontown quadrangle a substage of erosion was recognized at an altitude of about 1100 feet. This was marked by a number of important divides which had such a close agreement in their altitudes that it seems probable that they marked approximately a base level of erosion.

At first sight this level is not apparent in the Brownsville–Connellsville area, but if the 1100-foot contour is followed carefully it reveals essentially the same phenomena as in the Masontown quadrangle.

Along Monongahela River this level is represented by a great many spurs and also by many of the principal divides, and few of the summits are cut below this line. The 1100-foot level is shown in the high land between Krepp Knob and California. It also marks the summits of the spurs along the river in the bend south of Charleroi, but it is not particularly prominent in this region. In the bend back of Donora it is well developed, and also back of Monongahela; and in the northwestern corner of the quadrangle it is the most prominent feature of the topography.

Between the two rivers conditions have been favorable for rapid reduction, and such a subcycle of erosion as is here postulated would leave well-defined traces of its existence. Most of the divides are reduced to near 1100 feet, and the spurs which project toward the principal streams rise quite regularly to this level.

Low divides are particularly noticeable at the head of Falling Timber Run in Allegheny County, and between Fayette City and Wickhaven, in Fayette and Westmoreland counties. South of the latter point massive sandstones cap the hills, and the streams did not succeed in reducing the divides to a common level, except in the vicinity of Kenneth, where the sandstones are less resistant and drainage conditions are especially favorable for their reduction.

East of Youghiogheny River the conditions are more diversified, and consequently there are greater variations in the surface features, than west of it. Along Sewickley Creek the rocks are comparatively soft, and the 1100-foot level is a marked feature in the vicinity of Old Stanton and from Walts Mill to the mouth of the creek. If the valley of Sewickley Creek were filled to an altitude of 1100 feet it would constitute a plain nearly 2 miles in breadth, connecting in several places with the river plain through low gaps along the West Newton and Mount Pleasant pike.

Extending diagonally across the Connellsville quadrangle from the northeast to the southwest corner is a low ridge composed of hard rocks upon which this stage of erosion had little effect; but in the soft rocks constituting the surface along Galley and Hickman runs and the upper course of Jacobs Creek the topographic features due to this epoch are plainly apparent. The valley of Jacobs Creek is particularly interesting, for it has changed but little since the development of the 1100-foot level. The creek has been hampered by the hard rocks below Tyrone Mills, and it has not succeeded in keeping pace with the river in its recent epoch of downcutting. The upper part of Jacobs Creek is still living in a late Tertiary cycle, and it is an interesting survivor of that stage.

From the extended development of the above described features, it seems highly probable that after the general reduction of the surface of this region to about 1250 feet in early Tertiary time, the land was elevated about 150 feet and again remained stationary, allowing the streams to reach a very low grade and to reduce many of the divides at their headwaters nearly to the altitude of the principal valleys. Under favorable conditions the valleys of the principal streams were reduced to comparatively flat surfaces, having a width of from 2 to 3 miles and bordered by gentle slopes leading up by easy stages to the residual uplands farther back.

Below the 1100-foot level just described, the streams cut rather steep slopes for a distance of 150 to 200 feet. Though these slopes are steep compared with those above 1100 feet, they are not so steep as those bordering the modern streams, which are precipitous in many places. In the smaller valleys the bottom of the intermediate slope is not clearly defined, but along Monongahela and Youghiogheny rivers the line is generally apparent, being marked by a series of rock shelves and abandoned valleys. The latter form a unique feature and deserve special mention.

From Pittsburg to Morgantown, W. Va., Monongahela River is marked by an almost continuous display of rock terraces and abandoned channels cut from 200 to 300 feet below the surrounding highland and standing from 150 to 180 feet above the water level of the modern stream. Youghiogheny River is likewise affected from its mouth to the edge of the mountainous region at Connellsville, and even above this point there is an excellent example at Ohiopyle.

The extent of these abandoned channels is shown in fig. 2, which is a map of the Brownsville, Connellsville, Masontown, and Uniontown quadrangles, showing the courses that the streams have occupied at different periods of their history.

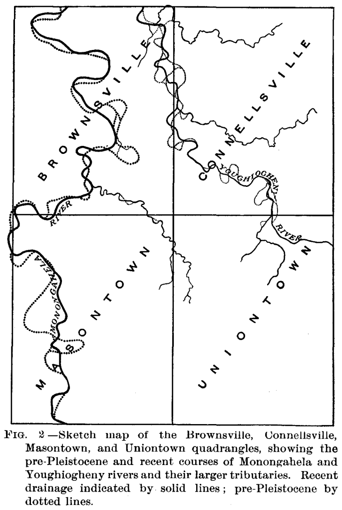


FIG. 2.—Sketch map of the Brownsville, Connellsville, Masontown, and Uniontown quadrangles, showing the pre-Pleistocene and recent courses of Monongahela and Youghiogheny rivers and their larger tributaries. Recent drainage indicated by solid lines; pre-Pleistocene by dotted lines.

The terraces and rock floors of the valleys are overlain by a variety of transported material, such as clay, sand, gravel, and bowlders derived from the country rock which occurs along the upper courses of the streams. In all places the rock floor is directly overlain by a pavement composed of sand, gravel, and rounded bowlders, evidently the original deposit laid down by an active stream. On the gravel pavement, which usually does not exceed 4 or 5 feet in thickness, there are rudely stratified clay and sand ranging in depth from a few inches to 60 or 70 feet. This resembles ordinary flood-plain material, and indicates that the water, although presumably ponded to a considerable depth, was affected by fairly strong currents, which produced alternations of fine and coarse material. In the great Carmichaels bend in the Masontown quadrangle finely laminated clay is found, but this locality was presumably protected from the sweep of the currents and contained only still water which permitted undisturbed sedimentation to take place. In the little amphitheatre opposite Bellevernon subangular blocks of sandstone measuring 4 or 5 feet in their largest diameter are present in the midst of fine material. These can be accounted for only on the supposition that they have been floated into their present position by some buoyant material upon which they found lodgment. From their abundance it is probable that floating ice was the vehicle by which they were transported.

In passing down the river through this territory the first feature of the kind one sees is in the vicinity of Fredericktown. A rock shelf is well developed on the west side of the river at this point, but it lies mainly outside of the Brownsville quadrangle and hence need not be described in this folio. The same shelf extends down the river around the bend below Riverville and dies out at the Fox mine. This shelf is nearly one-quarter of a mile in width, and its rock floor stands at an altitude of about 900 feet. The old valley was evidently wider than that of the present stream, for in cutting its new channel the river has occupied only a part of its old bed. In most cases of this kind the stream crowds to the other side of the bend, leaving the rock shelf on the inner side of the curve. This is the normal action of a stream of this size, and the failure to do so indicates that the old valley was silted up before the present channel was cut.

In the vicinity of Lock No. 5 the river originally made a détour to the west about one mile from its present location. The floor of this channel has about the same altitude as the Riverville terrace, but the deposits seem to extend to a greater distance above the rock floor. West of Lock No. 5 the upper limit of the main body of silt is about 950 feet, but scattering deposits occur on the hillsides to an altitude of 1020 feet.

From Bridgeport to Lucyville the channel of the modern stream agrees approximately with the old course, except here and there, where side swings of the stream have left portions of the rock floors of the old channel as terraces skirting the present stream. The upper parts of Brownsville and Bridgeport are built upon such terraces. So is the extreme upper part of the village of California. Here the rock floor has an altitude of about 900 feet, and the silts extend up 60 to 80 feet above the valley floor. Extensive deposits occur on the point opposite California, and a narrow terrace is visible back of Lucyville. From the arrangement of these remnants it seems probable that the original course of the stream was more direct than that of the modern river, and that the change has been in the nature of lateral corrasion on the outside of the bends, and consequent increase of their acuteness. The altitude of these rock shelves is about 900 feet, and they are all covered by a heterogeneous assemblage of gravel, sand, and clay.

From Lucyville the old channel swung directly across the present valley and formed an elongated loop about 3 miles in length and returned to within one-half mile of its former course. The minor drainage which has been established in this channel since its abandonment has removed much of the silt that was deposited in it and has deeply trenched the rock floor, exposing it to view in many places. In the middle of the valley the floor is remarkably uniform in height, having an altitude of almost exactly 900 feet above sea level. The main body of silt in this channel has a depth of about 50 feet, but the silt extends up the sides to a height of at least 70 feet above the lowest point in the rock floor.

One of the most remarkable examples of abandoned valleys is that which occurs back of Bellevernon and Fayette City. This is not a single channel which has been abandoned, but there are two distinct valleys and one of questionable character, besides the channel of the modern stream. In this example the rock floors are well exposed by the small streams, and their altitude is 900 feet. The close agreement in the altitude of the rock floors of these remnants shows that although they mark successive stages in the migration of the river, they were cut during a single cycle of erosion. From the great depth of filling it seems probable that the outermost channel is the one originally occupied by the river, and that this was abandoned in favor of the middle course, which was occupied for so long a time that it was cut as broad as the original channel and its slopes were reduced to as low an angle as those leading into the old channel. The original course of the stream was across the sites of Fayette City and Arnold City, and thence along the broad, open valley to Bellevernon. The second course separated from the first near Arnold City and united with it again just back of Bellevernon. It seems probable that there was a third channel formed that followed the present course of the river to near Vesta mines and then turned to the north and united with the second channel north of Arnold City.

The old course of the river at Bellevernon is almost perpendicular to the line of the present stream. Consequently it impinged on the west bank, cutting an amphitheater-like valley at what was formerly the mouth of the South Branch of Maple Creek. This valley was subject to strong currents, and it has been deeply filled with coarse sand that has been used extensively for glass making. It has also been full of ponded water into which ice has floated, carrying large blocks of sandstone from the mountainous region of West Virginia. On the melting of the ice these have been dropped upon the muddy bottom, and to-day they are exposed in large numbers in the sand pits, resting on and frequently surrounded by fine material.

From Bellevernon north the rock terrace on the west side of the river is almost continuous as far as Lock No. 4. From this point the old valley swung to the east more sharply than the present channel of the stream, and a remnant of its floor is to be seen in the upper part of the town of Monessen. The altitude of the rock floor is here a little below 900 feet, and from this point to the northern edge of the quadrangle it holds a constant altitude of about 880 feet.

From Sheppler to Webster the modern stream channel corresponds with the old one, but from the latter point to the mouth of Mingo Creek the modern stream generally runs farther north than its ancestor. Rock terraces are visible back of Fredericktown and Baird and in the vicinity of Monongahela and New Eagle.

The courses again correspond around the bend below Mingo Creek, but back of Bunola the old valley swung to the south in a reverse curve which crosses the present channel near the north edge of the quadrangle. Below this point details are wanting regarding the old courses of the river, but abandoned channels are reported from the vicinity of McKeesport and Braddock.

Youghiogheny River has suffered as severely as Monongahela River. Being a smaller stream, its bends were not so large and pronounced, but many of them were equally well developed and are now visible in a well-preserved condition.

Back of Sutersville there is a wide shelf, which extends across the bend at least half a mile from the present course. The rock floor at this point is about 900 feet above sea level, and the channel is filled to a depth of 80 or 90 feet with the customary clay, sand, and gravel of the abandoned channels of Monongahela River.

The old channel appears to have extended from back of Sutersville across the present stream to Collinsburg and West Newton. At Collinsburg there is a low gap, cut to the depth of the rock floor through the hills west of the old channel. Through this gap, presumably, Pollock Run joined the parent stream; it has now abandoned this course, and finds an outlet due north, toward Gratztown.

At West Newton the river swung in a sharp curve to the west, cutting out the small amphitheater in which part of the town is built. The rock floor of this channel is at an altitude of about 775 feet, and consequently it belongs to a different age from the abandoned valleys so far described; but even here there are traces of terraces at the 900-foot level. These occur on the south side of the amphitheater and are well shown on the main road which climbs to the upland in this direction.

The next place at which a terrace is well shown is on the west side of the river on a projecting point midway between West Newton and Cedar Creek. The stream has probably crossed this point in different directions at different times, as is shown by the complicated system of channels about Port Royal; but the various courses have been cut during one epoch, for the rock floors of the abandoned channels, and the terraces below Cedar Creek, stand at a constant altitude of about 900 feet.

In the vicinity of Port Royal and Smithton the old drainage lines are exceedingly complex and it is difficult to determine the sequence of events. The altitudes of the rock floors are approximately the same; consequently the clues to the various changes and to the order in which the changes occurred are to be found in the depth of filling. Since the original course of the stream is more sinuous than the present channel, it seems reasonable to suppose that the river first flowed by Smithton and thence up a small branch to the north and returned in a short curve to Port Royal, where it crossed the present course and swung in a sharp bend by Rostraver, regaining the present course a short distance above the mouth of Cedar Creek. For some reason to be explained later that part of its channel by Port Royal and Rostraver was abandoned and an outlet was found in a new channel which led directly from the northernmost bend in the old course to the present river valley below Flynns. Later the whole of this course from above Smithton was vacated and a new course was found about a mile west of that village, and the river probably flowed through its former valley by Fitzhenry. Again its upper course was blocked and it cut a new channel from Smithton to Fitzhenry along the present course. Lastly, the lower part of the channel was abandoned and the present route was selected from Fitzhenry to Flynns.

The various channels may be accounted for by some other sequence of change, but this is given as the most probable order in which they were cut.

The depth of filling varies from point to point. In general it does not exceed 60 feet in the bottoms of the valleys, but a thin mantle of silt and gravel is present on almost all the slopes up to an altitude of a little over 1000 feet.

In the vicinity of Jacobs Creek the old stream swung well to the east, leaving a rock shelf at about 900 feet. The ancient valley was located farther to the east, on the point above Jacobs Creek, and its presence is attested by quantities of gravel on the slopes of this spur.

One of the finest examples of abandoned channels on this river occurs at Perryopolis, where the stream has cut a symmetrically curved valley down to an altitude of about 940 feet. The original course of the stream was probably back of the small knob south of Washington Run, but this was abandoned early in favor of a more direct course from Layton up Washington Run. Perryopolis is located on the low point of the spur projecting into this bend from the northeast. It is an ideal location for a small town, but until recent years the town has been too far removed from a railroad to be successful. The filling in this valley ranges from 40 to 70 feet in depth, and the thin mantle of gravel extends up the slopes to a height of 80 feet, or to 1020 feet above sea level.

From Layton to Laurel Run the river was too well intrenched in the hard rocks of the low ridge which crosses its pathway to be deflected from its original course, except in the sharp bend at Oakdale, where the present stream has exaggerated the bend, leaving a trace of the original débris-covered rock floor on the inner side of the curve.

On the relatively soft rocks in the vicinity of Dawson the original stream wandered in a striking meander which began near Hickman Run Junction. Keeping to the right of Dawson it swung in a graceful curve to the north for about one mile and then returned and crossed the present valley to the mouth of Dickerson Run, curving back to its present course at Laurel Run. In the bend north of the river a prominent hill that was once doubtless the continuation of the spur back of East Liberty occupies the center of the curve, but on the south side no such hill is now visible. The rock floor in the channel stands at about 940 feet, and the valley filling extends up to about 1000 feet.

In the vicinity of Connellsville the old stream appears to have wandered somewhat widely and to have occupied different positions at different periods of its history. This is possibly due in part to the softness of the rocks outcropping along this line, but is probably more largely the result of the deposition of an alluvial fan by the river as soon as it struck the lower grade at the foot of Chestnut Ridge. East of this point the stream was closely confined by steep walls which enabled it to carry all débris that it received from the surrounding slopes; but as soon as it reached the low grade established on softer rocks in the Connellsville region it immediately deposited its coarsest material and so obstructed its pathway that it was obliged to cut new channels by lateral corrasion. Striking examples of such action are shown in the Latrobe quadrangle, where, for 10 miles from Chestnut Ridge, Conemaugh River shows rock shelves from 1 to 2 miles wide, deeply covered with coarse and well-rounded material.

The terraces about Connellsville are doubtless due to such action, but the valley through New Haven and Trotter is truly an abandoned channel, and its abandonment was doubtless the result of the same set of conditions which led to the evacuation of the other channels just described. The rock floor has an altitude of about 960 feet, and scattered sediments extend to a height of at least 100 feet above the floor.

The abandoned river channels constitute the most striking topographic feature of the region. They have been recognized as abandoned channels by Stevenson, White, Lesley, Wright, and Chamberlin, but so far no adequate explanation of their origin has been offered. They have been described as "oxbows" or "abandoned channels" as though it were the most natural thing in the world for a stream to abandon its channel. If western Pennsylvania were a country of low relief, it might be possible for a stream, during its normal development, to cut off oxbows as the Mississippi does on its low flood plain below the mouth of Ohio

River; but western Pennsylvania is a rugged region, with a general upland surface rising as much as 500 feet above the water level of the principal streams. In such a region it is an extremely difficult and slow process for a stream to cut off any of its meanders, and it is manifestly impossible for it to establish a totally new course unless the conditions under which it operates are very different from those which normally affect the development of a stream.

Prof. I. C. White describes the anomalous character of the deposit and the physical features of the region, and in a vague way he has attributed them to the ponding of the northward-flowing waters by the advance of the glacial ice sheet in the Beaver Valley. If the valley were silted up to an altitude of about 1050 feet the change in the course of the stream might be accounted for by superimposition; but the absence of silt in a part of the Carmichael channel shows clearly that the valley was not silted up in all its parts, and consequently the present drainage cannot be regarded as superimposed.

In attempting to account for these abandoned valleys it is necessary to go outside of the territory under consideration and briefly describe similar phenomena in other parts of the province, in order to determine the general conditions under which they were formed.

Outside of the glaciated region abandoned river channels of the character here described do not occur except in the Ohio Valley. So far as the writer's knowledge goes, they are limited to the following streams: Allegheny, Kiskiminitas, Youghiogheny, Monongahela, Kanawha, Guyandot, Big Sandy, Kentucky, and Ohio rivers. These streams are located a short distance south of the limit of glaciation; therefore the abandonment of the channels seems to be due to some condition induced by the presence of the ice sheet. The contemporaneity of the two phenomena is corroborated by the occurrence of fossil leaves in an abandoned channel near Morgantown, W. Va. According to Dr. F. H. Knowlton these leaves have an arctic facies and probably were deposited during the Glacial epoch. In studying the problem still further it will be noted that abandoned channels are most abundant on streams that flow to the north or northwest, directly toward the ice front. The streams flowing in that direction are the Monongahela, Youghiogheny, Kanawha, Guyandot, Big Sandy, Kentucky, and some minor streams that originally drained a part of the Ohio Valley above Kanawha River. On all these streams except possibly Kentucky River abandoned channels are abundant.

In this connection it may be noted that the drainage of the upper Ohio has suffered decided changes through the advance of the glacial ice-sheet. It is now fairly well established that the present Allegheny River system was formerly divided into three parts, all of which drained into the St. Lawrence Basin. The waters of Monongahela River also found a northern outlet through Beaver River into the same system. Kanawha River with its tributaries, Guyandot and Big Sandy, flowed northward through the present Scioto Valley, and probably constituted a branch of the river system which occupied the basin of Lake Erie. The advancing ice sheet is supposed to have dammed these northward-flowing streams and forced the water to seek another outlet along the present course of the Allegheny and Ohio rivers. In the pond which ensued from this ice blockade the silts found along the abandoned channels of Monongahela River were formerly supposed to have been deposited, and to the cutting down of the new outlet and the draining of this immense pond has been attributed the origin of the abandoned valleys. While it must be admitted that ponding to a certain extent took place during these changes of drainage, and probably silt was deposited in the lakes so formed, it is plainly apparent, as is shown on another page, that general ponding can not account for the irregularities of deposition that are shown in the sediments. It is possible that scattering gravel, which occurs in many places up to altitudes of from 1050 to 1070 feet, was deposited in the ponded waters at the time of the formation of the Allegheny–Ohio River. In fact the Monongahela Valley may have been filled by these gravel deposits to a depth of 1050 feet; but, if so, they were almost completely removed before the Carmichaels valley was abandoned.

The irregularities of the principal deposits indicate that local conditions controlled the deposition of the material, and also that they were responsible for the change in the alignment of the streams. The question now presents itself, What local conditions could produce such profound changes in the drainage of the region? They evidently occurred during the prevalence of arctic conditions, and if so it seems probable that ice was the instrument which caused them. The glacial ice sheet did not reach so far south, and hence it can not have been directly instrumental in producing them. It seems probable that during the short summers which must have prevailed at that time the ice in the rivers which flowed north, or toward the ice front, would break first near the heads of the streams. This broken ice on being swept down would tend to form jams or gorges, as the ice to-day is gorged in most of the northern rivers during the break-up in the spring. With the topographic environment and under the arctic condition then existing, it seems possible that immense dams may have been built by floating ice, and owing to the shortness of the summer season they were not melted away before the rigors of the ensuing winter fixed them firmly in position. During the second summer they may have been increased in the same manner in which they were originally built, and it seems possible that the result may have been a dam so strong as to have persisted for a great many seasons, and so high as to force the water to seek a new outlet in some more favorable locality. In the pond produced by such dams immense quantities of silt would accumulate, but the character and arrangement of the material would depend largely on the shape of the channel and on the location of the outlet. If the outlet occurred near the dam, strong currents would, doubtless, sweep through the entire pond, and the finer material would be carried on, leaving only the coarser sediments in the bottom of the pond. If the outlet occurred at some distance from the point where the dam was built, as in the Carmichaels channel, there would be a large body of water nearly free from currents, and in such places finely laminated clay would be deposited. The most striking example of such deposition is in the great Teays Valley of southern West Virginia, which was vacated by Kanawha River under similar conditions. In this valley laminated clay of the finest character accumulated to a depth of 60 feet. The outlet was 14 miles above the dam, and sedimentation in the lake was quiet and undisturbed. Below such a dam little or no deposition would occur, and the channel would be left in the same condition as when it was occupied by the active stream before the formation of the dam.

It may be urged that it would be impossible for such a dam to persist long enough for the stream to intrench itself in a new course. It must be remembered, however, that during the cutting of the new channel the old is being silted up, and that the work necessary is only sufficient to lower the grade of the stream below the top of the silt in the old valley. This presumably, would be less than 50 feet in all cases; and with the volume of water that, doubtless, then prevailed, it may have been accomplished during the life of the dam.

The number of such ice gorges is indefinite, but it is easy to conceive that each abandoned channel is the result of an independent ice jam. If only one such barrier were formed in the Monongahela Valley it would be possible to determine its exact location through a careful study of the sediments deposited behind the barrier; but if the hypothesis is correct a great many such barriers were formed, and the sedimentation which took place in the pond behind any dam was a very important factor in concealing the deposits which had previously been laid down in other ponds above it. On account of this fact the abandoned channels of the Monongahela Valley are fairly uniformly covered with clay and sand deposits, but in the case of the great abandoned valley at Carmichaels, which is located a few miles south of Brownsville, part of the valley is apparently left in the same condition as it was when it was vacated by the stream. This is one of the longest abandoned valleys of the river, having a length of about 8 miles. The upper part for a distance of about 6 miles is filled from 10 to 80 feet deep with alternating beds of sand and clay. About 2½ miles northeast of Carmichaels these deposits end abruptly, and the valley floor below this point, a part of which is well preserved, shows a filling of only a few feet of sand and gravel. This lower portion is apparently left in the condition in which it was occupied by the Monongahela before the barrier was formed which permitted the silting up of its upper course, and the location of this barrier is definitely determined by the northern limit of the heavy silt deposits.

Similar conditions prevailed in the great Teays Valley of southern West Virginia, and the location of two barriers can be determined with considerable certainty.

In the Brownsville and Connellsville quadrangles there are two distinct classes of features associated with change in the drainage—abandoned channels and rock terraces. According to the hypothesis just presented the former are to be attributed to local obstructions caused by river ice; but the latter are only indirectly and in part attributable to the same cause.

In the first place the old valley is broader than that occupied by the present stream, and the cutting of a narrow valley in the floor of a broad one will necessarily leave fragments of the old floor as terraces bordering the present valley. Their distribution, however, is not regular, and they show the way in which the stream has developed since the abandonment of the old course. The most noticeable change in the stream is the downward migration of the bends, which is well illustrated in the arrangement of the new and old courses between Brownsville and Lucyville. In streams flowing over broad flood plains, like Mississippi River, such a migration is not surprising, but in a stream flowing in a comparatively narrow valley, appreciable movement is hardly to be expected. It is probably due, in large measure, to the silt deposits which doubtless covered its channel about the time when the current of the stream was accelerated by an uplift of the land. Such deposits of silt would cause the river to meander as broadly as its rocky bluffs would permit, and would fix the stream in position to continue the work by lateral corrasion when the uplift occurred. Cases of this kind are to be seen on Monongahela River below Brownsville and Charleroi, and on the Youghiogheny near Jacobs Creek and West Newton.

In most cases the bends have been increased in sharpness by recent corrasion, but in a few localities the opposite movement has taken place. Examples of this kind of change may be seen on Monongahela River in the southwestern corner of the Brownsville quadrangle and from Bellevernon to Charleroi. Presumably this is due to accumulations of silt by which the course of the river was superimposed upon its old channel in a curve with a longer radius than it formerly had; and the subsequent lateral corrasion of the stream has not succeeded in reaching its original position.

Each of the abandoned valleys of Monongahela River may be explained by the existence of a local barrier of ice in some part of its course; but in the case of multiple channels, as at Bellevernon, it is necessary to assume the existence of several dams. From the comparative depth of filling it is probable that the outermost channel is the one originally occupied, and that by successive ice blockades the stream has been forced to cut off the bend until it has reached its present position. In this case three dams are required to explain the different courses of the stream.

It is natural to suppose that on the abandonment of an extensive channel the minor tributaries would direct their courses along the pathway already established. Where the old channel was deeply and irregularly filled with silt the minor drainage might not follow closely the abandoned valley, but generally speaking it would, unless the subsequent drainage was affected by barriers in its pathway. The most remarkable examples of this lack of harmony are exhibited in the old abandoned river valley by Redstone and Gillespie. The narrowness of the neck of land on the inside of this bend might suggest that the cut-off was effected by lateral corrasion of the river. A close examination, however, shows that while the old stream had cut well back into this narrow divide, it still maintained a curve that carried it by without interfering with the returning curve on the opposite side of the divide; therefore it seems extremely probable that the change was due to an ice blockade somewhere in this bend. This held the water up to such a height that it found an outlet over a low divide in the vicinity of Stockdale, and the new course of the river was established directly across the neck of the bend. During this process the old channel was silted up to a depth of between 40 and 50 feet, and upon this deep covering of silt the new drainage was established. The South Fork of Little Redstone Creek entered the old valley at Woodglen and passed to the west in the direction of Troytown, but instead of following the old channel to the river it turned abruptly to the right and cut across the neck of the bend in the narrow channel toward Gillespie. The other fork of the creek entered the old valley about a half mile east, and turning to the north followed approximately the abandoned channel to about a half mile west of Redstone. Instead of continuing in the broad, open valley which the river had previously established, the minor drainage turned to the left and cut a narrow gorge through the hills, returning to the old valley in the vicinity of Gillespie. Even at the headwaters of this tributary it did not follow exactly the main channel previously eroded, but it turned to the left at Redstone and cut through the low hills composed of rocks in place, emerging to the valley again a little below the post-office. The Little Redstone, formed by the union of the two branches at Gillespie, should, presumably, have followed the old channel to the west; but instead it continued directly across the old valley and cut into the high hills which border it on the north, forming a narrow gorge from Gillespie to the river.

At present there are no obstructions in the valley to account for the abnormal courses of these minor tributaries. The valley floor below such points is only slightly strewn with silt, and it does not appear ever to have been so deeply covered as to cause the streams to take the positions in which they are found to-day. The abnormalities of the minor drainage seem to be best accounted for, therefore, on the same hypothesis that has been applied to the larger streams, namely, the ice blockade. If the original ice gorge was formed about one-half mile east of Gillespie, it is possible to conceive of the water finding three outlets, one to the south and just around the end of the dam, one across the neck of the divide, in the position of Little Redstone Creek, and one at Stockdale. These three spillways may have been utilized for a long time, and all of them may have been reduced approximately to the level of the silts deposited in the old valley. In the end the channel at Stockdale, having the advantage of directness in course, prevailed against the others, and the main body of water found an outlet at this place. The other channels were so well reduced by this time that the minor drainage found in them the easiest pathways from the valley, and they have been utilized up to the present time. It is more difficult to account for the cut-off which Little Redstone Creek has made north of Gillespie, but it seems possible that this may be due to an independent ice dam which formed in the old channel west of Gillespie.

In many cases the minor drainage is located on the margin of the old channel instead of along its central part, in what naturally would be supposed to be the lowest course. A good example of this is found in the South Branch of Maple Creek, which enters the old valley west of Bellevernon, but which keeps along the western side of the valley to Charleroi, where it unites with the other branch of the creek and cuts directly across the old channel to the present river. This position of the creek may be explained by supposing that the amphitheater which the river excavated west of Bellevernon was silted up to a greater depth than the channel further east, and the small stream, instead of forcing its way across this heavy deposit, found an outlet along its inner edge and became established on the rocky wall of the valley. It also may be explained on the assumption that this portion of the river bed was not occupied by a strong current, and, in the eddy thus created, ice accumulated which formed a complete barrier to the minor tributary, causing it to seek a new location along the boundary wall of the valley.

Youghiogheny River is characterized by phenomena similar to those described along Monongahela River, and they are probably due to the same set of conditions. In many cases the abandoned valleys are simple and show but one cut-off, while in other cases they are complex, indicating that the river has been blocked by ice a number of times.

The change at Connellsville was doubtless due to an ice gorge in the bend near Trotter, and the abandonment of the sharp reverse curve in the vicinity of Dawson was due to a similar obstruction. At Perryopolis two distinct ice blockades must have occurred, which gave rise to the two channels already described at this point.

In the vicinity of Smithton and Port Royal the abandoned channels are so numerous that it is difficult to determine the various courses that the river has pursued and to fix the position of the ice dam that caused each change. It seems probable, however, that each remaining channel calls for the assumption of an ice blockade to account for its abandonment. On this supposition there must have been four or five extensive ice gorges in this locality, and time enough must have elapsed between the formation of these dams for the cutting of new channels and the reduction of the adjacent slopes to a comparatively easy grade. This seems to require a length of time so vast that it is difficult to conceive of its occurring during any ice invasion; but since the accepted idea regarding the length of time occupied by such an invasion is confessedly vague, this objection has comparatively little weight.

Below West Newton the changes have not been so profound. The channel has swung from side to side, but it is doubtful whether there is any distinct feature that may be classed as an abandoned valley due to an ice blockade.

There are a few cases along Youghiogheny River which seem to indicate that changes of this character were produced at two distinct periods of its history. In the older channels the rock floor stands at an altitude of 900 to 940 feet above sea level, and in the younger cut-offs it is below 800 feet. This is well shown in the little amphitheater carved in the hills opposite West Newton, where the upper terrace is plainly visible at about 900 feet and the abandoned channel shows a floor at about 780 feet.

SUMMARY.

In a brief way the physiographic history of this region may be summarized as follows:

First. A long period of subaerial erosion in early Cretaceous time during which a well-developed peneplain was produced over most of this territory; but this is now so deeply eroded as not to be recognizable in these quadrangles.

Second. An elevation of about 1000 feet and the formation of a second peneplain which was not so well developed as that of the first period. This probably belongs to early Tertiary time and may possibly represent the Eocene period.

Third. An elevation of from 100 to 150 feet, and a second cycle of reduction, which was terminated before erosion had progressed so far as to give the streams a low grade or to reduce the principal divides of the region to a nearly horizontal plain not very far from base-level.

Fourth. A rise of about 200 feet, and a third stage of subaerial erosion, which extended into Pleistocene time and is marked by the higher abandoned valleys just described. As stated in another paragraph, this probably corresponds with the earliest great ice invasion, which is generally referred to the Kansan stage. This epoch in the history of the region was terminated by an uplift of about 200 feet. No substages in the further erosion of the region down to the present level have been detected, except the low-level abandoned valley opposite West Newton, which probably is due to the recurrence of climatic conditions induced by a late ice invasion—possibly the Wisconsin stage.

GEOLOGY.

STRUCTURE.

The geologic structure of the Appalachian coal field is very simple, consisting, in a general way, of a broad, flat, canoe-shaped trough. This is particularly true of the northern extremity, a generalized map of which is shown in fig. 94. The deepest part of the trough is along a line extending southwest from Pittsburg across West Virginia. On the southeastern side of this axis the rocks dip to the northwest, and on the northwestern side they dip toward the southeast. About the canoe-shaped northern end the strata show in rudely semicircular lines of outcrop, and generally they dip toward the lowest part of the trough, which is in the southwest corner of the State.

Although the general structure of the region is of this simple character, the eastern limb of the trough is crumpled into a number of parallel wrinkles or folds that make the detailed structure somewhat complicated and break up the regular westward dip of the rocks so that at first sight it is not apparent. Close examination, however, shows that from the Allegheny Front west each succeeding trough is deeper than the one on the east and that the arches show a corresponding decrease in altitude, until beds which have an altitude of over 2000 feet at the Allegheny Front extend below sea level in the central part of the basin.

In describing these folds the upward-bending arch is called an anticline and the downward-bending trough is called a syncline. The axis of a fold is that line which at every point occupies the highest part of the anticline or the lowest part of the syncline, and from which the strata dip in the anticline and toward which they dip in the syncline.

STRUCTURE IN THE BROWNSVILLE AND CONNELLSVILLE QUADRANGLES.

In the folios previously published geologic structure generally has been represented by means of structure sections drawn to natural scale and showing the rocks as they would appear if cut by a deep trench across the quadrangle. Where the dips are steep and the structures pronounced this is undoubtedly the most effective way of illustrating the attitude of the rocks; but where dips are light, as in western Pennsylvania, structure drawn to natural scale is scarcely perceptible, and consequently a structure section, although accurately drawn, fails to convey to the eye any information regarding the structural features of the region. Moreover, a section shows the structure along a single line only, whereas for economic purposes the coal operator wants to know the size, shape, and depth of the basins, and the oil and gas prospectors want similar information regarding the arches or anticlines.

In order to represent the geologic structure at all points in the quadrangles structure contours are employed as follows: The most prominent and persistent stratum in the region is selected as a key-rock. The top or bottom of this bed is called the datum surface, and the form of this surface is ascertained, first, from observations of its outcrop; second, from its depth beneath beds above it; and, third, from its height above beds beneath it. In the first case the stratum outcrops and the altitude of the datum surface is determined by observation. In the second the datum is underground, and its position is calculated by subtracting from the surface altitude the thickness of the interval separating the datum surface from the stratum observed in outcrop. In the third case the datum is in the air, that is, it has been eroded, and its position is determined by adding to the surface altitude the estimated thickness of the interval between the stratum showing in outcrop and the datum surface.

From the topographic map the approximate altitude of any outcrop can be ascertained, and thus the height above sea level can be determined for a corresponding point on the datum surface. In this manner the altitudes of hundreds of points on the datum surface are determined in each quadrangle. Points having the same altitude are then connected by a contour line which gives the form of the datum surface at that altitude. Many such lines are drawn at regular vertical intervals, and, as printed on the topographic map, they show, first, the horizontal contours of the troughs and arches; second, the dip of the beds; and third, the depth of the datum below, or its height above, the surface at any point.

The accuracy of the structure contours varies from place to place, according to local conditions. Where mines have been opened on the datum surface, as in the case of the Pittsburg coal, the contours are based upon precise levels and consequently are thorough reliable; but in other cases they are liable to errors of several kinds. Since in all cases they are determined from the altitude of observed outcrops, their position depends upon the degree of accuracy of the topographic base maps; and while in many instances topographic altitudes are determined by spirit level, they do not all attain this degree of accuracy. Geologic determinations are usually based upon readings of the aneroid barometer or upon determinations of the hand level; and though these are constantly checked against precise bench-marks, and the instrumental error is probably slight, it may in some cases be appreciable. Another source of possible error is that all estimates are based upon the assumption that over small areas the rocks maintain a constant thickness or vary uniformly. If the rocks change suddenly in thickness or vary irregularly, then the position of the contour lines will be in error by the amount of the irregular variation. Finally, the determination of structure at the surface can be extended to buried or eroded strata only in a general way, and consequently many of the details are lost. These various sources of error may combine or they may compensate one another; but in any case it is believed their sum is less than the contour interval.

In these quadrangles the most pronounced structural features lie in the mountainous country southeast of Connellsville. The parallel ridges which are conspicuous features of this region owe their existence to anticlines of hard rocks that have withstood erosion better than the softer rocks of the adjacent synclines.

In order to bring out the structure of this mountainous belt, the top of the Pottsville sandstone is selected as a datum surface, and is represented by contour lines at intervals of 100 feet.

Chestnut Ridge anticline.—Only a small area of the mountainous region is included in the Connellsville quadrangle, and that is made up of the Chestnut Ridge anticline, the axis of which crosses the southeastern corner of the quadrangle. It is the highest fold in the two quadrangles, and brings up the Mississippian rocks on the mountain slopes so that in the deepest part of Breakneck gorge they are exposed nearly to the base of the Pocono sandstone.

This fold originates in the Ligonier Valley south of Youghiogheny River. Its first appearance as a recognizable fold is on the National Pike near Mount Washington. From this point it increases in magnitude northward and gradually approaches the main line of Chestnut-Laurel Ridge.

Near the southern margin of the Connellsville quadrangle it is joined by the Laurel Hill fold, which forms merely a wrinkle on the west side of the Chestnut Ridge anticline. The axis swings into line on the Springfield Pike, where it may be observed at the extreme summit of the mountain. At this point the upper surface of the Pottsville sandstone has an altitude of almost 2300 feet above sea level. For about a mile on either side of the axis the rocks are nearly flat, but the slopes soon change and the rocks dip steeply on the flanks of the ridge. Toward its base they flatten somewhat as the anticline unites with the synclinal fold which borders it on the northwestern side.

So far as can be determined in this quadrangle the anticlinal fold is symmetrical and regular. The only possible exception is in the vicinity of Green Lick Run, where the contours swing away from the ridge in sympathy with a cross anticline which exists at this point and which will be described more fully in the discussion of the Fayette axis.

On the west slope of Chestnut Ridge the Pottsville sandstone dips beneath the surface, and it does not show in outcrop, with one small exception, until the western limb of the basin is reached in east-central Ohio. In the central part of the basin the stratum passes far below sea level, and its presence is revealed only by the drill when the region is prospected for oil or gas. On account of its inaccessibility it has not been used at a datum surface. The most prominent stratum west of Chestnut Ridge is the Pittsburg coal, and the floor of this bed has been selected as the datum surface upon which to draw structure contours. The interval between the top of the Pottsville sandstone and the Pittsburg coal is about 900 feet; so one system of contours may be converted into the other by adding or subtracting 900 feet.

Since the Pittsburg coal is mined extensively in this region, the data for determining the position of the contours in the coal basins are very accurate. In such areas contour lines with a vertical interval of 20 feet have been drawn. Where there are many large mines, as in the Connellsville basin and along Monongahela and Youghiogheny rivers, the contours have been determined from mine maps, showing the altitude of the coal as determined by instrumental surveys; and in such localities the contours are generally accurately located.

In the areas from which the Pittsburg coal has been eroded, the datum surface, if restored, would lie above the present surface of the earth, and its position has been calculated from that of the outcropping beds. In such areas the contours are much less accurately determined, and a contour interval of 50 feet is sufficient to express all the recognizable details.

Latrobe syncline.—The Chestnut Ridge anticline is bordered on the west by a synclinal trough which extends from the West Virginia line to beyond the Conemaugh River. This in reality consists of two synclines which are connected in a measure, but are slightly offset in the vicinity of Scottdale. From Scottdale south the syncline consits of a symmetrical, elongated basin, which in the Masontown-Uniontown folio is called the Uniontown syncline. From Scottdale to the Conemaugh River there is another regular basin which is here called the Latrobe syncline. This is probably not so regular as the Uniontown basin, but it is essentially a single syncline, and will be considered apart from the Uniontown basin.

In the Uniontown syncline the Pittsburg coal reaches its lowest altitude, 550 feet above sea level, about 3½ miles northeast of Uniontown. Thence it rises along the axis of the syncline to about 650 feet at the southern margin of the Connellsville quadrangle, and then more rapidly to 1080 feet at the northern end of the syncline, one-half mile east of Everson. The dips on the Pittsburg coal reach 5° on the eastern side of the syncline and a little more than 2° on the western side, and then flatten out around the northern end to 1° or less. The syncline is thus decidedly unsymmetrical in cross section. Its eastern and western slopes are very regular, but many minor irregularities exist around the northern end in the bottom of the basin, as is indicated by the sharp crooks and broad swings of the contours. The northern end of the syncline is rounded and canoe-shaped, in strong contrast to the southern end of the Latrobe syncline, next to be described.

The Latrobe syncline is separated from the Uniontown syncline by a cross anticline which proceeds as a spur from the highest part of the Fayette anticline on the west and extends eastward to unite, about a mile slightly east of north of Scottdale, with a similar though much less developed spur on the western side of the Chestnut Ridge anticline. The effect of this cross anticline is plainly observable in the course of the contour lines at the southern end of the Latrobe syncline, where they are at right angles to the main axial lines of the region. At its southwestern extremity the Latrobe syncline has no definite axis. The line might just as well be located as far west as Alverton as in its present position, and thus make a prominent offset in the general axial line of the Connellsville basin. The axis as located pitches rapidly from 1080 feet elevation at Iron Bridge to 840 feet one-half mile north of Mount Pleasant, and then more slowly to 770 feet, its lowest point, a short distance east of the quadrangle and about 1½ miles east of Southwest. The dips of the Pittsburg coal are about equal on the two sides of the syncline, reaching a maximum of about 3° along the outcrop of the coal, and flattening in the bottom of the trough. This gives a symmetrical cross section with very regularly sloping sides, except around the broad southern end, where the strata are much puckered on account of the conflicting strains to which they have been subjected.

In both the Latrobe and the Uniontown syncline the outcrop of the coal is marked on the east in a general way by the 1100-foot contour and on the west by the 1200-foot contour, with a few outliers on the high hills beyond. Jacobs Creek crosses the axial line of the basin on the crest of the cross anticline, and cuts out the Pittsburg coal for a space about one-half mile wide, so that there is no connection between the coal in the two synclines.

Fayette anticline.—West of the two synclines described the strata rise to the axis of the Fayette anticline, which begins near the southern boundary of the State and extends to the Conemaugh River. At its southern extremity the Pittsburg coal has an altitude of 1150 feet on the axis of the fold. The arch increases in magnitude toward the north, and the coal has been eroded; but if it were restored to its original position it would have an altitude of 1450 feet on the southern line of the Connellsville quadrangle and 1800 feet at the point of maximum development, where it crosses Jacobs Creek. From this point the axis pitches slightly to the northeast, and the coal, if restored, would have an altitude of 1450 feet where the axis leaves the territory, northeast of Youngwood. This seems to be a local depression, for west of Latrobe the anticline again expands to about the same size as in the Jacobs Creek region.

Disregarding local deviations, the direction of the axis is about N. 30° E. to a point about 1¼ miles east of Centerville, where it swings eastward and bears about N. 40° E. to the northern border of the quadrangle. Where the arch reaches its greatest development it is broad and rather flat and throws off to the east the spur which has been described. Both northward and southward from the flat portion of the arch its crest narrows rapidly and the contours are extended into long points. The eastern and western dips differ but little in the southern part of the quadrangle, being about 3½° on the west and 3° on the east in the Jacobs Creek region.

In the northern part of the quadrangle the Fayette anticline is modified to some extent by the development of the Greensburg syncline and the Grapeville anticline, which extend from this region at least as far north as the Conemaugh River. The most pronounced effect of these folds is to change the direction of the Fayette axis, causing it to swing in a broad curve from a course a little east of north to one directly northeast. The minor folds have also steepened the northwestward dips in the vicinity of Youngwood and flattened them at Walts Mill, giving to the Fayette arch an irregular, unsymmetrical appearance.

In previous reports on this region the Fayette anticline is represented as bifurcating southwest of Hunkers into two branches which inclose the Greensburg basin. The present work shows clearly that this is not the case. The Fayette anticline is a single fold across this quadrangle, and it shows no direct connection with the Grapeville anticline. Unfortunately, in the region north of Sewickley Creek and between Madison and Youngwood, key rocks are almost entirely lacking and it is extremely difficult to determine how the folds terminate. They undoubtedly appear in this territory, but their forms are somewhat hypothetical.

The magnitude of the Fayette arch was not realized by Professor Stevenson when he surveyed this region in 1876, for he classed the lowest rocks exposed along Jacobs Creek and Youghiogheny River as parts of the Allegheny formation, whereas there is now incontestable evidence that these rocks belong to the Pottsville sandstone.

Lambert syncline.—One of the most pronounced local basins is the Lambert syncline, which enters the Brownsville quadrangle from the south. The most southerly point at which it has been recognized, as shown in the Masontown-Uniontown folio, is in Greene County, a few miles north of the West Virginia State line. It deepens toward the north, reaching its maximum development west of New Salem in Fayette County, where the Pittsburg coal lies at an altitude of about 450 feet in the center of the syncline. The axis extends into the Brownsville quadrangle, crossing Redstone Creek near the mouth of Washwater Run, and terminating in a cross anticline 2 miles west of Perryopolis. Near the southern line of the quadrangle the coal has an altitude of about 500 feet. It rises rapidly, and at the extremity of the axis, west of Perryopolis, it attains an altitude of about 780 feet. This basin is steeper on the southeast side, the rocks rising more rapidly over the great Fayette anticline than over the low, irregular arch of the opposite border.

Brownsville anticline.—West of the Lambert syncline occurs a small, irregular anticlinal fold, or rather a series of elongated dome-shaped structures on a common axis. This axis is about as long as that of the Lambert syncline, beginning at Whiteley Creek, in Greene County, and extending northeastward, crossing the Monongahela at East Riverside, and thence passing east of Brownsville and terminating within a mile of the northern end of the Lambert syncline. South of Monongahela River the fold is very poorly developed, and it can be traced only in a general way to the southern extremity just mentioned. North of the river the fold is somewhat more pronounced, but its greatest development is in the vicinity of Brownsville, where the Pittsburg coal reaches an altitude of over 800 feet above sea level. This extreme height extends a little beyond Redstone Creek, and then the fold becomes rather insignificant, with a total height, measured from the flat, irregular syncline on the northwest, of 50 or 60 feet. Toward the northeast it rises again, and back of Gillespie the coal attains the same altitude that it has in the vicinity of Brownsville. Beyond this point the axis plunges, and the anticline is merged in the minor folds that mark the termination of the Port Royal syncline.

Port Royal syncline.—In the northern part of the quadrangles the coal dips rapidly from the Fayette anticline on the east into a deep basin the axis of which crosses Youghiogheny River at Port Royal and cuts the northern line of the territory about a mile east of the northwest corner of the Connellsville quadrangle. In its deepest part this syncline carries the coal below drainage level from West Newton to near the mouth of Jacobs Creek. Near the northern line of the territory the coal in the center of the basin lies at an altitude of about 620 feet. It deepens toward the southwest, reaching its minimum altitude of 570 feet about 2 miles southeast of West Newton. From this point the axis rises gradually to the southern line of Westmoreland County, where it rises suddenly, and the syncline is terminated in an irregularly rounded point which has no definite axial line. In a vague and indefinite way the Port Royal synclinal axis may be extended along the slight depression back of Fayette City and connected with a shallow basin near Kenneth. From this basin the lowest line of the floor of the coal passes to the northwest for about a mile, and then swings sharply into the regular northeast-southwest line along which another basin of greater magnitude has been developed north of Krepp Knob. From this basin the axis may be continued into a low area west of Bridgeport and extended southwest to about the southern line of the quadrangle. The general altitude of the coal in this flat, irregular trough is about 780 feet above tide in the vicinity of Fayette City and Kenneth. The axis plunges to the south, and the coal reaches a minimum of 680 feet in the inclosed basin north of Krepp Knob. South of this point the floor of the basin appears to be flat and regular at an altitude of about 700 feet, but the absence of mine data makes it impossible to determine the minor irregularities of the structure contours.

Through this broad trough, which includes the Port Royal and Lambert synclines and the Brownsville anticline, the structure contours generally have been determined with considerable accuracy. Throughout much of the territory bordering the two rivers the contours are based upon precise levels, and therefore are very nearly correct. This is also true of the east side of the basin along Washington Run, where the contours have been determined from mine data for a mile and a half back from the outcrop. On Redstone Creek similar mine data are available; but the general shape of the point of the Lambert syncline was determined largely from drill records in the region between Big and Little Redstone creeks. Between the two large rivers there is considerable territory in which no mine data are available. This extends from Arnold City to Wickhaven, from Ohio City to Rostraver, and from Fells Church to West Newton. Throughout this territory there are a few gas well records in which the coal is noted, but the contours generally have been determined by tracing the Waynesburg coal and its associated beds at the surface.

Bellevernon anticline.—The most pronounced structural feature in the Brownsville quadrangle is the Bellevernon anticline, which enters the territory about 2 miles north of its southwest corner. The axis of the fold crosses the National Pike at East Bethlehem and then swings to the west somewhat in harmony with the great curve of the river below California. The axis continues to the northeast, crossing Monongahela River at the mouth of Maple Creek, and again coming to the river bank in the vicinity of Sheppler mine. From this point it follows the river to within a mile of Webster, and then extends in a general northeasterly course across Youghiogheny River, where it terminates in the vicinity of Sutersville and Blackburn.

In former reports this has been called the Waynesburg anticline; but since the fold reaches its maximum development in the vicinity of Bellevernon, and since the gas field which has been extensively developed along this axis from Salem Church to the South Branch of Maple Creek is generally known as the Bellevernon gas field, the anticline has been designated by the same name. Where the axis enters the quadrangle on the west the Pittsburg coal has an altitude of about 840 feet, and it rises rapidly to an altitude of 1000 feet about one mile northeast of Pike Run. From this point the fold increases slowly in height to the South Branch of Maple Creek, where a sharp dome is found that marks the greatest development of the anticline. The coal at this point has an altitude of about 1060 feet. Toward the northeast the axis plunges irregularly, the coal reaching an altitude of about 1000 feet near the mouth of Maple Creek and 950 feet in the vicinity of Sheppler. At this point the fold sends off a small spur to the east, but this is soon lost in the general irregularity of the slope of the anticline. The axis descends sharply to Webster, where the coal has an altitude of 900 feet; but beyond this point it has a low grade to Salem Church and Sutersville, having an altitude at the latter locality of about 740 feet. At this point the anticline is terminated abruptly by a sharp synclinal wrinkle which crosses the river near Industry and extends to the northeast directly across the pathway of the Bellevernon anticline. The axis of the anticline may be followed nearly to Blackburn, but beyond this point the fold is broken up into several irregular minor undulations and has no distinct axial line. It plunges rapidly as far as the north line of the quadrangle, and presumably extends only a short distance from this point before being completely lost in the irregular margin of the broad synclinal basin.

Throughout the extent of this fold the contours have been determined with a fair degree of certainty. In the vicinity of the rivers, mine data are available for most of the territory, and consequently the contours are well fixed. Outside of this belt the position of the contours is determined by surface observations and by drill records, which are fairly abundant in the gas field that everywhere marks this fold.

Pigeon Creek syncline.—Northwest of the Bellevernon anticline, the structure in the Brownville quadrangle is extremely irregular. In a general way the anticlinal fold is bordered on this side by a synclinal depression, the axis of which enters the territory near the middle of its western border. It coincides with the course of Pigeon Creek for several miles, but below the station of this name it swings to the east across Taylors Run and crosses the river midway between Gallatin and Manown. The axis rises and falls irregularly, but continues in a general northeasterly course as far as the east line of Forward Township in Allegheny County. Here it swings decidedly to the east and coincides almost exactly with the course of the small stream which enters the Youghiogheny at Douglas. At this point the structure is better described as a wrinkle than as a synclinal fold, and as such it extends to the northeast, as heretofore described, cutting off the Bellevernon anticline and probably merging into the irregular basin floor north of the quadrangle. The greatest development of this basin is in the valley of Pigeon Creek, and consequently it has been designated by that name, although in previous reports it has been called the Waynesburg syncline.

Where the axis enters the territory on the west the Pittsburg coal has an altitude of about 725 feet. The axis plunges to the northeast into a broad, shallow basin, about 2 miles north of Pigeon Creek station, in which the coal has an altitude of about 690 feet. The structure between Pigeon and Mingo creeks is somewhat obscure. From surface indications it could not be determined definitely, but from a gas well which was recently drilled at Baidland the altitude of the floor of the Pittsburg coal was found to be about 780 feet. This is lower than any exposure known on Mingo Creek. It seems probable that the synclinal structure indicated by this well is an offshoot of the Pigeon Creek basin, and as such it has been contoured on the map; but it is also possible that the low altitude of the coal at the Baidland well is due to a local depression and not to a bifurcation of the Pigeon Creek syncline. In this part of the territory the contouring must be accepted merely as provisional and subject to revision on the establisment of more accurate data.

From the broad basin of the Pigeon Creek syncline the axis rises to the northeast, as shown by altitudes obtained in the Catsburg, Ivil, and Black Diamond mines, to an altitude of about 770 feet where the axis crosses Monongahela River. Beyond this point there is a slight constriction in the trough shown in the levels of the Gallatin mine, and then a wide expansion into a basin-like depression in which the coal holds the same altitude as on the river. From this basin to the northeastern extremity of the synclinal fold, as here recognized, the trough is narrow and deep, being, as before mentioned, merely a wrinkle in the Bellevernon anticline. It has a depth of 40 or 50 feet along its axial line, and has been a rather serious factor in the development of the coal mines of this region.

Peters Creek anticline.—North of Monongahela the Pigeon Creek syncline is bounded on the west by a pronounced anticlinal fold which plunges rapidly to the south and presumably disappears in a distance of a few miles. At the northern line of the territory the Pittsburg coal has an altitude of 900 feet on this axis, but at Monongahela it is only about 800 feet above sea level. The northeastward extension of this fold has not been definitely determined, but in previous reports it has been mapped as the Peters Creek anticline. The abrupt termination of this pronounced fold gives rise to northwest-southeast strike lines across the northwest corner of the quadrangle, but beyond the river, in the vicinity of Shire Oaks, the strike lines curve sharply to the west and pursue a normal northeast-southwest direction across the extreme corner of the quadrangle. The northwestward rise of the rocks is due to an anticlinal axis in the valley of Peters Creek beyond the limits of the quadrangle. Its exact position has not been determined by this survey, but in previous reports it was mapped and designated by Prof. I. C. White as the Pinhook anticline.

In the region bounded on the southeast by the Pigeon Creek syncline, on the northwest by the Pinhook anticline, and on the northeast by the Peters Creek anticline, the geologic structure is extremely complicated. In general the dips are rather light, but the structures do not appear to be regular, and hence do not follow definite axial lines. One of the most pronounced features is a slight anticline in the vicinity of Ginger Hill. This appears to be best developed west of the territory, and is nearly cut off by the cross syncline which is thrown off on the northwestern side of the Pigeon Creek axis. At Ginger Hill the Pittsburg coal has an altitude of about 800 feet. It descends to the northeast, reaching an altitude of about 775 feet where it crosses the river in the vicinity of Riverview. Beyond this point there are no decided swings of the anticlinal fold, but the axis appears to connect with a slight bulge on the side of the Peters Creek anticline. On the northwest side of this slight anticline there is an irregular synclinal basin which appears to reach its maximum development in the old Eagle mine, on the east side of the river. This showed as a decided swamp, having a depth of 20 or 30 feet and trending in a northeast direction.

SUMMARY.

So far, the accurate determination of geologic structure has extended only over the Brownsville, Connellsville, Masontown, and Uniontown quadrangles. Fig. 3 is a sketch map showing the structure of this region by contour lines with a 50-foot contour interval. The area of any one quadrangle is so small that it is difficult to comprehend the broader relations of the geologic structures there shown. For this purpose the more comprehensive sketch map is introduced. On this will be seen the Fayette anticline, which extends nearly across the territory, but reaches its best development a little north of Youghiogheny River in the Connellsville quadrangle. The Bellevernon anticline is seen extending across the Brownsville quadrangle and reaching its greatest development a little south of Monongahela River.

On the east side of the Fayette fold and lying between it and the Chestnut Ridge anticline are the Uniontown and Latrobe synclines, separated by a cross anticline in the vicinity of Scottdale. The Uniontown syncline reaches its maximum development north of the town of Uniontown, and the Latrobe syncline attains its maximum development a little beyond the eastern border of the quadrangles. Between the Fayette anticline and the Bellevernon anticline is a great synclinal trough, which is broken up into local basins by a cross anticline from Perryopolis to Fayette City and also by a low, irregular longitudinal fold along the Brownsville axis. The most southerly deep basin is the Lambert syncline, and it reaches its maximum development in the northern part of the Masontown quadrangle. The deep basin on the north is the Port Royal syncline, which attains its greatest development near the crossing of Youghiogheny River. A close examination of the structural features shows that the greatest development of the anticlines is opposite the least development of the synclines, and, conversely, that the greatest development of the synclines is opposite the low points of the anticlinal folds. Thus the lowest points of the Lambert and Uniontown synclines are on an east-and-west line through the northern part of the Masontown and Uniontown quadrangles, and the greatest development of the Port Royal and Latrobe synclines is along a corresponding line in the northern part of the Brownsville and Connellsville quadrangles. The maximum development of the Fayette and Bellevernon anticlines is along an east-and-west line in nearly the central part of the Brownsville and Connellsville quadrangles.

Aside from this systematic arrangement of anticlines and synclines, it will be noted that the folds are not generally of great longitudinal extent, but are broken up into relatively short basins and ellipsoidal domes. This structure is extremely favorable for gas accumulation, and to it probably is due the location of the great pools of western Pennsylvania.

STRATIGRAPHY.

The rocks exposed at the surface in these quadrangles are all of Carboniferous age. They may be separated into two series, which differ from each other in character and in the conditions under which they were deposited. The lower and generally marine sediments are included in the Mississippian series, and the upper coal-bearing rocks in the Pennsylvanian series.

Carboniferous System.

MISSISSIPPIAN SERIES.

The rocks of this age are found only in Chestnut Ridge, in the southeastern corner of the Connellsville quadrangle. They are naturally divided into two formations, a sandy formation below and a shaly and calcareous formation above.

POCONO SANDSTONE.

This comprises the lower and more sandy division of the Mississippian series. The sandstones of this formation are best exposed in the valley of Breakneck Run. They extend down from a bed of siliceous limestone to the bottom of the ravine, about 400 feet, without showing any marked change of character, though the rocks are more shaly toward the base.

The lower limit of the Carboniferous system has never been satisfactorily determined in southwestern Pennsylvania. In an exposure along the National Pike in the Uniontown quadrangle the Pocono sandstone is a lithologic unit, and its base is sharply defined by a thin bed of conglomerate which marks the beginning of the deposition of sandy material; but even in this case it is not certain that this horizon marks the inauguration of the Carboniferous period. Characteristic Chemung fossils are reported by Professor Stevenson as occurring within two feet of the base of this conglomerate. Hence the underlying rocks clearly belong to the Devonian system; but no fossils have been found in the sandstone above, so its age is in a measure hypothetical.

In the Brownsville and Connellsville quadrangles the basal part of the Pocono sandstone is not exposed at the surface, and the only available information regarding its composition is afforded by deep wells. Only a few such wells have been sunk in the Connellsville quadrangle, but a large number have been drilled in the gas belt of the Brownsville quadrangle. From these records it is apparent that while the formation is prevailingly sandy, the mass of the sandstone is broken up in many places by bands of shale, which become more frequent as the distance from the top of the formation increases. Lower down the proportion of sand and shale is about equal, and finally the shale predominates and the rocks undoubtedly belong to the Devonian system. According to these records the mass of prevailingly sandy rocks ranges from 380 to 470 feet in thickness.

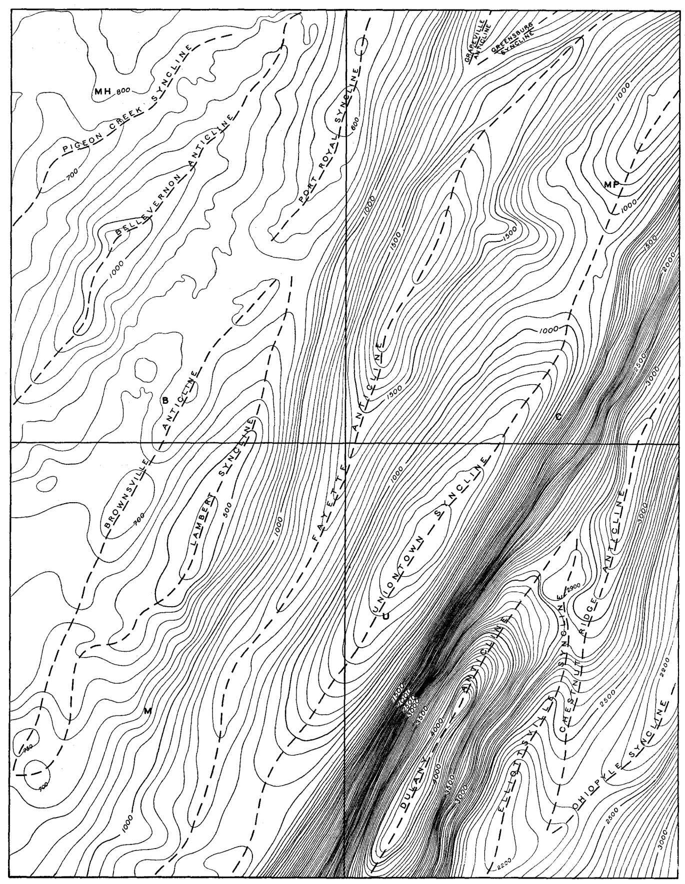


Fig. 3.—Sketch map of Brownsville, Connellsville, Masontown, and Uniontown quadrangles, showing the geologic structure by means of contour lines drawn on the floor of the Pittsburg coal. Contour interval, 50 feet. MH, Monongahela; B, Brownsville; MP, Mount Pleasant; C, Connellsville; M, Masontown; U, Uniontown.

The upper part of the formation is usually more massive and resistant than the lower, and on account of that fact it is a more prominent feature in the topography of the region. At the top the sandstone is replaced by a strongly arenaceous limestone, which, according to Professor Stevenson,[1] is generally present over the southern half of the State.

In previous reports on this region the limestone has been regarded as belonging to the formation next above, but during the progress of this survey it was not found practicable to attempt their separation in the field. Professor Stevenson recognized this difficulty, for in his report on Bedford and Fulton counties he states that "This bed [siliceous limestone] is much more closely related to the Pocono sandstone than to the Mauch Chunk shales."

[1] Notes upon the Mauch Chunk of Pennsylvania: Am. Geologist for April, 1902, vol. 29, pp. 242-249.

At the top the limestone is blue and only slightly sandy and would not for a moment be confused with the sandstone below, but in passing downward the limestone is found to become more sandy, until from an arenaceous limestone it becomes a calcareous sandstone, and farther down it grades into the nearly pure sandstone beds of the well-known Pocono formation.

The siliceous limestone is utilized for railroad ballast, large crushing plants having been erected in the Conemaugh Gap above Blairsville, in the Loyalhanna Gap above Latrobe, and in the Youghiogheny Gap above Connellsville. At the last-named locality the quarry face has a height of 60 feet, and the rock is overlain by a bed of very bright red shale.

The Pocono sandstone is remarkably persistent in the southwestern part of the State. It probably has been encountered in every deep well that has been drilled in this section of the country, but to the driller it is known only by the fanciful name of the Big Injun sand.

MAUCH CHUNK FORMATION.

Above the siliceous limestone are red and green shales with interstratified limestone and sandstone beds, comprising the Mauch Chunk formation. This is poorly exposed in Chestnut Ridge, in the Connellsville quadrangle. It shows as a narrow band of outcrop around the steep hillsides over the siliceous limestone, but it is so generally concealed by débris from the Pottsville sandstone above that it is difficult if not impossible to obtain an accurate measure of its thickness. It probably amounts to from 100 to 200 feet. Since the Pottsville sandstone rests unconformably upon it, its thickness varies from place to place, depending upon the amount of erosion that took place before the sandstone was deposited.

Very few details were obtained in the Connellsville quadrangle regarding the character of the shales of this formation. Their presence is usually indicated by the red color of the soil; outcrops are rare. Presumably the interval is occupied by variegated shales, among which red and green colors predominate. The shale beds are also frequently interstratified with beds of greenish sandstone, but these are generally soft and are inconspicuous in their effect upon the surface features of the region.

West of Chestnut Ridge the Mauch Chunk shale is below drainage level, but some information regarding its thickness and character may be obtained from deep wells. In the Highberger well, which is located one mile west of Walts Mill on Sewickley Creek, the Mauch Chunk may be identified. According to this well record its section is as follows:

Mauch Chunk formation near Walts Mill, on Sewickley Creek.

	Feet.
Red rock	15
Slate, white and shells	10
Red rock	40
Sand	5
Limestone (Greenbrier)	35
Slate and shells	10
Total	115

In the absence of red shale or limestone the various members of this formation are difficult to identify in well records. The usual practice is to group two or three of the heavy sandstone beds into one division and call it Pottsville, and the beds which occupy the interval between the Pottsville and Pocono sandstones are classed as Mauch Chunk. The top of the Pocono is generally well determined and is a reliable horizon marker, but it is not at all certain that the base of the Pottsville is equally well marked in all places. Where it consists of a massive sandstone or conglomerate it is easy to determine, but there are, doubtless, many localities in which there is no heavy bed at the base of the formation, and consequently the shale beds belonging to this group of rocks are separated with difficulty from those of the underlying Mauch Chunk formation. In the Stephen Applegate well, which is located northeast of Monongahela, the section of the Mauch Chunk appears to be as follows:

Mauch Chunk formation at Stephen Applegate's well.

	Feet.
Slate, white	10
Slate, red	75
Limestone	60
Total	145

It is somewhat doubtful whether the uppermost member in this section should be classed with the Mauch Chunk or with the overlying Pottsville. The same is true of the bed shown in the Gibson well at Gibsonton, which is as follows:

Mauch Chunk formation at Gibsonton.

	Feet.
Slate	58
Red rock	30
Slate	32
Sandstone	50
Slate	40
Total	210

In the Parsons well, which is located on the South Branch of Maple Creek, the Mauch Chunk shows a similar arrangement, with a questionable slate 10 feet in thickness at the top of the formation. The section of the Mauch Chunk shown in this well is as follows:

Mauch Chunk formation at Parsons well.

	Feet.
Slate	10
Limestone	10
Red rock	25
Slate	30
Sandstone	25
Slate	10
Limestone	40
Total	150

From these sections it appears that the Mauch Chunk is generally present throughout the western part of this territory, and that it ranges from 100 to 200 feet in thickness.

The irregularity of the thickness of this formation throughout western Pennsylvania, and the variability in character of the beds in contact with the Pottsville sandstone, are presumably due to the unconformity between the two formations. This unconformity is plainly apparent on the west side of the Appalachian coal basin from Pennsylvania to Alabama, and it extends beneath the basin at least as far as the Allegheny Front. Its effect upon the geology of the region will be more fully considered in the description of the Pottsville sandstone.

Greenbrier limestone lentil.—The Mauch Chunk formation, in the type locality in the eastern part of the State, is composed almost entirely of red and brown shales and brown sandstone, and no limestones are recognized. Farther west a limestone appears which at first is extremely thin, but which thickens to the southwest, until in a large measure it replaces the Mauch Chunk formation. This bed is the great Greenbrier limestone of central Virginia, which in its greatly expanded development constitutes most of the Mississippian series in the interior of the continent. In no part of Pennsylvania does this bed of limestone attain a greater thickness at its outcrop than 30 feet. It occurs about 50 feet above the siliceous limestone and throughout the southern part of the State this interval is always occupied by beds of typical Mauch Chunk red shale.

In a recent report on Allegany County, Md., the Greenbrier limestone is treated as an independent formation, including not only the thin band of fossiliferous limestone but also the underlying red shale. In approaching this region from the south the Maryland classification is undoubtedly the more rational one; but on entering the field from the northeast the fossiliferous limestone appears as a wedge in the Mauch Chunk red shale, and can not be separated from it as a distinct formation without separating the rocks above and below, which lithologically belong to the same formation. It is believed that to treat the Greenbrier limestone as a lentil is much more satisfactory than to consider it, with the underlying shale, as a separate formation.

In its best development in Pennsylvania the Greenbrier limestone lentil has a thickness of about 30 feet. The larger part of the formation is composed of thin beds of pure blue limestone, but toward the top it changes, through gradations of shaly limestone and calcareous shale, to olive-green shale. It is extremely fossiliferous, but during the progress of this survey no collections were made by which to determine its precise geologic age. Professor Stevenson (see paper cited) recently collected some fossils from a quarry on the east flank of Laurel Ridge east of Uniontown. The fossils are pronounced by Dr. Stuart Weller to be of Genevieve age and to be identical with those occurring in the Maxville limestone of southern Ohio. From these fossils it is apparent that the Greenbrier limestone lentil occurs near the base of the Chester formation.

The outcrop of this limestone is limited to Chestnut Ridge, around which it shows in a thin band seldom exceeding 20 feet in thickness. It is generally easy to find, for numerous quarries have been opened. The stone is largely used for burning into lime for agricultural purposes.

PENNSYLVANIAN SERIES.

POTTSVILLE SANDSTONE.

The Pottsville sandstone is the lowest member of the Pennsylvanian series or true coal-bearing rocks. It rests unconformably upon the soft shales of the Mauch Chunk formation, and it is overlain by the relatively soft rocks of the Allegheny formation. Sandwiched thus between formations which are easily eroded, the hard beds of the Pottsville are conspicuous features of the landscape. To their resistant character is due much of the mountainous topography of this part of the State, and the erosion of the soft shale beneath causes the heavy sandstone beds to stand out in prominent cliffs. The Pottsville sandstone is best exposed along Youghiogheny River just south of this territory. Its most accessible and best exposed outcrop is near the center of the Ligonier syncline, where it shows along the Baltimore and Ohio Railroad from near Indian Creek to Ohiopyle. In this locality it consists of two heavy benches of sandstone separated by an irregular shale interval which varies from 20 to 50 feet in thickness. In this interval there is usually an irregular coal bed from which fossil plants have been obtained that show that it is equivalent to the Mercer coals of the western part of the State. The upper sandstone is very massive and in places attains a thickness of from 80 to 100 feet. This bed occurs above the Mercer coal horizon, and consequently is equivalent to the Homewood sandstone of the Beaver Valley. The bottom plate of sandstone is variable in thickness, ranging from 30 to 80 feet, but occasionally it appears to be wanting. It undoubtedly corresponds to some part of the Connoquenessing sandstone of the Beaver Valley. The beds also are very irregular and seem to have been deposited as lenses in swiftly moving currents of water.

In the Brownsville and Connellsville quadrangles the Pottsville is exposed only on Chestnut Ridge. The upper sandstone is generally massive and resistant, and the slopes below its outcrop are deeply covered with its débris. For this reason it is difficult to obtain a good section of the formation. One of the best exposures is that which shows on Breakneck Run above the reservoir. The bed of sandstone against which the dam is built is the basal portion of this formation. This bed has an exposed thickness of 30 feet. Above it the rocks are mostly concealed to the base of the second sandstone ledge, 75 feet above the water of the reservoir. This ledge is underlain by black shale in which pits were excavated long ago, either for mining coal or for procuring iron ore from the body of the shale. Above the black shale is a massive sandstone with a thickness of about 20 feet. Above this there is a concealed interval of about 40 feet, and the top of the formation is apparently composed of a coarse but thin bed of white sandstone. The total thickness of the formation at this point is 155 feet. From the nature of the exposures it is now impossible to say whether the bed is composed of two or three sandstone members, but Professor Stevenson states that at the time of the previous survey the upper interval was exposed and was found to consist of sandstone separated by a few feet of sandy shale.

The Pottsville is exposed in every ravine along the west slope of Chestnut Ridge. It dips strongly to the northwest, and at the foot of the ridge passes below drainage level, and appears in only two localities in the territory, west of this line. The great size of the Fayette anticline where it is crossed by Jacobs Creek and Youghiogheny River carries the Pottsville to such a height that it has been exposed by both streams. In previous surveys of this region the Pottsville was not recognized west of Connellsville. The lowest rocks showing along the Baltimore and Ohio Railroad across the Fayette anticline were considered by Professor Stevenson to belong to the Allegheny formation. This identification was probably due to the fact that the Pottsville beds are not particularly massive in this locality, and consequently are not so conspicuous as they are farther east. The Pottsville sandstone rises from water level a little below Oakdale, and attains its greatest height of about 100 feet above railroad grade on the axis a little west of Virgin Run. It descends rapidly toward the northwest and reaches water level at the next sharp bend of the river. From this point to Layton the river swings eastward around a great bend, and in so doing cuts back well toward the anticlinal axis, and, in consequence, the Pottsville rises again in a pronounced arch, which has its maximum development near the sand works about a mile above Layton. The uppermost bench, presumably the Homewood sandstone, has a thickness of about 40 feet where it is first exposed, but in the quarry at the sand works its thickness is about 60 feet. The quarried rock is crushed and shipped to various points, where it is used in the manufacture of glass. The shale interval which separates the two sandy members of the formation is about 60 feet thick. It contains two or three small coal beds, one of which seems to have been mistaken for the Upper Freeport coal in previous surveys of the region.

The identification of these beds as a part of the Pottsville formation is based upon their stratigraphic relations, and also upon fossil plants which were collected from a shale lens showing by the side of the track of the Pittsburg and Lake Erie Railway about a mile above Layton. The stream has not cut deep enough to expose the base of the formation, and, consequently, its thickness has not been determined.

Similar exposures are to be found on Jacobs Creek where it crosses the Fayette anticline, but the channel of the creek is not so low as that of the river, and consequently the beds are not so well exposed.

Throughout the remainder of this territory the Pottsville is below drainage level, and its character is known only from the records of deep wells which have penetrated it. In the Highberger well the section of the Pottsville is as follows;

Pottsville formation at Highberger well.

	Feet.
Sandstone	80
Slate, black	10
Slate, white, and shales	20
Sand, black	10
Slate, black	10
Sand, white	35
Total	165

In the northwestern part of the territory it appears to have a slightly greater thickness, as shown by the record of the Stephen Applegate well, as follows:

Pottsville formation at Stephen Applegate well.

	Feet.
Sand, gray	50
Slate, white	20
Sand, white	30
Slate, while	30
Sand, gray	75
Total	205

The Homewood sandstone member seems to thicken southward, for, according to the record of the Gibson well, it has a thickness of 155 feet at Gibsonton. It is possible that the highest member contains more than one bed, but this fact was not noted by the driller. The reported section of the Pottsville in this well is as follows:

Pottsville formation at Gibson well, Gibsonton.

	Feet.
Sandstone	155
Slate	40
Sandstone	40
Total	235

The Parsons well shows a similar arrangement but a somewhat reduced thickness, as follows:

Pottsville formation at Parsons well.

	Feet.
Sandstone	105
Coal	8
Sandstone	67
Total	180

The events which attended the deposition of the Pottsville formation constitute one of the most interesting episodes in the geologic history of this region. It was formerly supposed that the variation in thickness of this formation was due to different conditions of sedimentation, and that the rocks in the thin sections on the west side of the basin corresponded in age with those of the thick sections on the east. Through the study of fossil plants Mr. David White[1] has recently demonstrated that this is not the case; that the thin sections are due to lack of sedimentation, and that they are separated from the underlying rocks by a long time interval that is represented by the deposition of at least the lower half of the formation, as it appears fully developed in the type locality in the Southern Anthracite field.

According to Mr. White, the thickness of the Pottsville in the Southern Anthracite basin is 1200 feet, in the Western Middle field 850 feet, and in the Northern field 225 feet. The published reports give it as 160 feet in thickness in the Broadtop basin and 65 feet in the Conemaugh gap, through Chestnut Ridge. In the Uniontown region it has a thickness of 200 feet, and in the western part of the State its general average is about 300 feet. Toward the south it increases steadily in thickness, until on the Kanawha River it exceeds the greatest measure known in the anthracite field.

From the evidence afforded by fossil plants, Mr. White proves conclusively that about the beginning of the Pottsville epoch an uplift occurred, which affected much of the Ohio Valley. A large land area was formed that extended as far east as the Broadtop and the Northern Anthracite fields. This land area persisted until at least 600 feet of Pottsville sediments were deposited in the Southern Anthracite basin. A subsidence then occurred in the western part of the State which allowed the Sharon conglomerate and its associated coal group to be deposited, but presumably this area of sedimentation did not extend as far east as the Connellsville quadrangle, since the plants found in this region indicate that the bed first laid down is equivalent to the Connoquenessing sandstone.

At the close of the Sharon episode the land along the Allegheny Front apparently sank, and unbroken sedimentation was resumed from the anthracite basins to the western edge of the bituminous field.

ALLEGHENY FORMATION.

The Allegheny formation overlies the coarse beds of the Pottsville sandstone, and its average thickness in these quadrangles is about 280 feet. This was formerly called the "Lower Productive Measures," from the fact that most of the workable coal beds in the lower part of the series occur within it. More recently it has been referred to as the Allegheny River series; but the practice is to drop the word "river" and call it simply the Allegheny formation.

Localities.—The Allegheny formation shows in outcrop along the western flank of Chestnut Ridge. It dips rapidly to the northwest and soon passes below water level. Throughout the Connellsville basin it is under several hundred feet of cover, but on the Fayette anticline it occupies a higher position and is exposed wherever the surface is deeply eroded.

The most northerly outcrop along this line is in the valley of Sewickley Creek, where the formation is exposed from Emmonston to some distance below Hunkers. The erosion of the valley has not been great enough to reveal the entire thickness of the formation, but about 100 feet of rocks belonging to the upper part are exposed in this locality. The Upper Freeport coal is of workable thickness along Sewickley Creek, and in the early days it was extensively mined to supply fuel for the salt works which were located at this point.

The valley of Barren Run is very deeply eroded, but throughout its lower part the creek is flowing on the western side of the anticline, and consequently it has not reached the horizon of the Upper Freeport coal. Above Centerville, however, the creek occupies a course considerably farther east and almost upon the axis of the fold. At this point it has undoubtedly cut below the horizon of the Upper Freeport coal, but the coal itself was not seen during the present survey. It is, however, reported from this locality, and there seems to be little doubt that it is exposed.

Jacobs Creek below Tyrone Mills has so deeply dissected the anticline that it has revealed not only the Allegheny formation but nearly a hundred feet of the Pottsville that underlies it. The coal beds of the Allegheny formation have been prospected along this creek to considerable extent, showing that the Upper Freeport and Lower Kittanning coals are probably of workable thickness. The formation rises above water level a short distance below Tyrone Mills, and disappears about a mile above the mouth of Barren Run. The Mahoning sandstone, which overlies the Upper Freeport coal, is well developed in this region, and it can be used as a guide in tracing the coal bed.

The most extensive exposure of this formation is along Youghiogheny River from a little below Laurel Run to Layton. All the rocks appearing in this interval were classed by Professor Stevenson as Allegheny, but recent work has shown that the lower part, for a thickness of about 100 feet, belongs to the Pottsville formation. The misidentification of these beds was probably due to several causes, among which is the fact that the Upper Freeport is thin and inconspicuous in this region. The usual criterion for the identification of the Upper Freeport coal is a bed of workable thickness underlying a heavy sandstone. Along the river the Mahoning sandstone is badly broken in places, so that it is not conspicuous in outcrop, and the Freeport coal, presumably, is not over 2 feet in thickness. The key to the solution of the structure and stratigraphy in this region lies in the heavy plate of Saltsburg sandstone which forms an extensive table-land in this locality. Where well developed its top is approximately 200 feet above the Upper Freeport coal. With this as a guide it is easy to determine the position of the Upper Freeport coal back of Layton, where the Bolivar clay underlying it has been dug for the manufacture of brick. The Lower Kittanning

[1] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 755-918.

coal is also identifiable, being the most important bed, so far as known, in the Allegheny formation. It shows in outcrop back of Layton about 50 feet above railroad grade. The Upper and Lower Freeport coals were identified on the south side of the river opposite Layton, but neither of them is thick enough to promise much for future development. In various hillside sections along the river the three Kittanning coals were noted in approximately their correct positions, but with the exception of the Lower they are not of workable thickness. The Lower Kittanning bed is underlain by a thick deposit of fire clay which resembles very stongly the fire clay at the same horizon in the Allegheny Valley. An interesting exposure on Virgin Run shows two small coal beds a short distance above the top of the Homewood sandstone. These, presumable, may be correlated with the Brookville and Clarion coals of the Allegheny Valley, and so far as known this is the most southerly point at which the two coal beds can be separated and identified.

On the western side of the Fayette anticline the Allegheny formation dips below water level and is not seen again in these quadrangles. It is not always easy to determine these rocks in the deep well records, but occasionally they can be identified. In the Highberger well near Walts Mill it is probable that the sandstone, 50 feet in thickness, which was reached at a depth of 297 feet, is the Mahoning sandstone. The Bolivar fire clay also seems to be present 15 feet below the sandstone. The 10-foot coal struck at a depth of 469 feet is hard to identify. In fact, it seems possible that this may be a bed of black shale, with some coal, at the Middle Kittanning horizon. The other members of the formation, as shown by this record, have no distinct characteristics and can not be identified. The total thickness of the formation as determined by this record is about 264 feet. In the Stephen Applegate well, north of Monongahela, the Upper Freeport coal was struck at a depth of 1030 feet. This bed occurs 285 feet above the top of the Pottsville, and has a reported thickness of 4 feet. The total thickness of the formation agrees very well with the measures obtained in other localities, but the reports made as to the character of the material found in this well is open to question. From the Upper Freeport coal to within 10 feet of the Pottsville the material is reported to consist of nothing but sand. This, without doubt, is a mistake.

In the Gibson well the Allegheny formation has a thickness of 265 feet. The Upper Freeport coal is reported to have a thickness of 6 feet and to occur 640 feet below the surface. A 4-foot coal was noted 155 feet lower. This doubtless belongs to the Kittanning group, but it is difficult to say which of the Kittanning coals it is.

In the Parson well, drilled on the South Branch of Maple Creek, the Allegheny formation is not clearly shown in the record, but a sandstone occurring 255 feet above the supposed top of the Pottsville may be regarded as the Mahoning sandstone. On the whole the well records and the measured outcrops show a remarkable agreement in the thickness of the Allegheny formation, so that it seems probable that the formation ranges in thickfrom 225 to 285 feet.

From data obtained on Sewickley Creek Professor Stevenson was inclined to believe that the Allegheny formation is 400 feet thick; but these figures rest on the assumption that the salt rock which occurs about 400 feet below the Upper Freeport coal bed is the Homewood sandstone. Apparently this determination is based on the fact that it is conglomeratic and that it carries salt water. In the well at Ruff's saltworks 200 feet of sandstone were pierced before the salt rock was reached. A part or the whole of this may belong to the Pottsville formation, and the salt rock may be the Connoquenessing sandstone. There is such a general agreement among the determinations of the thickness of the Allegheny formation, from other drill records and from surface outcrops, that the uncertain records of these old salt wells can not be accepted as conclusive evidence of a great thickness on the Fayette anticline.

The individual beds of this formation vary so greatly in character and thickness that it is difficult to find any one section that can be regarded as typical of the region. One of the best exposures in the Ligonier Valley is found at the mouth of Cucumber Run, near Ohiopyle. This may be regarded as typical of the Ligonier Valley and Chestnut Ridge region. This section was published by Professor Stevenson in report KKK of the Ligonier Valley; by Professor I. C. White in Bulletin 65, U. S. Geological Survey; and in the Masontown-Uniontown folio. The various coal beds so well known throughout the Allegheny Valley are represented in this section, with the exception of the Brookville or the Clarion bed. In the interval usually occupied by these two beds there is found only one coal throughout the southern part of the State. This coal has been referred by different writers to different horizons. Professor Stevenson classed it as Brookville, while Professor White inclined to the opinion that it belongs to the Clarion. In the Masontown-Uniontown folio this was called the Brookville-Clarion horizon, and it will be so designated in this report.

Another typical feature in this section is the Upper Freeport limestone, which occurs a few feet below the Upper Freeport coal. This limestone is generally present in the Ligonier Valley and along the west side of Chestnut Ridge. It was not seen in the Connellsville quadrangle, but doubtless it is persistent throughout this region.

The Bolivar fire clay is well developed in the region east of Connellsville. It shows in the Cucumber Run section about 40 feet below the Upper Freeport coal. It is mined in various places along the Baltimore and Ohio Railroad and also along the west face of Chestnut Ridge north of Connellsville.

An exceptional feature in the Cucumber Run section is the absence of the Freeport sandstone, which is generally present in the interval between the Lower Freeport and Upper Kittanning coal beds. The great thickness of the Upper Kittanning coal as compared with the Lower is also an unusual feature. The Upper Kittanning is usually referred to locally as the "pot vein," from its lenticular character and its great irregularity. The Lower Kittanning coal, on the other hand, is extremely regular in thickness and composition. In the Cucumber Run section the latter is so thin that it was noted simply as a bloom, but throughout the territory generally it probably has a greater average thickness than the Upper Kittanning.

In the Chestnut Ridge portion of the Connellsville quadrangle the Allegheny formation is poorly exposed. The rocks generally are less resistant than the measures that overlie them; and they are decidedly softer than the Pottsville sandstone upon which they rest. For this reason they generally form a sort of back valley which is deeply covered by débris from the mountain slopes above. The Upper Freeport coal bed has been opened in a number of places along this line of outcrop, and the Bolivar clay, which closely underlies it, has been developed for the manufacture of fire brick to be used in the construction of coke ovens.

CONEMAUGH FORMATION.

The coal-bearing rocks of Pennsylvania were originally subdivided with reference to the coal beds which they contained. The rocks lying above the Upper Freeport coal and below the Pittsburg coal contain only a few small coal beds, and consequently they were designated in the early reports of the region the Barren Measures. Dr. I. C. White has called them the Elk River series, from a locality in southern West Virginia; but recently the name Conemaugh has been revived and is applied to this formation in the same sense in which it was originally used by Rogers.

The formation varies somewhat in thickness, but its range is not great, and 590 feet may be regarded as its average thickness. It is composed largely of shale, but it carries a number of beds of sandstone, which in places are massive and which have had a great influence in shaping the topography of the region. Sandstones are particularly abundant in the lower part of the formation. In a general way a sandstone group having a thickness of about 200 feet may be said to exist above the Upper Freeport coal bed. The shales are somewhat variegated, but the prevailing tint is green or gray. The formation is almost barren of limestone, only two insignificant beds being known in this territory. The most important of these is the green fossiliferous limestone that usually occurs about 30 feet below the Morgantown sandstone. It is not a conspicuous feature in outcrop, and is hardly so valuable a key rock as the larger sandstone beds.

The formation shows in outcrop along the northwest base of Chestnut Ridge. It also forms the surface of the Fayette anticline, except in the deep gorges of the principal streams. These two areas of outcrop are connected in the vicinity of Scottdale, where the Pittsburg coal has been raised above drainage level by a cross anticline, and has been removed by erosion. West of the Fayette anticline the rocks dip steeply, and the Pittsburg coal reaches water level a short distance below the mouth of Jacobs Creek. It rises on the western limb of the syncline just below West Newton, and the uppermost beds of the Conemaugh formation are visible in the river bluffs to the northern edge of the territory.

Along Monongahela River the Conemaugh beds are exposed in continuous outcrop from the northern boundary of the quadrangle to Brownsville. At this point the Pittsburg coal passes below water level, but it reappears again in the bend in the southwestern part of the quadrangle, and the Conemaugh rocks are exposed above water level as far up as Fredericktown. The rocks are so nearly flat that the coal is near water level throughout most of this territory. It varies from 0 to 250 feet above the level of the river.

Mahoning sandstone member.—This sandstone overlies the Upper Freeport coal. It is usually separated from the coal by a shale bed about 10 feet in thickness, but occasionally the coal and the sandstone are in direct contact. The sandstone is generally coarse, but is not so massive in this region as either the Saltsburg or the Morgantown; neither does it seem to be so persistent as the upper beds, being frequently replaced by softer material. It shows in outcrop at a number of places along the western flank of Chestnut Ridge and in the vicinity of Paintersville and Hunkers, where the Upper Freeport coal is exposed on Sewickley Creek on the crest of the Fayette anticline. Along Youghiogheny River the Mahoning is not very conspicuous, being no heavier than any of the other sandstone beds that are exposed in the river bluffs. It is well shown, however, on Virgin Run, at the first road crossing, about 2 miles above its mouth. The stream here makes a picturesque cascade over this heavy bed, and the Freeport coal was once opened directly below it.

The Mahoning sandstone is frequently spoken of as composed of an upper and a lower member, and, indeed, there seems to be a tendency to include under this term most of the heavy sandstones of the lower Conemaugh formation. There seems to be no good ground for such a classification, since the Mahoning can generally be separated from the overlying sandstone with little difficulty, and the Saltsburg is clearly a separate and distinct sandstone.

Saltsburg sandstone member.—In the Connellsville quadrangle this bed is the most prominent member of the Conemaugh series. It is more massive and persistent than either the Morgantown or the Mahoning bed. It occurs about 400 feet below the Pittsburg coal, and its upper surface is generally about 200 feet above the Freeport coal. It is extensively developed on the Fayette anticline southwest of Hunkers, and through its ability to resist erosion has produced the high land which marks this anticline in the southern half of the quadrangle. On account of its prominence as a horizon marker in an otherwise monotonous series of sandstones and shales, and of its persistence and geographic development in the Connellsville region, it has been represented on the geologic map as a special member of the Conemaugh formation.

On the south side of Youghiogheny River this bed is a conspicuous feature. It caps the high land overlying the stream at an altitude of more than 1300 feet. Owing to the pitch of the anticlinal axis toward the southwest the Saltsburg sandstone disappears below the surface in the vicinity of Flatwoods and is not known as a particularly massive or thick bed south of this point. Its horizon is exposed at Redstone Creek, but at the time the Masontown and Uniontown quadrangles were surveyed it was not deemed of sufficient importanceto be represented on the map.

Probably it reaches its best development in the area enclosed by Jacobs Creek and the Youghiogheny River, in the vicinity of Fort Hill. It is here massive and forms an extensive plateau at an altitude of about 1400 feet. Curiously enough it attains its maximum development on the axis of the fold and diminishes in thickness and importance on both sides of the axis. It is with considerable difficulty that it can be traced to river level either above or below the point where the stream is crossed by the axis of the Fayette anticline. In passing down the river from the vicinity of Fort Hill the sandstone is seen at the surface and is easily traced as far as Layton, but below that point it is no more conspicuous than many other beds in the series, and it is difficult to say just where it passes below drainage level. On the opposite side of the stream it is conspicuous on the point east of Perryopolis. It is here a rather soft, friable sandstone, but is conspicuous from the fact that it forms the extreme summit of the point of land between Washington Run and the river.

On the southeastern side of the anticline it loses its massive character in the vicinity of Laurel Run, and its point of disappearance under the river is difficult to determine. It seems probable, however, that it reaches railroad grade about half way between the mouth of Laurel Run and the brickworks on the Pittsburg and Lake Erie Railway below Dickerson Run.

North of Jacobs Creek the sandstone is well developed, especially on the State road from a little west of Reagantown nearly to Centerville. Here the arch is very pronounced, and the sandstone can be followed from creek level on Meadow Run to the summit at Macbeth and then down on the west side to water level at the foot of the hill on Barren Run. The tracing and identification of this bed is somewhat complicated in this region from the fact that a sandstone of similar character occurs a short distance above. This is well developed along Barren Run and is easily mistaken for the Saltsburg. North of the State road the sandstone loses some of its massiveness and is not so conspicuous. It is easily identified on the West Newton and Mount Pleasant pike as far east as the intersection of the Pittsburg pike, but beyond that point it is thin bedded and can be traced only with great difficulty. It is well developed on the Pittsburg pike as far west as Walts Mill, where it is thin, but conspicuous on account of its coarseness and resistance to erosion. It is probable, however, that it loses its character near this point, for it has not been noted in the records of wells drilled on Sewickley Creek. North of this creek the bed may be followed continuously to a point about a mile east of Old Stanton, but beyond this point it has not been identified. It seems to disappear and has not been recognized in the region north of Old Stanton and Armbrust. On the Clay pike northwest of Old Stanton the Saltsburg sandstone is supposed to show in outcrop near the northern boundary of the quadrangle, being brought up on the Grapeville anticline, which develops north of Walts Mill. At this point the sandstone is thin and inconspicuous and it is possible that it has been incorrectly identified. This can be told only by tracing it to the north where the anticline is more fully developed. The absence of the sandstone in this region is extremely unfortunate, since it is almost impossible to determine the exact geologic structure without this key rock. The Morgantown is also poorly developed north of Old Stanton, and consequently there is no heavy bed that can be followed in outcrop. In the vicinity of Madison the Morgantown shows in full force, and east of Youngwood it occupies the high ridge north of Armbrust. The Saltsburg sandstone is not present east of Youngwood, but a few miles to the northeast it reappears, and it has been traced continuously from that point to Loyalhanna Creek northwest of Latrobe.

This sandstone has not been traced continuously to the type locality, and its correlation with the heavy bed of sandstone under the town of Saltsburg is therefore based entirely upon its stratigraphic position; but the intervals between it and the Freeport coal below and the Pittsburg above agree so well with the position of the Saltsburg sandstone at the type locality that there is scarcely a reasonable doubt of its identity. In thickness the bed ranges from 0 to 80 feet, and in its best development along Youghiogheny River it has been quarried extensively for heavy masonry work.

Morgantown sandstone member.—This sandstone lies about 150 feet below the Pittsburg coal. It is probably the most persistent sandstone in the region, being generally present in the southwestern part of the State wherever its horizon is exposed at the surface. It varies in character from a coarse, massive sandstone to a thin-bedded rock, and sometimes appears to be replaced by sandy shale, but generally it is present and has a decided effect on the topography of the region. In this territory the Morgantown sandstone is best developed in the northeastern quarter of the Connellsville quadrangle. It is responsible for many of the flat high-topped hills in the vicinity of Hunkers and Armbrust. In this locality it is a massive sandstone, and is quarried for heavy masonry. The bed is of sufficient importance here to deserve mapping, but does not hold this characteristic throughout the territory, and hence is not represented on the geologic map. It was named from the city of Morgantown, W. Va., where it is well exposed and extensively quarried.

Connellsville sandstone member.—There is generally present at a distance of from 40 to 60 feet below the Pittsburg coal a coarse sandstone which has received its name from the city of Connellsville, in which it shows in outcrop. It is not always present, sometimes appearing to break up into thin-bedded sandstone or sandy shale that does not make a marked showing on the surface. This bed lies so near the Pittsburg coal that its importance as a key rock is overshadowed by the coal, which is better known in its outcrop and in its underground extension than any other member of the series.

MONONGAHELA FORMATION.

This formation contains most of the coal beds of the upper part of the series, its bounding lines being so arranged as to include the Pittsburg coal at its base and the Waynesburg bed at its top. It is the best-known formation in these quadrangles, on account of the wide geographical distribution of its outcrop and of the fact that most of the shafts and prospect holes have pierced it in their descent to the famous Pittsburg bed, which constitutes the bottom of the formation. The limits of the formation are generally easy to determine in this region. The Pittsburg coal at the base is mined extensively on its outcrop along the two rivers and in the Connellsville basin. In other localities it has been well prospected for local use, so that its outcrop is always plainly apparent. The upper limit of the formation is more difficult to determine, since the Waynesburg coal is much less prominent than the Pittsburg bed. Where the sandstone, which normally overlies the Waynesburg coal, is present in typical development, the boundary line is easy to determine, but the sandstone is variable and at many points it seems to be wanting altogether. Other sandstones of equal coarseness and massiveness may occur in the section, both above and below the horizon of the Waynesburg sandstone. The coal beds of this part of the formation appear also to be somewhat variable from place to place, so that it is not always easy to determine which bed belongs at the Waynesburg horizon, and, consquently, forms the upper limit of the Monongahela formation.

The formation appears to be more variable in thickness than those which underlie it, though possibly it appears so only because more data are available for determining its exact thickness than for determining the thickness of the other formations. In the vicinity of Washington Run, southwest of Perryopolis, as determined from accurate mine levels, the Waynesburg coal lies about 400 feet above the Pittsburg bed. On the steep river bluff above California the interval between the two coal beds, determined by means of a hand level, is 360 feet, and at West Newton the same thickness seems to prevail. In a general way it appears that along the Port Royal and Lambert synclines the thickness of the Monongahela formation ranges from 360 to 400 feet. This is a greater thickness than is attained at any point in the Latrobe syncline, except northeast of Mount Pleasant, where the formation has a thickness of 400 feet. This was accurately determined from mine data on the Pittsburg bed and from surface outcrops of the Waynesburg. The outcrop of the latter is so limited in this basin that it is difficult to determine over what geographical range this thickness is maintained. It diminishes southward and reaches a thickness of only 337 feet in the Uniontown syncline at the southern edge of the quadrangle, as shown in the section of the Leisenring No. 1 mine shaft on the Columnar Section sheet.

West of the Bellevernon anticline the thickness of the formation is considerably less than in the Lambert and Port Royal synclines. A good measurement was obtained on the headwaters of Pike Run one-half mile west of Garwood, where a gas-well record shows the depth of the Pittsburg coal to be 330 feet. Since the Waynesburg coal outcrops at the surface at this point, these figures give the thickness of the Monongahela formation. The same interval prevails at Ginger Hill, as shown by a gas well which begins at the Waynesburg horizon, and also near Milesville, where a section was carefully measured on the river bluffs. Opposite Monongahela it appears to be only 310 feet thick, but since the determination was made with an aneroid barometer it is possible that it is incorrect and that the formation there holds its normal thickness of 330 feet.

The most important members of this formation are the coal beds. Beginning at the base, these beds have been called the Pittsburg, Redstone, Sewickley, Uniontown, and Waynesburg coals. They are generally present in the Brownsville and Connellsville quadrangles, but their detailed description will be reserved for the section on "Mineral resources."

The rocks of this formation differ markedly from those of the adjacent formations. They are prevailingly calcareous, and to this fact is due the excellent quality of the soil which is found on their outcrops.

The interval between the Pittsburg and the Redstone coal beds varies from 50 to 80 feet. The rocks immediately overlying the Pittsburg bed are usually shale, but in places a massive sandstone occurs which has been called the Pittsburg sandstone. This is particularly well developed in the southwest corner of the Brownsville quadrangle, where it is coarse and massive and attains a thickness of 40 feet. It was also noted in the vicinity of Fayette City and about Shire Oaks, in the northwest corner of the quadrangle.

The Redstone coal bed is generally underlain by a bed of limestone from 10 to 20 feet in thickness. This bed is fairly persistent, but occasionally it disappears, as shown in the shaft sections on the Columnar Section sheet. In the Leisenring No. 1 and Davidson shafts and in the Calumet bore hole, east of this territory, it is present in normal thickness, but in the Standard No. 2 shaft, shown on the Columnar Section sheet, there is no trace of limestone below the Redstone coal.

The Sewickley coal lies about 130 feet above the Pittsburg bed. The interval between the Redstone and the Sewickley is filled by limestone, shale, and sandstone, which vary considerably in character from place to place. The Fishpot limestone is supposed to be present at about the center of this interval, but this bed is variable in thickness and is sometimes absent in the Latrobe syncline. It has a thickness of only 6 feet in the Standard shaft and was not noted in the Calumet bore hole.

The Sewickley coal bed marks the bottom of a thick deposit of limestone which extends upward to the Uniontown coal horizon. The limestone is generally composed of two members having a total thickness of about 140 feet. The lower member is entirely limestone for a thickness of 70 or 80 feet, but the upper member is considerably broken by sandstone and shale beds.

The name "Great limestone," by which the bed was designated in previous reports, is manifestly inappropriate, and the name Benwood limestone, recently suggested by Dr. I. C. White (in correspondence), is here adopted. The name is derived from the town of Benwood, W. Va., situated on the Ohio River south of Wheeling. According to Dr. White, the limestone is well exposed on the river bluffs in that vicinity.

The Uniontown coal bed occurs about 270 feet above the Pittsburg coal and marks the upper limit of the Benwood limestone. It is poorly developed in the Brownsville and Connellsville quadrangles, not being thick enough to work at any point. Its outcrop usually is marked by a small coal stain, but the associated rocks fix its horizon.

The interval between the Uniontown and the Waynesburg coals is destitute of limestone except a small bed which usually occurs a short distance below the latter coal. The rocks are generally shaly, but frequently a heavy sandstone appears in this interval, which is easily mistaken for the Waynesburg sandstone, which normally overlies the coal beds of the same name.

The Waynesburg coal, which forms the uppermost member of the Monongahela formation, is persistent throughout this area, but it occurs so high in the series that it has been eroded from a large part of the quadrangles. In the Latrobe syncline only a few small areas of this coal remain. In the Uniontown syncline south of the river it underlies considerable territory, and in the deeper portions of the Port Royal and Lambert synclines it has a wide extent of outcrop; but west of this basin it is generally eroded from the Bellevernon anticline. West of this fold it occurs on the high hilltops throughout the region, but is badly dissected by the deep stream valleys which are almost everywhere present.

The Monongahela formation shows in outcrop in all the synclines of this region, and also on all the anticlines, except the great Chestnut Ridge anticline east of Connellsville, and the Fayette anticline, which separates the Uniontown and Latrobe synclines on the east from the Port Royal and Lambert on the west. Its upper coal beds are excellently exposed for mining purposes, but they are usually thin and doubtless will receive little attention until the great Pittsburg bed below is exhausted.

PERMIAN SERIES.

DUNKARD FORMATION.

This formation includes all the rocks lying above the Waynesburg coal. The original thickness of this formation in the Appalachian coal basin is not known, but probably it has lost much through the general erosion of the region. In the central part of the trough, near the southwest corner of the State, it attains a thickness of not less than 1000 feet, but presumably this thickness does not hold far to the north, for, according to Professor Stevenson, a part of the formation which is 400 feet thick in Greene County is only 150 feet thick in Washington County.

Since the Brownsville and Connellsville quadrangles lie on the eastern side of the great synclinal trough, their rocks are higher than the same rocks farther west, and consequently they have been greatly affected by erosion. This has been carried so far that all the Dunkard formation has been removed from the principal anticlines, and even in the synclines along the eastern side of the territory only a little of it remains. It shows generally in isolated outcrops on the hills, and consequently complete detailed sections are rarely obtained. Ordinarily the rocks of this formation remaining on the hilltops are from 100 to 200 feet thick, but in the deeper synclines a greater thickness is found. The deepest basin is that of the Lambert syncline, which carries the Waynesburg coal about 300 feet below the hilltops in the southern part of the Brownsville quadrangle. This is probably the greatest thickness of the Dunkard formation in this territory.

Waynesburg sandstone member.—This sandstone closely overlies the Waynesburg coal. Frequently it rests on the coal bed, but occasionally there is a thickness of from 10 to 15 feet of shale between. The sandstone varies from 10 to 40 feet in thickness, and in its best development it is coarse and massive and inclines to be friable when weathered. By these characteristics and its association with the coal of the same name it usually may be recognized, but in certain localities other sandstones of the same general characteristics as the Waynesburg appear near this horizon, and in such cases it is sometimes difficult to differentiate them with certainty. The Waynesburg bed generally is persistent, but occasionally it is thin and presumably is replaced by finer material. It is least developed in the Uniontown syncline, especially in the territory south of the Connellsville quadrangle, and in many of the mine-shaft sections which are published in the Masontown-Uniontown folio the Waynesburg sandstone is absent. In that territory it is extremely difficult to locate the Waynesburg at the surface, but in the part of the basin which extends into the Connellsville quadrangle the sandstone is fairly well developed and can be traced without much difficulty. In the Latrobe syncline the sandstone is very coarse, and though it is exposed at only a few points there is no difficulty in identifying it wherever met. In the Port Royal syncline the sandstone shows in typical form at many places, but on the western margin of the basin and on the flanks of the Bellevernon anticline it is occasionally thin and unimportant. The sandstone is very poorly developed in the valley of Pigeon Creek, and for this reason considerable difficulty was encountered in determining the exact geologic structure in this locality. In the southern part of the territory the sandstone is generally present in good form. It is particularly heavy on the west side of the river between California and West Brownsville. It is also conspicuous on the National Pike southeast of Brownsville, and in the region between Redstone Creek and Perryopolis. In the last-named locality sandstones are abundant in the lower part of the Dunkard formation, and the Waynesburg is no more prominent than some beds which overlie it. In a general way the lower part of the series is more sandy than that which lies above it, and the sandy portion ranges from 100 to 200 feet in thickness.

Rocks above the Waynesburg sandstone member.—In this region there are no particulary prominent beds above the Waynesburg sandstone. The measures consist of alternating limestone, shale, and sandstone, with no bed having any particular characteristics by which it can be identified. Several coal beds of considerable size occur in these rocks, but a detailed description of them will be deferred to the the chapter on "Mineral resources." The Washington coal is probably more prominent than any other bed. It shows in the Port Royal syncline east of West Newton and also in the Lambert syncline southwest of Perryopolis.

Pleistocene System.

CARMICHAEL CLAY.

After the deposition of the highest rocks of Carboniferous age this region was elevated above sea level, and since that time it has been continuously a land area. Throughout this long period rock material has been removed from the surface, and no deposition has taken place except during one epoch. This epoch marks the formation of the abandoned valleys of this region, and the material then deposited is found to-day filling these channels and occupying the rock shelves which represent parts of the old rock floors of the valleys. As outlined on a previous page, the region has been subjected to both general and local ponding, and in the ponds thus established the Carmichael clays were deposited. As the valley was originally occupied by an active stream, the lowest material is always coarse and well rounded. Above this layer of bowlders the deposition of material varied from time to time with no apparent regularity. At times the water appears to have been free from currents, and in it was laid down exceedingly fine, laminated clay. At other times fairly strong currents prevailed, and sand and other coarse material was brought in. Floating ice seems to have been abundant and to have transported large bowlders and dropped them in the midst of these fine deposits. Trees and other vegetable matter were washed down and buried in the accumulation. The material laid down at different points in the valleys is generally of similar composition, but in places there are local deposits that differ from the ordinary filling.

The old rock terrace opposite Bellevernon is covered with coarse sand which has a thickness of from 15 to 20 feet, and has been utilized to a large extent in the manufacture of glass. It contains many bowlders, rounded and angular, and also lenses of clay scattered through it. The whole is covered by a layer, a few feet in thickness, of loess-like material that has to be removed before the sand can be utilized.

Similar deposits also occur in the abandoned valley about Perryopolis, and they have been worked for the same purpose. In the pits that are worked at the present time the deposit of sand has a thickness of 22 feet. This is overlain by 14 feet of very fine white clay which is being shipped for use in the manufacture of brick.

At other localities the filling appears to be of much the same character, but it is generally so soft that exposures are difficult to find. In a general way the material along Youghiogheny River is coarser than that along the Monongahela. The terraces about Connellsville in particular are deeply covered with very coarse material. This is doubtless due to the slacking of the current of the stream by the lower grade which prevailed on the soft rocks west of Chestnut Ridge. Above this point the stream was confined by high banks, and its transporting power was sufficient to carry a heavy load, but at this point the reduced grade caused it to deposit the coarsest part of the material which it carried.

Age of these deposits.—As is stated under the description of the abandoned valleys, the epoch in which they were formed probably coincides with the earliest ice invasion in the region of the Great Lakes. This is supposed to be the same as the Kansan invasion, but this point is not definitely determined. It was certainly a very early epoch of the Pleistocene period, and it may represent a pre-Kansan stage. In the vicinity of Morgantown, W. Va., clays of this character carry well-preserved leaves which have been described by Dr. F. H. Knowlton as probably belonging to the Glacial epoch. Similar deposits are reported from the clays at Perryopolis. At the latter place they are of local occurrence and none have been saved for examination.

Although the level land found in these valleys is very acceptable for farm sites, the land itself is not so productive as that which is underlain by the more calcareous portion of the country rocks. In the old valleys the drainage is generally poor and the land is inclined to be somewhat swampy.

ALLUVIUM.

The large streams of this region are bordered in many places by narrow flood plains which are the work of the present streams. Some of these flood plains are above high-water level and represent the condition of the streams at a slightly earlier period of their history, but the most of such material is reworked at every flood stage of the river, and the plains are consequently in process of construction to-day. The narrowness of the present gorges allows little room for flood plains and consequently they are not so extensive as they usually are on streams of this size. They form very desirable sites, however, for towns and villages, and they have been utilized in this way in many places. Monongahela River, being a larger stream than the Youghiogheny, has succeeded in broadening its valley to a considerable extent, but Youghiogheny River is flowing in a very narrow gorge and its flood plain is usually only a few rods in width. Many of the small streams of the region have developed larger flood plains in proportion to their size than have the rivers. This is notable along the lower parts of Redstone and Pigeon creeks. Sewickley Creek also has some flood plains near its junction with the river, but the most pronounced flood plains on this creek are along its upper course, where the stream is still flowing on the bed which it eroded during the previous sub-cycle of its development. This is also true of Jacobs Creek above the Fayette anticline. The swampy character of this part of the valley presumably is due to the large amount of waste from the coke plants that has been allowed to obstruct the stream.

The flood plains in this territory are composed largely of sand, and consequently do not furnish so good a soil for farming purposes as does much of the upland, where the limestone rocks outcrop in abundance.

MINERAL RESOURCES.

COAL.

In undertaking the present geological survey of a region so well known as southwestern Pennsylvania it was considered unnecessary to duplicate work previously done, except so far as to test by modern methods the results obtained. The aim of the present workers is to devote most of their time to those features which received least attention in previous reports. Under this general plan the geologic structure of the region was determined with the greatest care possible, the delineation of the outcrop of the formations was carried to as great a refinement as the scale of the base map would permit, and a further careful study was made of the physiographic history of the region, but data regarding the detailed sections of coal beds and other economic features were collected only incidentally, since the previous reports abound with such information. Therefore in the preparation of the chapter on "Mineral resources" the writer has drawn largely from previous reports, and he takes pleasure in acknowledging his indebtedness to Professors Stevenson and White for the data thus obtained.

Coal is by far the most important resource of the Brownsville and Connellsville quadrangles. All the rocks occurring above the Mauch Chunk red shale are coal-bearing, but the beds are much larger and more abundant in certain parts of the series than in others. Formerly it was supposed that coal was limited to the rocks overlying the Pottsville formation, and the term "Coal Measures" was applied to them in contradistinction from the barren strata below. Later this was found to be incorrect, but the term still clings in geologic literature. The extent of the bituminous coal field in Pennsylvania is shown in fig. 94, Illustration sheet.

The most important coal in this territory is the great Pittsburg bed, which has made the region famous for its production of coal and coke. Its position is high in the geologic column, and consequently it has been largely eroded from the anticlinal folds. The area of the Pittsburg coal in Pennsylvania is shown in fig. 95.

No other coal bed is mined at present on a commercial scale, but there are several which have considerable prospective value. One of the most important of these is the Upper Freeport coal, which is supposed to underlie all this territory, except some parts of Chestnut Ridge. This bed ranges from 3 to 6 feet in thickness, but it carries many shale partings which detract very much from its value.

The Redstone coal is the most promising bed above the Pittsburg coal. Its general quality is good, but it is variable in thickness and so beset by clay veins and horsebacks that it has not been worked to any extent.

Over much of this territory the Waynesburg coal is of workable thickness, but it is badly broken by shale partings, and carries so much sulphur that it is little used.

The Sewickley and Uniontown coal beds are thin and generally worthless under present conditions, and the same is true of the coal beds of the Allegheny formation, such as the Lower Freeport, Kittanning, and Brookville–Clarion beds.

For convenience in describing the coal outcrops, the quadrangles have been divided into three areas, as follows: First, the region east of and including the Fayette anticline. This is intended to include not only the Fayette anticline, but the extreme points of the Grapeville anticline and the Greensburg syncline. It includes also the Uniontown and Latrobe syncline and the Chestnut Ridge anticline. Second, the territory between the Fayette anticline and Monongahela River. This division is based partly on structural features and partly on surface features, but it is thought to be a more convenient arrangement than to attempt to adhere to structural features where they are so slightly developed as they are in the western half of this territory. Third, the territory west of Monongahela River.

In treating of the coal beds of each of these divisions, the same order will be followed that has been used in the description of the geologic formations; namely, the oldest and lowest beds will be described first and the others taken up in consecutive order until all the coal beds of the particular area have been described.

REGION EAST OF AND INCLUDING THE FAYETTE ANTICLINE.

Coal beds in Pottsville formation.—The shale member of the Pottsville formation is not well exposed in this territory. As seen on the map the formation outcrops on the west flank of Chestnut Ridge, but so much débris falls from the upper, hard bed as to conceal to a great extent the softer member below. The coal beds in the Pottsville formation generally are unimportant in this region, but it is possible that there may be local developments in which they attain workable thickness.

The best exposure is in the gorge of the Youghiogheny River south of this territory. The side-hill cutting along the Baltimore and Ohio Railroad has exposed a small coal bed between the two heavy benches of the Pottsville sandstone from Indian Creek nearly to Ohiopyle. The coal is extremely variable in thickness; it probably never exceeds 2 feet, and from this maximum it diminishes to a few inches, and in places is altogether wanting. From fossil plants obtained along this line Mr. David White correlates this bed with the Mercer horizon of the western part of the State.

On Whites Run about three-quarters of a mile above its junction with Breakneck Run a coal has been mined for local use which appears to underlie the topmost heavy bed of the Pottsville sandstone. There is some doubt about its identification, since the Pottsville rocks were not seen in place, but the surface of the ground is strewn with huge blocks of white sandstone which are identical in character with those of the Pottsville bed. The coal at this point has a thickness of 2 feet, and it is underlain by at least 2 feet of fire clay. From the poorness of the exposures on Whites Run it is difficult to determine the exact horizon of this coal, but presumably it agrees in position with the bed just described on Youghiogheny River, and therefore is at the Mercer horizon. Some doubt is cast upon this determination by the fact that at the reservoir on Breakneck Run the Pottsville is composed of three distinct beds of sandstone separated by slight shale intervals. In this locality a small coal bed is reported as occurring in the lower interval, and therefore it is uncertain whether it should be correlated with the coal showing on Whites Run or not. On Youghiogheny River the sandstone above the coal is undoubtedly equivalent to the Homewood sandstone in the Beaver Valley, but where there are three benches of sandstone it is possible that the middle member should be correlated with the Connoquenessing sandstone of the western field. Since this threefold arrangement has not been recognized at other points on Chestnut Ridge than the one just mentioned at Breakneck Run and the one noted by Professor Stevenson on the head of Mounts Run, it seems better to regard the two upper benches as composing the Homewood, with simply a small shale lentil separating them.

In the Pottsville rocks which are exposed on Youghiogheny River on the Fayette axis at least two coal beds occur below the uppermost bench of heavy sandstone. The thickest bed is at the base of this sandstone and may be seen throughout almost the entire exposure from a point where it rises above water level a little below Oakdale to the sharp bend in the river where it disappears from view on the west side of the axis. About 1500 feet east of the mouth of Virgin Run the coal shows 35 feet above the Baltimore and Ohio Railroad. At this point it has a thickness of 2 feet; the same measure was obtained at an opening 80 feet above the same railroad opposite the mouth of Virgin Run, and a like measure shows above the Pittsburg and Lake Erie Railway about a mile west of Virgin Run. This underlies a heavy sandstone from 40 to 50 feet in thickness which is supposed to be equivalent to the Homewood sandstone along the same river in the Ligonier Valley. Below this heavy bed for a distance of 80 feet the interval seems to be almost entirely occupied by shales and thin beds of sandstone. At the forty-eighth milepost of the Baltimore and Ohio Railroad, which is located almost on the axial line of the fold, a coal 20 inches in thickness is exposed at the top of an irregularly bedded sandstone which presumably is equivalent to the Connoquenessing sandstone of the Beaver Valley. In previous reports upon Fayette County this coal was called "Upper Freeport," and the sandstone 80 feet above was supposed to be at the Mahoning horizon.

The rocks of the Pottsville are also exposed to a slight extent upon Jacobs Creek where it is crossed by the axis of this fold. At a northerly bend of the creek about 2½ miles below Tyrone Mills coal has been prospected at a height of only a few feet above water level. The entire thickness of the bed is not known, but at least 4 feet of coal is now visible. The exact relation of this bed to the Pottsville sandstone was not determined in the field, but it seems probable from the geologic structure that it occurs immediately below the Homewood sandstone. If this identification is correct, it marks the point at which the Mercer coal is most highly developed in this general region.

Brookville-Clarion coal.—In the Uniontown quadrangle there is a coal bed of some importance, from 20 to 30 feet above the top of the Homewood sandstone. Along Laurel Ridge east of Uniontown this coal is underlain by a thick bed of flint clay, which has been extensively developed for the manufacture of fire brick. Through the development of the clay and the prospecting of the coal bed, the latter has been exposed at a number of places. It attains its greatest thickness on the west side of Chestnut–Laurel Ridge, but it is so badly broken by clay partings that its value is not so great as is indicated by its total thickness.

There is considerable difference of opinion regarding the name which should be applied to this coal. Professor Stevenson called it Brookville, while Professor White inclined to the opinion that the Brookville coal is absent throughout the southern counties of Pennsylvania, and that the coal referred to more properly belongs to the Clarion horizon. On stratigraphic evidence it is impossible to settle this question; therefore in the Masontown–Uniontown folio it was called the Brookville-Clarion coal.

In the southeastern part of the Connellsville quadrangle the same conditions appear to prevail that were found in the Uniontown region, but the coal beds are so poorly exposed along Chestnut Ridge that it is impossible to speak definitely regarding the character and thickness of this bed. The bloom of the coal was seen at the summit of the mountain, on the Springfield pike, east of Connellsville. It is small, and, presumably, the coal is worthless in this locality. On Jacobs Creek just east of this territory Professor Stevenson reports this bed as ranging from 3 to 6 feet in thickness, but there is no evidence to show that such a thickness as this extends into the Connellsville quadrangle.

Where Youghiogheny River crosses the Fayette anticline the rocks at this horizon are well exposed. The coal beds are thin, but the exposures are of considerable interest, since they seem to indicate that both the Brookville and the Clarion beds are present. The Brookville or lower coal occurs 10 feet above the Homewood sandstone, the interval being occupied largely by a bed of fire clay. This coal bed is exposed on both sides of the river from a little below Oakdale to the bend in the river 1½ miles below Virgin Run. At four points the thickness of the bed was found to be 14 inches, 18 inches, 20 inches, and 24 inches. About one-half mile up Virgin Run it shows in natural exposure 30 inches of bright, clear coal (fig. 4, Coal-sections sheet 1). On the north side of the river, opposite the mouth of Virgin Run, coal was observed 140 feet above the Baltimore and Ohio Railroad track. This occurs about 40 feet above the sandstone. It has a thickness ranging from 2 to 2½ feet, and it probably corresponds to the Clarion coal of the Allegheny Valley. The same bed was observed about half a mile up Virgin Run, where it has a thickness of about 1 foot and lies about 35 feet above the Homewood sandstone.

Kittanning group.—The coal beds of this group do not seem to be well developed in this region, either on Chestnut Ridge or in the gorges cut across the Fayette anticline. In the former locality the soft rocks of the Allegheny formation are so generally concealed by débris from the mountain side that it is difficult to find exposures of the the coal beds, even though they be of considerable size. For this reason it is possible that some of the Kittanning coal beds are of workable thickness in this region, but have not been discovered On the west side of Chestnut Ridge some of the Kittanning coals show as blooms on the Springfield pike, but it is impossible to determine their horizon or their thickness. A coal bed at about the horizon of the Lower Kittanning was observed east of the clay pits above Heminger Mills. It has a thickness of 2 feet 8 inches (fig. 5) and it dips sharply to the northwest, clearly passing below the Upper Freeport coal. The blossom of this bed also was seen near the head of Mounts Run, but the coal was not opened and its thickness could not be ascertained.

In the gorge cut by Youghiogheny River across the Fayette anticline the coal beds of this group are better exposed, but generally they appear to be thin and of little value. In opening up some clay pits about 1½ miles above Layton, a coal has been exposed from 90 to 100 feet above the Homewood sandstone. It is 2 feet thick and rests upon a bed of fire clay about 12 feet thick. Its distance above the Homewood sandstone, together with the occurrence of the heavy bed of fire clay below it, makes it seem probable that this coal is at the Lower Kittanning horizon. The same bed of coal is exposed back of Layton by the side of the road which leads to the upland on the north. Its exact thickness at this point could not be determined, but it appeared to range from 3 to 4 feet. The same bed is visible as a bloom in the road east of Layton in the direction of Fort Hill, but it had not been opened and its thickness could not be determined.

In the vicinity of Layton a coal from 1 to 2 feet thick shows about 80 feet above the Lower Kittanning. This presumably belongs to the Upper Kittanning horizon, but it is a small bed and is of little value. On the west side of the river the Lower Kittanning was observed about 2 miles above Layton. At this point it has a thickness of 18 inches, and it closely underlies a heavy bed of sandstone which is a characteristic feature throughout this region. At this locality a coal bed 12 inches in thickness was observed 50 feet higher than the Lower Kittanning. This, presumably, is the Middle Kittanning bed, and consequently it seems as though the full number of beds belonging to this group are present, but all are so thin that it is doubtful whether they are of commercial value.

It is also probable that the coal beds of this group are present along Jacobs Creek, but the exposures are not so good as along Youghiogheny River and the coal beds were not observed. The country is very broken and heavily wooded and exposures are not readily seen unless their locality is known.

Freeport coal group.—Both coal beds of this group have been recognized in the Connellsville quadrangle, but both are not always well developed in the same locality. The Upper Freeport bed is generally present, though not always exposed, on the west face of Chestnut Ridge, along Sewickley Creek from Foxtown to Hunkers, and on Jacobs Creek and Youghiogheny River where these streams cross the Fayette anticline. The Lower Freeport bed does not seem to be present on Chestnut Ridge, but was seen along Youghiogheny River above Layton, and on Sewickley Creek it is as well developed as the upper bed.

The Upper Freeport coal has been well prospected in the southeast corner of the quadrangle. Its best showing is at an opening in South Connellsville, where it has the following section (see fig. 8, Coal-section sheets):

Upper Freeport coal at South Connellsville.

	Feet.	Inches.
Coal	0	2
Shale	1	0
Coal	3	5
Bony coal	0	1
Coal	0	9
Bony coal	0	1
Coal	0	9
Bony coal	0	1
Coal	0	10
Total	7	2

This coal is of excellent quality, and it has been mistaken for the Pittsburg bed, the outcrop of which occurs about a mile farther west. Probably the great thickness shown at this opening does not hold over a very large territory, since prospect pits on Reagan Run show only from 3 to 4 feet of coal. It is possible that the partings are thicker toward the north, and only one bench of the coal has been mined. The outcrop of this bed is easily traced along Chestnut Ridge, by the prospects which have been opened on it and by the pits that have been dug in the Bolivar clay lying 10 or 15 feet below the coal, but the prospecting of the coal was done so long ago that in most cases the pits are closed and the coal is not visible.

On Spruce Run the Upper Freeport coal bed has been mined in several places. At the Moyer clay pits, about one-third of a mile from Heminger Mills, the following sections were measured (see figs. 9 and 10):

Upper Freeport coal at Moyer clay pits.

No. 1.	Feet.	Inches.
Coal	1	0
Shale	0	1
Coal	0	9
Shale	0	4
Coal	0	5
Shale	0	2
Coal	0	10
Total	3	7
No. 2.		
Shale	0	2
Coal	2	4
Shale	0	7
Coal	1	4
Total	4	5

About three-fourths of a mile slightly southeast of Heminger Mills two measurements gave the following sections (see figs. 11 and 12):

Upper Freeport coal near Heminger Mills.

	Feet.	Inches.	Feet.	Inches.
Carbonaceous shale	0	6	0	3
Coal	1	4	0	7
Carbonaceous shale	1	0	0	9
Coal	1	4	1	4
Totals	4	2	2	11

On Jacobs Creek a few miles beyond the eastern boundary of the Connellsville quadrangle the Upper Freeport coal has the following section (see fig. 13):

Upper Freeport coal on Jacobs Creek.

	Feet.	Inches.
Slaty coal	1	1
Black clay and slaty coal	0	7
Coal	0	3
Black slate	0	6
Coal	0	3
Black slate	0	5
Ferruginous clay	0	4
Coal	3	0
Total	6	5

From the sections given above it will be seen that although the Upper Freeport coal has a considerable aggregate thickness, it is so broken by partings, except locally in South Connellsville, as to have little prospective value.

Where Sewickley Creek crosses the Fayette anticline the valley is eroded so deeply that the upper part of the Allegheny formation is exposed, including probably the Upper and Lower Freeport coal beds. The Upper Freeport rises from creek level near Emmonston, and is almost continuously exposed along the creek as far as Hunkers and up Buffalo Run for a distance of a mile and a half from the main creek.

In the report on Westmoreland County Professor Stevenson states that both coal beds are visible along Sewickley Creek. He evidently regarded the lower bed as the more important, since all his detailed sections were obtained from it, and he figures the upper bed as being absent in places or too thin to be represented. During the present work a coal bed was traced almost continuously within the area designated, and this bed was regarded as belonging to the Upper Freeport horizon. The lower bed was not seen at any point, although it is reported that it was struck in a number of wells. It is rather difficult to reconcile the two statements, but it seems possible that openings on the lower coal were available at the time of Professor Stevenson's visit which since then have been lost to view. During the early days of the salt industry in this region these beds were extensively worked for fuel, but with the decline of this industry in later years the mines have been abandoned and the coal is now scarcely accessible.

The Upper Freeport rises from water level at the road crossing between Armbrust and Emmonston, where it is overlain by the coarse, heavy-bedded Mahoning sandstone. It rises westward and is visible on both sides of the creek as far as Emmonston. At this point the Lower Freeport coal is reported from a well about 40 feet below the horizon of the Upper Freeport. On the west side of the anticlinal axis the coal descends more rapidly, reaching railroad level in the vicinity of Foxtown. Professor Stevenson published a section which presumably was measured near the junction of Jacks Run with the main creek. In this section the Upper Freeport coal is shown simply as a blossom too thin to measure, while the Lower Freeport coal occurring 38 feet below has the following section (see fig. 6):

Lower Freeport coal near junction of Jacks Run and Sewickley Creek.

	Feet.	Inches.
Coal	3	0
Clay	0	1
Coal	0	9
Clay	0	2
Coal	1	4
Total	5	4

It seems altogether probable that at the point where this section was measured the Upper Freeport coal was so obscured locally that it appeared too thin to be represented. This section certainly does not show its general thickness in this region, which, as stated before, ranges from 2 to 4 feet. According to the same authority the two coal beds were encountered in boring a salt well at Ruff Salt Works, which, presumably, were in this vicinity. In that reported record the Upper Freeport has a thickness of 5 feet and occurs 30 feet above the lower bed, the thickness of which is not given. In this locality thecoal is reported to be poor and slaty; but in the observed outcrops in the same vicinity it appears to be of fairly good quality, and it was used extensively in the manufacture of salt. Professor Stevenson gives the following detailed section of the Lower Freeport coal at an opening near Cochran's old salt works (see fig. 7):

Lower Freeport coal near Cochran's old salt works.

	Feet.	Inches.
Coal	1	4
Clay	0	1
Coal	1	2
Clay	0	2
Coal, seen	0	10
Total	3	7

The Upper Freeport coal is well exposed along the railroad below Foxtown. A short distance below this point it rises above the grade and shows a thickness of 3 feet under a heavy bed of sandstone. It is exposed along the railroad on the south side of the next ravine, and again about a half mile above New Stanton, where it also has a thickness of 3 feet and underlies the heavy Mahoning sandstone. Professor Stevenson reports the Lower Freeport coal to have a thickness of 2 feet in the vicinity of Paintersville, but it seems probable that this is an incorrect identification, since the Upper Freeport coal shows at this locality. The Lower Freeport coal presumably passes below water level north of New Stanton, but the upper bed remains above water level for a distance of at least 2 miles. At the Westmoreland brick works at Hunkers it is 5 feet thick, immediately underlying the Mahoning sandstone. Professor Stevenson reports two detailed sections from this general locality which are as follows (see figs. 14 and 15):

Upper Freeport coal near Hunkers.

	Feet.	Inches.	Feet.	Inches.
Coal	3	6	2	10
Clay	0	2	0	2
Coal	1	6	1	5
Clay	0	0	0	1
Coal	0	4	0	5
Totals	5	6	4	11

Near the point where the Upper Freeport coal passes below water level on Sewickley Creek, 1 mile below Hunkers, the following section is given by Professor Stevenson (see fig. 16):

Upper Freeport coal west of Hunkers.

	Feet.	Inches.
Coal	3	3
Clay	0	2
Coal	1	6
Clay	0	1
Coal	0	5
Total	5	5

The outcrop of this coal bed extends up Buffalo Run to within about a mile of Ruffsdale. Near the point where it passes below water level an old mine opening shows the following section (see fig. 17):

Upper Freeport coal near Ruffsdale.

	Feet.	Inches.
Coal	0	4
Clay	0	1
Coal	0	10
Clay	0	2
Coal	0	10
Total	2	3

This is certainly not a very promising section, and the coal can not be worked with profit unless its quality is exceptionally good.

The Freeport coal beds along Sewickley Creek are generally thick enough to be mined at a profit if the quality of the coal were such that it could stand in competition with the Pittsburg coal; but the Freeport carries a rather heavy percentage of ash, and also an amount of sulphur that renders it of comparatively little value at the present time.

On Jacobs Creek the Upper Freeport coal rises from water level about 2 miles above the mouth of the creek. It rises rapidly to the southeast, and along the line of the axis reaches an altitude of approximately 300 feet above creek level. Beyond the axis it descends at about the same rate and reaches water level a short distance below Tyrone Mills. The coal has been prospected at a number of places along this line of outcrop, but particularly in the vicinity of Tyrone Mills. It has been mined on the north side of the creek about a quarter of a mile below Tyrone Mills, and also in the ravine by the side of the road leading toward Fort Hill. At the latter locality the bed has the following section (see fig. 18):

Upper Freeport coal east of Fort Hill.

	Feet.	Inches.
Coal	2	9
Shale	0	3
Coal	1	3
Shale	0	3
Coal	0	2
Total	4	8

The Bolivar fire clay appears to be well developed in this region also. An exposure occurs on the east side of Meadow Run about a half mile from the river, where the clay shows a thickness of 12 feet. It presumably lies close below the Upper Freeport coal, but this is not visible here, except in a few fragments of coal on the slopes. The clay has not been worked, but farther down the stream, on the road leading from Fort Hill to Barren Run, old pits are visible at which the clay appears to have been worked many years ago. At this point 18 inches of coal is visible, but, according to report, the bed has a total thickness of from 3 to 4 feet. The quality of the coal is reported to be excellent in this locality, and coke has been produced from it, though not for commercial use.

No trace of the Lower Freeport bed was seen along Jacobs Creek, but most exposures are so poor that this is no evidence of its absence.

On Youghiogheny River the Upper Freeport coal bed was seen at a number of places, especially west of the axis of the fold. It shows on Virgin Run at the first road crossing above the river. At this point the road crosses on a heavy bed of the Mahoning sandstone, over which the creek flows in a picturesque cascade. At the foot of the falls the Freeport coal has been prospected, but at present the pit is closed and no coal is visible except fragments on the dump.

In the vicinity of Layton the coal has been prospected to some extent in connection with the development of the underlying fire clay. The latter has been replaced in the fire-brick works by refractory clays obtained from other localities, and the coal mines have been abandoned, so that at present the coal is not visible and it is difficult to obtain an idea of its character or thickness. Presumably it is thin in this locality and not of very high quality. The Lower Freeport coal bed was not noted along the river, and it seems possible that it is not present along either Youghiogheny River or Jacobs Creek.

Wilson Run coal.—In the vicinity of Sewickley Creek there is a coal about 90 feet above the Upper Freeport bed which attains considerable local importance. It was formerly mined about a half mile below Armbrust, but the mine has been abandoned and the coal bed itself is not visible. Within a few years it has been opened on Wilson Run about a mile above Paintersville, where it shows the following section (see fig. 19):

Wilson Run coal above Paintersville.

	Feet.	Inches.
Coal	2	9
Shale	0	2
Coal	1	6
Total	4	5

This coal appears to have been identified by Professor Stevenson as the Upper Freeport bed, but it hardly seems possible that this identification can be correct. In its most extended outcrop along Sewickley Creek the Upper Freeport coal bed is everywhere overlain by the Mahoning sandstone; in the outcrop on Wilson Run no sandstone is visible above the coal. Since the axis of the anticline is probably well determined in this locality, it is impossible for the Upper Freeport coal bed to extend any considerable distance up Wilson Run; moreover, the interval between this coal bed and the Morgantown sandstone, which occupies a mesa-like hill between Wilson Run and Sewickley Creek, is too small for this coal to be at the Upper Freeport horizon. Therefore it has been correlated with the coal formerly mined below Armbrust, and with a small coal which at one time was opened east of Hunkers. The thick section on Wilson Run appears to be a local development, for the coal was not noted at any other locality.

Pittsburg coal.—At present the only coal bed worked on a commercial scale in this region is the Pittsburg bed, which is regarded as the basal member of the Monongahela formation. This is one of the most remarkable beds in the bituminous coal field. It is more constant in its thickness and character and has a wider geographic distribution than any other known bed. It is present throughout much of eastern Ohio, northern West Virginia, and southwestern Pennsylvania. The sketch map, fig. 95, shows roughly its distribution in Pennsylvania. Owing to the slight folds which affect the rocks in this region much of the Pittsburg coal has been removed by erosion, leaving the outline of the field irregular, with long fingers pointing to the northeast along the synclinal axes. The Connellsville basin constitutes the easternmost outlier of importance, and the part of this basin included in the Connellsville quadrangle is about the central part of the trough.

On account of the cross anticline which divides this basin into two separate synclines, the outcrop of the coal is not continuous across the quadrangle. The northwestern line of outcrop in the Latrobe syncline enters this territory near the northeastern corner, pursues a southwesterly course by Tarrs and Bethany, and then swings to the southeast with a somewhat irregular line of outcrop. At Iron Bridge it turns again to the northeast, and leaves the territory near the line of Brush Creek.

That part of the Uniontown syncline which is included within the Connellsville quadrangle is not so deep as the Latrobe syncline, and consequently the outcrop of the coal is much less regular. This is especially true north of the Youghiogheny River, where the small streams, like Hickman and Galley runs, have cut entirely through the bed, leaving it exposed in a double line of outcrop near creek level. In the vicinity of Scottdale the syncline lies so high that the coal is preserved only near the tops of the hills, in a series of outcrops having an exceedingly irregular outline. South of Youghiogheny River the syncline deepens rapidly, and the coal remains in an almost unbroken bed, except in the vicinity of Vanderbilt, where Dickerson Run has dissected it to a considerable extent.

Throughout this basin the bed ranges from 8 to 11 feet in thickness. It generally consists of two divisions separated by what is usually known as the main clay parting. This parting varies in thickness from a few inches to several feet, but is always found above the breast coal which is the most valuable bench. The roof division, or that which lies above the main clay parting, is exceedingly variable. Generally it is made up of alternating bands of shale or clay and coal, but occasionally the coal thickens up and constitutes the main body of the roof division. The quality of the coal in some of these upper benches is good, but they are never removed in mining on account of the expense involved in separating the impurities from the coal. The lower division comprises the workable part of the bed. In the Connellsville basin it is usually broken by one or two slate partings, which generally run less than an inch in thickness. The "bearing-in slate," which occurs about 3 feet from the floor, is the most persistent. In this region the roof of the mine is frequently weak, and a little of the top of the coal is therefore left in for safety.

The thickness and the character of the bottom bench are very regular throughout this basin, as shown by sections at some of the most important mines. The section in the Standard mine, near Mount Pleasant, may be regarded as the type for the field (see fig. 48):

Pittsburg coal at Standard mine, near Mount Pleasant.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Bone coal	2	0		
Slate	0	1		
Coal	0	6		
Slate	0	3		
Coal	0	10		
Slate	0	1		
Coal	0	5		
			4	2
Main clay			0	9
Lower division:				
Coal	2	11		
Slate	0	0¼		
Coal	2	0		
Slate	0	0½		
Coal	3	0		
			7	11¾

The variability of the roof division may be easily seen by comparing the section just given with that of the Buckeye mine at Pershing, 2 miles south of Mount Pleasant (see fig. 49):

Pittsburg coal at Buckeye mine, Pershing.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	1	0		
Slate	1	0		
Coal	1	6		
			3	6
Main clay			2	6
Lower division:				
Coal	4	0		
Slate, thin.				
Coal	2	0		
Slate, thin.				
Coal	3	0		
			9	0

On the west side of the basin the section is similar to that of the Buckeye mine. At Bethany the roof division has a total thickness of 2 feet, 10 inches; the main clay 10 inches, and the lower division 8 feet, 4 inches.

In the Uniontown syncline the section of the coal is similar to that of the Latrobe syncline A section measured at the Valley mine is as follows (see fig. 50):

Pittsburg coal at Valley mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	0	10		
Slate	0	11		
Bone coal	0	10		
Slate	0	2		
Bone coal	0	10		
			3	7
Main clay			1	0
Lower division:				
Bone coal	0	1½		
Coal	3	0		
Slate	0	0¾		
Coal	1	11		
Slate	0	0¾		
Coal	3	2		
			8	4

At Broadford the roof division has a thickness of 3 feet, the main clay 11 inches, and the lower division about 9 feet. This is broken into three benches of 4 feet, 2 feet, and 3 feet, separated by thin slate binders. At Connellsville the roof division is 5 feet 1 inch, the main clay 1 foot, the lower division 8 feet 1 inch. The lower division is here divided into four benches, 45, 26, 4, and 20 inches thick, with partings of from one-half to one inch. The section at Pennsville shows the roof division to have a thickness of 4 feet 3 inches, the main clay parting 8 inches, and the lower division 8 feet. The uppermost bench of the lower division has a thickness of 5 feet 6 inches, a greater thickness than is usually found free from partings. At the Adelaide mine the section is as follows (see fig. 51):

Pittsburg coal at Adelaide mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Bone coal	1	3		
Coal	0	3½		
Slate	0	2½		
Bone coal	2	2		
			3	11
Main clay			1	2
Lower division:				
Coal	2	8		
Slate	0	0⅜		
Coal	2	0		
Slate	0	0⅜		
Coal	2	10		
			7	6¾

Southwest of this point, along the western limb of the syncline, the same general arrangement of benches prevails, but they change from place to place, as is shown by the following section, which was measured in the vicinity of Vanderbilt:

Pittsburg coal near Vanderbilt.

	Feet.	Inches.
Roof division	3	8
Main clay	0	5
Lower division	8	0

The lower division is made up of three benches, 48, 20, and 28 inches in thickness. The coal does not change appreciably in section in passing to the south, except that thin slate partings appear locally in the lower division, and the arrangement of the beds in the upper division changes from place to place. This is illustrated by the following section, which is from the Leisenring No. 1 mine, a short distance south of the boundary line of the Connellsville quadrangle, in the vicinity of Rogerstown (see fig. 52):

Pittsburg coal at Leisenring No. 1 mine, at Leisenring.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Bone coal	0	8		
Slate	0	0½		
Bone coal	0	6		
Coal	0	1½		
Slate	0	6½		
Coal	0	6		
Slate	0	2½		
Coal	0	9		
			3	4
Main clay parting			0	8
Lower division:				
Coal	3	6		
Slate	0	0⅝		
Coal	2	1		
Slate	0	0¾		
Coal	0	2		
Slate	0	0½		
Coal	2	4		
			8	2⅞

The quality of the coal in this basin is so well known that it needs only a brief notice here. This territory is not only the geographical center of the Connellsville coking field, but it is usually regarded as the type locality from which the standard coke is produced. The coal is comparatively soft; it is not well adapted for shipping, but it comes from the mine in the best condition for the manufacture of coke. The following analyses made by Mr. A. S. McCreath from mines at Broadford may be considered typical of the region:

Analysis of Pittsburg (Connellsville) coal from Bradford.

	Per cent.
Water	1.260
Volatile matter	30.107
Fixed carbon	59.616
Sulphur	.784
Ash	8.233
Total	100.000

Brownsville and Connellsville.

The average of a number of determinations made in 1893 by the H. C. Frick Coke Company shows the following composition:

Average analysis of Pittsburg (Connellsville) coal, H. C. Frick Coke Co., 1893.

	Per cent.
Water	1.130
Volatile matter	29.812
Fixed carbon	60.420
Sulphur	.689
Ash	7.949
Total	100.000

In the Connellsville quadrangle are located some of the largest mines in the region, and the coal is rapidly being exhausted in the Latrobe and Uniontown synclines. It is probable that the actual number of mines is not so great to-day as formerly, for abandoned mines are abundant; but these were generally small and their abandonment was due to the working out of the limited territory which they controlled. The mines operating to-day are generally large and most of them have considerable territory yet to be developed. By far the greater number are operated by the H. C. Frick Coke Company. The second largest operator is W. J. Rainey. These two control almost all the mines of the region, the independent operators being limited to the smaller properties, generally located on the outcrops.

Redstone coal.—In the Connellsville basin the coal beds occurring above the Pittsburg are generally thin and unimportant. They are poorly exposed and it is difficult to obtain exact information regarding them. Mine-shaft sections give the most accurate measurements of the thickness and position of the coal beds. Notwithstanding the fact that there are a number of shaft mines in the basin, sections are available from only three. These are Leisenring No. 1, just south of the boundary of the Connellsville quadrangle; Davidson, near Connellsville; and Standard, near Mount Pleasant. From these sections, shown on the Columnar Section sheet, it will be seen that the Redstone coal is generally present, though notin very great thickness. In the Leisenring shaft it consists of bony coal, 8 inches thick, and it occurs 80 feet above the floor of the Pittsburg coal. In the Davidson shaft it has a thickness of 2 feet 3 inches, and it is 81 feet above the base of the Pittsburg bed. In the Standard shaft it has a thickness of 2 feet, and is 80 feet above the same datum surface.

These three sections show a remarkable agreement in the interval between the Redstone coal and the base of the formation, and this measure is within a foot of the interval at the type locality for the Redstone coal, near Uniontown. In the report of the First Geological Survey of Pennsylvania, Rogers named this bed from an outcrop observed on Redstone Creek east of Uniontown, and gave its position as 50 feet above the Pittsburg bed. In sinking the Lemont air shaft, which is in this vicinity, the Redstone coal was found to be 80 feet above the floor of the Pittsburg coal, and not 50 feet, as was supposed. The mine shafts throughout the basin from Mount Pleasant to beyond Uniontown show that the interval is extremely constant, ranging from 80 to 90 feet.

It is probable that in this territory the Redstone coal ranges from 2 to 4 feet in thickness, but its quality is such that even in its greatest development it has little prospective value. It certainly will not be utilized until the Pittsburg coal is exhausted, and then in all probability it will be so badly broken by the falling of the roof of the mines below that it will be useless.

Sewickley coal.—Only two of the mine shafts mentioned above are deep enough to expose the Sewickley coal bed. In Leisenring No. 1 shaft it is 170 feet above the floor of the Pittsburg coal, and has a thickness of 2 feet 3 inches. In the Standard shaft it is 157 feet above the same datum surface and has a thickness of 2 feet. It is probable that these sections are fairly representative of the condition of the Sewickley coal bed in this region.

In the Leisenring No. 1 section there is a coal 2 feet in thickness at a height of 120 feet above the floor of the Pittsburg bed, intermediate in position between the Redstone and the Sewickley bed. This is shown in many of the shaft sections south of this point, but it is generally small, and apparently has not been recognized at the surface and distinctively named.

Uniontown coal.—This appears to be the least persistent coal bed of the Monongahela formation. According to the shaft sections it is not known in the Uniontown syncline north of Uniontown, and the section of the Standard shaft shows that it is not present in the southern part of the Latrobe syncline. It is supposed to mark the upper limit of the Benwood limestone, but in this region its place is occupied by other rocks.

Waynesburg coal.—This coal is generally so impure that it is of little value, even where it is thick and covers considerable territory. In the Uniontown syncline it is well preserved over a rather large area in the center of the basin. Its outcrop extends into the Connellsville quadrangle, being found in the high land west of Trotter. According to the section of Leisenring No. 1 shaft the coal has a thickness of 3 feet 4 inches, and its roof is 337 feet above the floor of the Pittsburg coal. It is probable that the coal contains partings that were not carefully measured at the time the shaft was excavated. In the future this bed may furnish some fuel in the Uniontown syncline, but it is not at all promising in this direction.

In the Latrobe syncline the Waynesburg coal is preserved only in a few of the highest hills. The area under cover is so small that it would not be important even if the coal were as valuable as the Pittsburg, for the slaty coal that is usually found in the Waynesburg bed is practically worthless. The Standard mine shaft is not deep enough to show this coal, but from its bloom the coal appears to have a thickness of from 4 to 5 feet.

TERRITORY BETWEEN THE FAYETTE ANTICLINE AND MONONGAHELA RIVER.

The territory included in this division is occupied largely by the Lambert and Port Royal synclines, but in the northern part of the quadrangle, by reason of the westward swing of the Monongahela River, it includes the northern end of the Bellevernon anticline and also the Pigeon Creek syncline. Throughout this territory the Pittsburg coal is generally above water level, so that the Conemaugh rocks are exposed along the principal streams. Where the Bellevernon anticline crosses Monongahela River the rocks of this formation are exposed for a distance of about 300 feet below the Pittsburg coal, but in that interval there are no coal beds that have been noted. Where the Pittsburg bed lies so far above water level the highest hills extend but little above the Waynesburg horizon, and consequently only the coal beds of the Monongahela formation are present; but along the synclinal axes which cross Youghiogheny River at Port Royal, and Redstone Creek at the mouth of Washwater Run, the Pittsburg coal lies so deep that the upper measures are exposed with a thickness of several hundred feet, including all the lower coal beds of the Dunkard formation.

Pittsburg coal.—This great bed is under cover throughout the district between the Fayette anticline and Monongahela River except where it has been eroded by the larger streams. Its eastern outcrop is extremely regular considering the rugged country through which it passes. It extends from Smock on the south through Stickel Hollow to the mouth of Jacobs Creek. From this point it is somewhat irregular on account of the sharpness of the ravines, but in a general way its outcrop follows the ridge west of Centerville and Menden to Sewickley Creek, which it crosses about a mile above Bells Mills. Beyond this point it continues a northeasterly course to the limit of the territory.

In this field the coal is characterized by the same major subdivisions that are found in the Connellsville district. It consists of a main lower division, which carries the merchantable coal of the region, and a roof division, separated by a persistent parting of clay. The roof division is variable both in total thickness and in the arrangement of its members; the lower division is extremely regular, and the benches of coal may be recognized in almost every exposure.

According to Dr. I. C. White the lower division, with its slate binders, may be described as follows: "Along Monongahela River two of these slates are especially constant, since they occur about 2½ to 3 feet above the bottom of the bed and are 4 to 6 inches apart. They are generally known as the 'bearing-in slates,' and are seldom more than one-half inch thick. Then 1 foot to 1 foot 6 inches below there is generally another thin parting of slate which runs through the bed with great persistency, dividing the lower portion into two layers known by the miners as the 'brick' coal and 'bottom' coal. Of course, there are other partings which occasionally make their appearance in the bed at some localities, but they are irregular and not persistent."

Although the general character of the bed is extremely regular and persistent there are local variations from place to place which can be brought out only by a comparison of a great number of sections. For that purpose the following details obtained from published reports are introduced.

The general condition of the Pittsburg coal bed along the northern boundary of the quadrangle is shown by the following section, which was obtained at the Herminie mine on Little Sewickley Creek a few miles north of this territory (see fig. 53):

Pittsburg coal at Herminie mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal and clay			4	7¼
Main clay			0	10
Lower division:				
Bone	0	1		
Breast coal	3	6		
Slate	0	0½		
Bearing-in coal	0	4		
Slate	0	0¾		
Brick coal	1	0½		
Slate	0	0¼		
Bottom coal	1	2		
			6	3¼

In this locality the roof division is wonderfully expanded, consisting of no less than 21 distinct bands of shale and coal. In this intimate mixture the largest bed of coal occurs near the bottom. It has a thickness of only 10 inches, and, of course, has no commercial value. Of the lower division all the coal benches are mined except the lowest, which is so impure that it does not pay for removal. The thickness of merchantable coal is thus reduced to about 4 feet 10 inches.

The general arrangement and thickness of divisions holds to the south on the eastern edge of the syncline, as shown by the following section, which was obtained from a well record near the outcrop of the coal on Sewickley Creek:

Pittsburg coal on Sewickley Creek.

	Feet.	Inches.
Roof division	2	3
Main clay	1	1
Lower division	6	11

On the west side of the syncline the condition of the coal is shown by the following section, which was obtained at Youghiogheny No. 4 mine, at the mouth of Sewickley Creek (see fig. 54):

Pittsburg coal at Youghiogheny No. 4 mine, mouth of Sewickley Creek.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	1	0		
Clay	1	0		
Coal	2	0		
			4	0
Main clay			1	0
Lower division:				
Breast coal	3	6		
Bearing-in coal	0	4		
Brick coal	1	0		
Bottom coal	1	0		
			5	10

In this section the roof division carries considerably more coal than it does in the vicinity of the Herminie mine, but as before stated, this is never removed. The lower division shows a total thickness of 5 feet 10 inches, but the bottom bench is not removed, and consequently the amount of merchantable coal is reduced to about 5 feet. In the Yough Slope mine the commercial coal consists of two upper benches 4 feet 4 inches and 1 foot 2 inches in thickness, or a total of 5 feet 6 inches, while the aggregate thickness of the lower division is 6 feet. On Pollock Run the Pittsburg coal has been mined for local use, and at one of the country banks between the West Newton pike and the river the following section was obtained (see fig. 55):

Pittsburg coal on Pollock Run.

	Feet.	Inches.	Feet.	Inches.
Roof division			4	4
Main clay			0	10
Lower division:				
Breast coal	3	9		
Bearing-in coal	0	4		
Brick coal	1	0		
Bottom coal	1	1		
			6	2

The benches which are mined consist of the breast coal, 3 feet 9 inches in thickness; the bearing-in coal, 4 inches in thickness; and the brick coal, 1 foot in thickness.

From the Yough Slope the lower division thickens southward along the river to Port Royal, where the breast coal alone is 5 feet thick and the lower division as a whole is 7 feet thick. In this mine no coal is removed below the bearing-in bench, the bottom coal being too impure.

The same general character and thickness is maintained on the eastern limb of the syncline, as is shown in the following section, obtained at Robertson's mine, on the West Newton and Mount Pleasant pike, where it is crossed by the outcrop of the coal (see fig. 56):

Pittsburg coal at Robertson's mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	0	10		
Clay	1	0		
Carbonaceous shale	0	4		
Coal	0	4		
Clay	0	2		
Coal	1	0		
			3	8
Main clay			0	10
Lower division:				
Breast coal	4	11		
Bearing-in coal	0	4		
Brick coal	1	0		
Bottom coal	1	6		
			7	9

Along the southeastern margin of the syncline the breast coal thickens south of the outcrop last described, and at Banning it is separated into two benches and has a total thickness of 6 feet 2 inches, as shown in the following section (see fig. 57):

Pittsburg coal at Banning.

	Feet.	Inches.	Feet.	Inches.
Main clay			1	0
Lower division:				
Breast coal	4	11		
Breast coal	1	3		
Bearing-in coal	0	3		
Brick coal	1	0		
Bottom coal	1	8		
			9	1

At Whitsett it still continues large, as shown by the following section, obtained from the Rainbow mine (see fig. 58):

Pittsburg coal at Rainbow mine, Whitsett.

	Feet.	Inches.	Feet.	Inches.
Roof division (coal)			1	0
Main clay			1	0
Lower division:				
Breast coal	5	3		
Bearing-in coal	0	3		
Brick coal	1	0		
			6	6

The roof division is thin and not so conspicuous in this region as it is near the northern edge of the quadrangles, but it is thicker in the vicinity of Perryopolis, as the following section shows (see fig. 59):

Pittsburg coal near Perryopolis.

	Feet.	Inches.	Feet.	Inches.
Roof division (coal and slate)			2	10
Main clay			1	0
Lower division:				
Breast coal	5	9		
Clay	0	0½		
Bearing-in coal	0	4		
Clay	0	0½		
Brick coal	0	5		
Clay	0	1		
Bottom coal	0	7		
			7	3

In this locality the lower division generally yields good coal, but in places a part of the breast bench, which is somewhat more impure than the rest, is left as a support to the roof. The great thickness of breast coal seems to hold south of this point in Stickel Hollow, where the brick and the lower bottom coals are united into one bench 3 feet in thickness, as shown in the following section (see fig. 60):

Pittsburg coal in Stickel Hollow.

	Feet.	Inches.	Feet.	Inches.
Roof division			3	0
Main clay			0	3
Lower division:				
Breast coal	5	6		
Bearing-in coal	0	3		
Brick and bottom coal	3	0		
			8	9

On Crabapple Run, where the coal has long been mined for local use, the following section was obtained (see fig. 61):

Pittsburg coal on Crabapple Run.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Bituminous shale	0	4		
Coal	1	0		
Clay	0	4		
Coal	0	4		
Clay	0	6		
Coal	0	5		
			2	11
Main clay			0	8
Lower division (seen)			7	0

The lower division is said to contain the usual thin slate partings, but they must be exceedingly thin, since they are not visible on a weathered surface. Between Crabapple Run and Smock the roof division seems to undergo a decided change, since in the latter locality it shows no coal. The lower division has a thickness of 8 feet, without distinct shale partings.

From Smock the Pittsburg coal dips rapidly west, and on the axis of the syncline, which crosses a short distance below Washwater Run, the floor of the coal is about 200 feet below creek level. It rises somewhat more gently on the northwestern limb of the syncline, and is mined at a number of places between the axis and the outcrop of the coal, which is located a short distance below the station of Braznell. From this point to beyond the river the coal is continuously above water level. This is due to the influence of the Brownsville anticline, which on its axis carries the coal 40 feet above creek level. Near the river it again dips to the west and it is lost in the flood plain on the west side of the stream. At Brownsville it is above water level, but on the turn of the stream to the west it soon passes from sight and appears again only in the great bend in the southwestern part of the Brownsville quadrangle. It has been mined extensively near Brownsville and Bridgeport, and up Dunlap Creek nearly to the south edge of the quadrangle. An old bank on this creek shows the following section (see fig. 62):

Pittsburg coal on Dunlap Creek.

	Feet.	Inches.	Feet.	Inches.
Roof division			0	8
Main clay			0	10
Lower division:				
Breast coal	4	5		
Bearing-in coal, with thin parting	0	9		
Brick and bottom coal	2	4		
			7	6

Along the river above Brownsville the lower division swells to about 9 feet and the ordinary benches of the coal are not distinguishable. The upper 2 feet of the breast coal contains many thin binders, but the whole bed is merchantable.

In the old Umpire mine, above the mouth of Redstone Creek, the coal has the following detailed section (see fig. 63):

Pittsburg coal at Umpire mine.

	Feet.	Inches.	Feet.	Inches.
Roof division			0	3
Main clay			2	0
Lower division:				
Breast coal	5	2		
Slate	0	0¼		
Bearing-in coal	0	2		
Slate	0	0½		
Brick coal	1	2		
Slate	0	0¼		
Bottom coal	1	3		
			7	10

This mine is abandoned, but when it was being worked the bearing-in was done 6 inches above the floor, so that about 7½ feet of merchantable coal was obtained.

North of Redstone Creek the lower division is somewhat thinner, as shown by the following section, which was obtained in the Albany mine, about a mile below the mouth of the creek (see fig. 64, Coal-section sheets):

Pittsburg coal at Albany mine, below mouth of Redstone Creek.

	Feet.	Inches.	Feet.	Inches.
Roof division (coal)			1	1
Main clay			1	0
Lower division:				
Breast coal	3	3		
Bearing-in coal	0	3		
Brick and bottom coal	3	0		
			6	6

In the sharp bend opposite California the coal has been entirely mined out, but in the old Cedar Hill mine, the section was as follows (see fig. 65, Coal-section sheets):

Pittsburg coal at Cedar Hill mine, opposite California.

	Feet.	Inches.	Feet.	Inches.
Roof division (coal)			0	4
Main clay			1	0
Lower division:				
Breast coal	5	0		
Bearing-in coal	0	3		
Brick coal	1	2		
Bottom coal	1	6		
			7	11

About 6 inches of the bottom bench was left in, but the remainder of the lower division consisted of coal of good quality. From this point as far around the bend as Fayette City mines are abundant. In most of them the coal in the immediate vicinity of the river has been removed, and work is being done in them at a distance of from 1 to 2 miles from their mouths. The following section was obtained from the Snow Hill mine, which is located nearly opposite Lucyville (see fig. 66, Coal-section sheets):

Pittsburg coal at Snow Hill mine, near Lucyville.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal and partings	1	0		
Shale and slate	10	0		
Coal	0	6		
			11	6
Main clay			0	9
Lower division:				
Breast coal	5	3		
Slate	0	0½		
Bearing-in coal	0	2		
Slate	0	0½		
Brick coal	1	3		
Slate	0	0½		
Bottom coal	1	4		
			8	1½

From this it will be seen that the roof division has increased materially in thickness and complexity, and the lower division also shows a larger amount of coal than farther south.

In Little Redstone mine, which cuts across the point of land about opposite Stockdale and works back into the high hills surrounded by the old abandoned valley of the Monongahela River, the Pittsburg bed yields a thickness of 7½ feet of coal with 1 foot at the bottom left undisturbed. At the forks of Little Redstone Creek is the following section:

Pittsburg coal at forks of Little Redstone Creek.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Bituminous shale	1	0		
Shale	5	0		
Sandstone	1	0		
Coal	1	0		
			8	0
Main clay			1	0
Lower division			8	2

The lower division is divided by small shale partings into seven benches, the upper three forming the breast coal, 3 feet 9 inches thick. The bearing-in bench is double and is 5 inches thick and the bottom benches are separate and distinct.

In this vicinity the roof division is mainly shale, as shown by the following complete section measured near Fayette City (see fig. 67):

Pittsburg coal near Fayette City.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Bituminous shale	0	4		
Brown shale	1	0		
Slaty coal	0	10		
Sandy shale	0	10		
Coal	0	9		
			3	9
Main clay			0	10
Lower division:				
Breast coal	4	10		
Bearing-in coal	0	3		
Brick coal	1	0		
Bottom coal	1	0		
			7	1

The roof coal shows great irregularity in the number and arrangement of its benches as shown by comparison of the Fayette City section with the following section from an old mine in the vicinity of Bellevernon (see fig. 68):

Pittsburg coal near Bellevernon.

	Feet.	Inches.	Feet.	Inches.
Roof coal			0	2
Main clay			0	10
Lower division:				
Breast coal	5	0		
Bearing-in coal	0	3		
Brick and bottom coal	1	2		
			6	5

Opposite Charleroi the roof division exhibits a complex arrangement of coal and clay, and the main bench is somewhat thinner than in the sections just described. these features are shown by the following section, which was obtained from the Rostraver mine (see fig. 69):

Pittsburg coal at Rostraver mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	0	7		
Clay	0	2		
Coal	0	4		
Clay	0	5½		
Coal	0	7		
Clay	0	2		
Coal	0	9		
			3	0½
Main clay			0	7
Lower division:				
Breast coal	3	5		
Bearing-in coal	0	3		
Brick coal	1	2		
Bottom coal	0	10		
			5	8

East of Monessen the same character is shown by the following section from old Sheppler mine (see fig. 70):

Pittsburg coal at Sheppler mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Carbonaceous shale	0	6		
Shale	1	0		
Coal	0	8		
Carbonaceous shale	0	6		
Coal	1	0		
Clay	0	3		
Coal	0	10		
Hard clay	0	2		
Coal	1	2		
			6	1
Main clay			1	6
Lower division:				
Breast coal	3	6		
Bearing-in coal	0	3		
Brick coal	0	11		
Bottom coal	1	4		
			6	0

At Webster the roof division is also very complex, as shown by the following section (see fig. 71):

Pittsburg coal at Webster.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	0	10		
Slate	0	7		
Coal	0	4		
Slate	0	1		
Coal	0	3		
Slate	0	1		
Coal	0	2		
Clay	0	8		
Coal	0	9		
Slate	0	1		
Coal	1	2		
			5	0
Main clay			0	0 to 8
Lower division:				
Breast coal	3	6		
Slate	0	0¼		
Bearing-in coal	0	2		
Slate	0	0½		
Brick coal	1	0		
Slate	0	0¼		
Bottom coal	1	3		
			6	0

The main clay is very irregular in thickness and in some parts of the mine it is absent.

From this point to the northern edge of the quadrangle the coal in the immediate vicinity of the river front has been removed, and many of the mines which depended on it for their supply have been abandoned. In this direction the roof division of the coal is somewhat reduced in thickness, but the main bench holds its own with great persistency. This is shown by the following section from the outcrop of the coal on Becket Run (see fig. 72):

Pittsburg coal on Becket Run.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal and shale	1	3		
Coal	0	8		
Shale	1	0		
Coal	2	0		
			4	11
Main clay			1	0
Lower division:				
Breast coal	3	5		
Bearing-in coal	0	2		
Brick coal	0	10		
Bottom coal	1	2		
			5	7

At this point the strata are disturbed by a fault which has been traced for some distance north of the river. Its course is about N. 40° E., but its longitudinal extent is unknown. West of Milesville the roof division increases in thickness and complexity, as shown by the following section from the vicinity of Gallatin mine (see fig. 73):

Pittsburg coal in vicinity of Gallatin mine.

	Feet.	Inches.	Feet.	Inches.
Roof division;				
Carbonaceous shale	0	4		
Coal	0	3		
Clay	1	3		
Coal	0	7		
Slate, thin.				
Coal	1	0		
Clay	0	2		
Coal	0	10		
Slate	0	0½		
Coal	0	2		
			4	7½
Main clay			0	10
Lower division:				
Breast coal	3	0		
Bearing-in coal	0	3		
Brick coal	1	0		
Bottom coal	1	5		
			5	8

The greatest development of the roof division that has been noted in this territory occurs in the extreme western point of the bend in Forward Township, Allegheny Co. The coal from this point has been exhausted, but the following section from the Old Eagle mine, near Elkhorn, shows the alternating bands which compose it (see fig. 74):

Pittsburg coat at Old Eagle mine, near Elkhorn.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Carbonaceous shale	0	2+		
Slate	0	0¾		
Coal	0	7		
Slate	0	4		
Coal	0	4		
Slate	0	0½		
Coal, bony	0	5		
Clay slate	0	9½		
Coal	0	1		
Slate, sulphur	0	0¼		
Coal	0	3		
Slate	0	1		
Coal, slate, and sulphur	0	6		
Coal, sooty	0	1½		
Coal	0	2		
			3	11½+
Main clay			1	3
Lower division:				
Breast coal	3	3		
Bearing-in coal	0	3		
Brick coal	1	7		
Bottom coal	0	9		
			5	10

From Webster to the north boundary of the Brownsville quadrangle there is little variation in the total thickness of the lower division. It ranges from 5 feet 8 inches to 5 feet 10 inches in most of the mines. At the mouth of Kelly Run, near the northern edge of the quadrangle, the roof division is somewhat reduced, but the lower division holds its full thickness of 5 feet 10 inches. This is shown by the following section at the Parke mine (see fig. 75):

Pittsburg coal at Parke mine, mouth of Kelly Run.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Carbonaceous shale	0	10		
Coal	0	1		
Shale	0	3		
Coal	0	7		
Clay slate	0	10		
Coal with clay vein	2	6		
			5	1
Main clay			0	10
Lower division:				
Breast coal	3	4		
Bearing-in coal	0	3		
Brick coal	1	1		
Bottom coal	1	2		
			5	10

Very little information is obtainable regarding the exact structure of the coal bed between the two rivers, at least after passing beyond the limits of the most extensive mines. Throughout most of this territory the Pittsburg coal is under considerable cover, and consequently has not been exposed. At the northern edge of the quadrangle Falling Timber Run has cut so deep as to expose the coal at Hilldale. At this point it was formerly worked in the Horner and Roberts mine, which is now the property of the Monongahela River Consolidated Coal and Coke Company. In this part of the territory swamps are of rather common occurrence in the coal, and in most cases the thickness of the bed is greater in these swamps than in other places. This is illustrated by the two following sections, which were measured in the mine (see figs. 76 and 77):

Pittsburg coal at Horner & Roberts mine, Hilldale.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	0	5		
Shale	1	6		
Coal	1	0		
Shale	0	3		
Coal	1	0		
			4	2
Main clay			0	11
Lower division:				
Breast coal	4	6		
Slate	0	0¼		
Bearing-in coal	0	3		
Slate	0	0¼		
Brick coal	1	0		
Slate	0	0¼		
Bottom coal	1	6		
			7	3¾

Pittsburg coal at Horner & Roberts mine, Hilldale.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	0	7		
Clay slate	1	9		
Coal	1	0		
Slate	0	1½		
Coal	1	1		
			4	6½
Main clay			0	11
Lower division:				
Breast coal	2	10		
Bearing-in coal	0	3		
Brick coal	1	0		
Bottom coal	1	1		
			5	2

The first section was obtained at the foot of the pump shaft which was sunk for the purpose of draining one of these swamps; the second is the normal section of the coal. It will be seen on comparison that there is a difference of almost 2 feet, and this difference is largely in the breast coal.

Throughout this division of the territory coal mining has been going on for a great many years, and the hillsides are scarred by small mines. The tendency in later years has been to consolidate these small properties, and to-day they are almost all under control of two leading companies, the Pittsburg Coal Company, and the Monongahela River Consolidated Coal and Coke Company. Such a consolidation results in decreasing the number of mines, for as fast as the small properties are exhausted the mines are abandoned and the energies of the company are confined to points where a larger acreage of coal is available. For that reason it is possible that the number of mines to-day is not equal to that of times past; but it is safe to assume that the output is much greater than heretofore and that it is constantly increasing.

Redstone coal.—In this division the next most important coal is the Redstone, which lies from 50 to 80 feet above the Pittsburg bed. This coal is remarkably persistent and regular in thickness. It appears to be present wherever its horizon outcrops, and it ranges in thickness from 2 to 4 feet. The quality of the coal is generally good, but occasionally it carries a heavy percentage of ash, which detracts from its value. The most striking peculiarity is the frequency with which clay horsebacks affect the bed. In many places these are so pronounced as to cut out the coal entirely, but generally they simply reduce its thickness to a fraction of its normal measure. The peculiar and individual characteristics which seem to belong to coal beds are well illustrated by a comparison of the Redstone and Pittsburg coals; the latter, especially in the lower division, is remarkably regular even to the smallest partings, while the former is constantly beset by clay horsebacks and veins which produce great variations in its thickness.

Along Youghiogheny River, in the northern part of the territory, the Redstone coal holds a fairly constant thickness of about 4 feet. It has been worked at many localities to supply local needs, but such mines are now generally abandoned and fuel is obtained from the great Pittsburg coal below. Several of these old mines were observed in the vicinity of Madison, where the bed ranges from 3 to 4 feet in thickness. Near Bells Mills also it has a thickness of 4 feet and the coal is of good quality, but the bed is badly disturbed by horsebacks of clay. At this point a well was drilled some years ago, which shows that the Redstone coal lies 82 feet above the Pittsburg coal.

On the opposite side of the river the Redstone coal bed has been mined extensively on Pollock Run. It shows at the crossing of the pike west of West Newton, and from that point up the run there is an almost continuous line of exposures for at least a quarter of a mile. In this locality its general thickness is about 4 feet (fig. 20), but it is sometimes reduced by horsebacks to only a few inches in thickness.

In the vicinity of Smithton the Redstone coal also is well exposed, its thickness ranging from about 2 feet 9 inches to 4 feet. An opening showing the latter thickness was noted about midway between Smithton and Mendon, where it appears nearly 100 feet above the Pittsburg bed. In the small ravine directly back of Smithton it has been prospected in several places, and shows a fairly constant thickness of 4 feet, but, as usual, with numerous clay veins and horsebacks. South of this point the interval between the Redstone and the Pittsburg appears to grow much smaller. At an exposure at the mouth of Browneller Run, near Wickhaven, its thickness ranges from 4 to 5 feet (fig. 21) and it appears to lie about 50 feet above the Pittsburg bed. South of this point along the eastern margin of the Lambert syncline the bloom of the Redstone coal was noted in several places, but at no point could the exact thickness of the bed be determined. Along Redstone Creek it is generally present wherever its horizon is above water level, and it appears to offer from 2½ to 4 feet of fairly good fuel. Along Monongahela River from Bridgeport to near Fayette City the Redstone coal is generally present and its thickness seems to range from 3 to 4 feet. On Little Redstone Creek the coal is about 40 feet above the Pittsburg bed and shows a thickness of 3 feet (fig. 22). Near Fayette City it was formerly opened at about the same distance from the Pittsburg bed, and, according to report, it showed a thickness of from 3 to 4 feet. It seems probable, however, that the small interval between the Pittsburg and Redstone coal beds observed in this part of the district is due in part to inaccuracies of determination, since wherever a shaft or well section has been obtained the interval which separates the coal beds is greater than 50 feet. This is well shown in a shaft which was sunk to the Pittsburg coal southeast of Sheppler, back from the river. In this shaft the Redstone bed shows a thickness of 3 feet (fig. 23) and occurs 60 feet above the Pittsburg coal. It was, however, impossible to determine its average thickness, for within the limits of the shaft it varies from 0 to 3 feet, being cut out by a horseback of clay.

Back of Webster the coal shows a thickness of 3 feet 8 inches (fig. 24), with 10 inches of cannel shale on top. The coal is of fairly good quality but is cut by many clay veins. In the northern part of the district, between the two rivers, the type section of the Redstone coal was obtained in a shaft of the old Horner & Roberts mine near Hilldale. In this section the Redstone coal is 88 feet above the floor of the Pittsburg coal and shows a thickness of 4 feet (fig. 25). It is generally present on Falling Timber Run, having formerly been mined in a number of places. It carries from 3 to 4 feet of clear coal, having little sulphur, but a very heavy percentage of ash—nearly twice as much as the Pittsburg coal.

In a general way the Redstone coal makes a very favorable showing in this district, at least from Perryopolis north, but the great irregularity of bed section, together with its proximity to the Pittsburg coal below, renders its prospective value slight.

Sewickley coal.—The Sewickley coal occurs near the base of the Benwood limestone. In many cases it immediately underlies the limestone, but occasionally beds of shale and sandstone occur above it. Throughout this district the coal is generally present, but it is invariably thin and of little value. Its greatest development on the east side of the basin, so far as present knowledge goes, is in the vicinity of Tippecanoe, on Redstone Creek, where it has a thickness of from 2 feet to 2 feet 6 inches. Its aggregate thickness on Sewickley Creek is about the same, but there it consists largely of a rich carbonaceous shale instead of coal. On Pollock Run west of West Newton it is well exposed, with a thickness of only 4 inches, and near Wickhaven it has a similar thickness.

Taken as a whole, on the east side of the basin the coal has a maximum of only 2 feet 6 inches, and its average thickness is probably considerably less than one foot. Under present commercial conditions such a coal is valueless, and it will continue to be so until there is a great scarcity of fuel in this region.

Along Monongahela River the Sewickley coal is generally thicker than on the east side of the basin, but it is not thick enough anywhere to be of great prospective value. Along Redstone Creek, on the west side of the Lambert syncline, it ranges from 8 to 24 inches in thickness. At Brownsville it was reported by Professor Stevenson to be absent in one section measured by him, but 2 miles west of the town it has a thickness of 2 feet 3 inches. Near Fayette City it is about 2 feet thick in one locality, and on Lamb Lick Run it measures 18 inches. North of this point its bloom was noted in many places, but, presumably, it is generally less than a foot thick.

Uniontown coal.—This coal bed overlies the Benwood limestone of the Monongahela formation, but throughout this district it is thin and frequently wanting. Its blossom was noted in a number of places, but at no point does it appear to be thick enough to have been prospected, and, consequently, its exact section is not known. As a source of fuel supply for the future it appears to have no value whatever in this region.

Waynesburg coal.—In the First Geological Survey of the State the Waynesburg coal was supposed to be the uppermost coal of value in southwest Pennsylvania, and therefore it was regarded as the top of the Upper Productive (Monongahela) Coal Measures. In a general way this statement is correct, but in the region under consideration none of the coals above the Redstone have much practical value, and the Waynesburg is of but slightly greater importance than the Washington coal, which lies above.

The Waynesburg coal bed is presumably persistent over the region west of the Fayette anticline, but it is not generally of workable thickness. It appears to reach its best development in the southern part of the territory, south of Redstone Creek, where it shows the following section (see fig. 34):

Waynesburg coal south of Redstone Creek.

	Feet.	Inches.
Coal	0	4
Shale	5	0
Coal	0	4
Clay	0	2
Coal, bony	0	4
Coal	1	8
Clay	0	4
Coal	2	5
Total	10	7

North of Redstone Creek it has been prospected as far as Perryopolis and Fayette City, and mines have been opened for supplying the local trade. These mines are now generally abandoned and it is difficult to obtain an idea of the character of the coal. In the vicinity of Redstone post-office it appears to have a thickness of about 4 feet, but the prospect pits are in such condition that exact measurements are impossible. From this point north it was observed simply as a bloom wherever its horizon was reached. Presumably it is persistent over the entire territory, but north of Fayette City it is not thick enough to have been prospected.

Where the Waynesburg sandstone is well developed it is easy to identify the Waynesburg coal, but where the former is poorly developed or lacking it is sometimes difficult to differentiate this coal from other beds. This difficulty was encountered in the northern part of the territory, where the Waynesburg coal is not thick enough to be of commercial importance and where there are several other small coals lying close above it. The identification of the Waynesburg coal in this region is not a matter of commercial importance, but in the determination of the geological structure of the region it is of the greatest moment. On account of the lack of distinguishing characteristics of the coal it is possible that some of the contours have not been well determined; but, fortunately, mine data are generally abundant, and in the interval between mines the structure does not vary greatly from that which is indicated on the structure sheet.

Washington coal.—About 130 or 140 feet above the Waynesburg coal occurs the Washington coal, which when seen in weathered outcrops appears to be a large and promising bed. Sections of the bed, however, show that it is composed of many alternating layers of coal and clay or shale, and that for commercial purposes the bed is practically valueless. In some localities single benches are found of sufficient thickness to mine, but generally the benches are small and the coal worthless.

This bed occurs so high in the series that it is preserved only in the deeper synclines. It is quite prominent in the Port Royal syncline east of West Newton, where it has been prospected in several places. An opening about 2 miles from West Newton and a little south of the Mount Pleasant Pike shows the following section (see fig. 45):

Washington coal east of West Newton.

	Feet.	Inches.
Coal	2	0
Clay	0	1
Coal	0	2
Clay	0	1
Coal	1	0
Clay	0	2
Coal	0	2
Clay	0	3
Coal	0	2
Clay	0	1
Coal	0	3
Clay	0	3
Coal	2	0
Clay	0	2
Coal	2	0
Total	8	10

This coal bed also shows west of Youghiogheny River in Sheppler Hill, where it is not so badly broken as east of the river, the bottom bench of coal having a thickness of 4 feet 2 inches, as shown by the following section (see fig. 46):

Washington coal at Sheppler Hill.

	Feet.	Inches.
Coal	0	6
Clay	0	8
Coal	0	8
Clay	0	2
Coal	2	0
Clay	0	2
Coal	0	8
Clay	0	3
Coal	4	2
Total	9	3

In the Lambert syncline this coal bed makes a large showing in natural outcrop, but its poor quality seems to be generally understood and openings upon it are not readily found. In the high land north of Redstone Creek and west of Woodglen the section of the Washington coal is reported to be as follows (see fig. 47):

Washington coal west of Woodglen.

	Feet.	Inches.		Feet.	Inches.
Coal	0	10		0	10
Clay	0	2	to	0	6
Coal	2	7	to	3	7
Clay	0	½	to	1	2
Coal	1	10	to	2	11
Total	5	5½	to	9	0

Although the Washington coal bed contains a large amount of fuel it is so disposed that the bed as a whole has little value. Generally its acreage is limited, but in the Lambert syncline there is a large area in which it would be of great value were it clear coal or broken only by a few shale partings.

DISTRICT WEST OF MONONGAHELA RIVER.

The coal beds of this district are very similar to those lying between the two rivers. No beds of importance below the Pittsburg are exposed, and very little of consequence above the Waynesburg horizon remains on the hilltops. Aside from the great Pittsburg bed, the Redstone and the Waynesburg coal are the most important members of the series.

Pittsburg coal.—The Pittsburg coal bed is exposed along the river bluffs from the northern edge of the quadrangle nearly to Brownsville, where it passes slightly below water level and remains there to the southern margin of the quadrangle. In the great bend of the river by Fredericktown it reappears under the influence of the Bellevernon anticline, coming to view first about 3 miles below Riverville and disappearing below water level near the mouth of Tenmile Creek, beyond the limits of this territory. Throughout this long outcrop the character and thickness of that part of the coal bed which is mined is remarkably regular, but slight variations appear which have considerable effect upon the practical value of the coal, as will be seen from the following descriptions at various points along the river. In the southwest corner of the quadrangle, or in the Fifth Pool, as it is more generally called, the coal is not extensively mined. On the Washington County side of the river there are two mines working on a commercial scale, and one mine on the Fayette County side. In the vicinity of Riverville the coal has the following section (see fig. 78):

Pittsburg coal near Riverville.

	Feet.	Inches.	Feet.	Inches.
Roof division (coal)			0	10
Main clay			1	0
Lower division:				
Breast coal	3	8		
Bearing-in coal	0	4		
Brick and bottom	3	4		
			7	4

The only extraordinary feature about the coal in this locality is a rock fault in the Riverville mine, which completely cuts out the coal across the mines in a direction about N. 20 E., rudely parallel with the axis of the Bellevernon anticline. This feature was not seen in the mine, but from reports and mine maps it has the appearance of being produced by a regular fault or break of the strata.

About 2¼ miles below Riverville the Fox mine is located on the Washington County side of the river. At this point the section of the coal is as follows (see fig. 79):

Pittsburg coal at Fox mine, east of Riverville.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Carbonaceous shale	2	0		
Coal	1	0		
			3	0
Main clay			1	0
Lower division:				
Breast coal	4	6		
Slate	0	0¼		
Bearing-in coal	0	2		
Slate	0	0¼		
Brick and bottom coal	2	6		
			7	2½

East of this point the coal bed thickens considerably, both in the roof and lower divisions. At the Knob mine, above West Brownsville, the lower division has a total thickness of 9 feet 1½ inches, but the bottom of the coal bed, consisting of brick and bottom coal, is not generally removed, so that the amount of available coal is about 6 feet. The roof division is greatly expanded at this place, including about 17 feet of carbonaceous shale, as shown by the following section (see fig. 80):

Pittsburg coal at Knob mine, opposite Bridgeport.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal	2	0		
Carbonaceous shale	17	6		
Coal	0	6		
			20	0
Main clay			1	0
Lower division:				
Breast coal	5	10		
Bearing-in coal	0	4		
Brick coal	1	2		
Slate	0	0½		
Bottom coal	1	9		
			9	1½

At this mine the coal is reached by a short slope. It does not outcrop at the surface for some distance below. It probably could be seen at West Brownsville were it not for the flood plain deposit, which conceals its outcrop. It lies close to water level for 2 miles below the mouth of Redstone Creek, then gradually rises and remains well above the river to the northern limit of the quadrangle. In the western bend of the river below Coal Center it is mined in several places. The thickness at this point is about normal, the roof division showing about 2 feet, the main clay parting 1 foot, and the lower division about 7 feet. The following section is a detailed measure at one of these mines (see fig. 81):

Pittsburg coal near Coal Center.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal, bony	0	2		
Slate	0	1		
Coal	0	6		
Slate	0	2		
Coal	0	9		
			1	8
Main clay			1	0
Lower division:				
Breast coal	4	6		
Bearing-in coal	0	3		
Brick coal	0	10		
Bottom coal	1	4		
			6	11

On account of the westward rise of the strata over the Bellevernon anticline the Pittsburg coal is visible on Pike Run nearly as far west as East Bethlehem, and it also shows in outcrop on Little Pike Run to the road crossing one-half mile above its mouth. The dips are strong in this section and somewhat irregular, and for that reason the position of the coal varies considerably from creek level. At the bend a mile above Granville it lies at least 60 feet above the level of the creek. It then descends rapidly and follows approximately the bottom of the valley to the sharp bend about a half mile below Little Pike Run, where it disappears from view for a distance of nearly half a mile. It rises again and continues above creek level for nearly two miles to the road crossing north of East Bethlehem. A great many country banks have been opened along this creek to supply the local demands, but most of them are in such a condition that the thickness of the coal could not be determined. Four detailed measures were made by Professor Stevenson, which show the following sections (see figs. 85, 86, 87, and 88, Coal-section sheets).

Pittsburg coal along Pike Run.

	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Roof division:								
Coal......	0	3	0	2	0	4	0	2
Clay......	0	2½	0	4	0	3	0	2½
Coal......	1	1	1	0	1	1	1	0
Main clay...	0	11	1	0	1	2	0	11
Lower division:								
Coal......	6	10	7	3	7	2	6	10

The coal is well exposed along Gorby Run for 3 miles above its mouth, and it also shows on several of the minor tributaries.

Along the river below Coal Center mining is very active and apparently it has been so for a long time, for there are many old abandoned mines in this region. The coal is exhausted over much of the territory in the bend between Lucyville and Dunlevy. In this bend are the three Vesta mines, the output of which is coked near Pittsburg by Jones, Laughlins & Co. for use in their iron furnaces. At Caledonia mine, west of Wood Run, the coal is reported to have the following section (see fig. 82):

Pittsburg coal at Caledonia mine, west of Wood Run.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal..................	0	2		
Slate..................	0	4		
Coal..................	0	8		
Carbonaceous shale..........	2	2		
Coal..................	0	9		
			4	1
Main clay..................			1	0
Lower division:				
Breast coal..................	4	9		
Slate..................	0	0½		
Bearing-in coal..............	0	2		
Slate..................	0	0½		
Brick coal..................	1	4		
Slate..................	0	0½		
Bottom coal..................	1	6		
			7	10½

At the Wood Run mine the lower division is essentially the same, showing a thickness of 7 feet 11 inches, with the breast coal 5 feet, bearing-in coal and slate 4 inches, brick coal 1 foot 3 inches, and bottom coal 1 foot 4 inches. In the vicinity of Allenport the section is similar to that of Wood Run, as shown by the following section from Clipper mine (see fig. 83):

Pittsburg coal at Clipper mine, near Allenport.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal..................	0	6		
Slate..................	0	0½		
Coal..................	0	4		
Slate..................	0	0½		
Coal..................	0	2		
Slate..................	0	0½		
Coal..................	0	6		
Slate..................	0	10		
Coal..................	1	0		
			3	5½
Main clay..................			0	10
Lower division:				
Breast coal..................	4	9		
Slate..................	0	0½		
Bearing-in coal..............	0	2		
Parting..................	0	0½		
Brick coal..................	1	1		
Slate..................	0	0¼		
Bottom coal..................	1	4		
			7	5¼

Below this point the coal is well exposed on the South Branch of Maple Creek to within a mile of the village of Lover. Many of the river mines extend through to this creek, and hence mines have not been established here, except country banks. On the main fork of the creek the coal is also well exposed for 2½ miles from its mouth, but this likewise is undeveloped territory. Numerous openings have been made on the coal in this vicinity, and from one near Charleroi the roof coal is found to have a thickness of 1 foot 2 inches, the main clay 6 inches, and the lower division 8 feet 9 inches. In the ravine opposite Lock No. 4 the coal is mined by the Pittsburg Plate Glass Company, but below this point there are no commercial mines above Pigeon Creek, except the Catsburg, Ivil, and Black Diamond, which are near the mouth of the creek. The reason for the scarcity of mines along the river from Baird to Charleroi is found in the geologic structure, which would make mining expensive, since the coal would have to be lifted up the slopes of the Bellevernon anticline, whereas the mines near the mouth of Pigeon Creek, located in the synclinal basin and extending their entries to the south and east, are drawing the coal down the slopes of the anticline. The coal has been well prospected in the bend below Charleroi. At three-quarters of a mile below Lock No. 4 the roof division has a thickness of 3 feet 3 inches, the main clay 11 inches, the lower division 5 feet 8 inches. In the northern part of the quadrangle the roof division becomes exceedingly complex, consisting of many thin alternating bands of clay or shale and coal. This is well illustrated by sections from the Black Diamond and Catsburg mines which were published by Mr. Wall in Report K[4] of the Second Geological Survey. These sections are as follows (see figs. 84 and 89, Coal-section sheets):

Pittsburg coal at Black Diamond mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Carbonaceous shale..........	2	0		
Black slate..................	0	9		
Carbonaceous shale..........	0	8		
Calcareous shale; nodules of iron ore..............	0	5		
Carbonaceous shale..........	0	3		
Coal..................	0	2		
Slate..................	0	0¼		
Coal..................	0	2		
Slate..................	0	0½		
Coal..................	0	3		
Clay..................	0	3		
Coal..................	0	3		
Slate..................	0	0½		
Coal..................	0	4		
Slate..................	0	0¼		
Coal..................	0	6		
Clay..................	0	2		
Coal..................	0	10		
Slate..................	0	0¼		
Coal..................	0	1		
Slate..................	0	0½		
Coal..................	0	2		
			7	5⅝
Main clay..................			0	10
Lower division:				
Breast coal..................	3	2		
Slate..................	0	0¼		
Bearing-in coal..............	0	3		
Slate..................	0	0¼		
Brick coal..................	1	1		
Slate..................	0	0¼		
Bottom coal..................	1	2		
			5	8¾

Pittsburg coal at Catsburg mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Black slate..................	0	7		
Carbonaceous shale..........	0	8		
Slate..................	0	7		
Coal..................	0	8		
Slate..................	0	0¼		
Coal..................	0	8		
Slate..................	0	0¼		
Coal..................	0	2½		
Clay..................	0	8		
Coal..................	0	8		
Slate..................	0	0¼		
Coal..................	0	4		
Clay..................	0	3		
Coal..................	0	10		
Clay..................	0	0⅝		
Coal..................	0	3		
			6	5⅜
Main clay..................			0	10
Lower division:				
Breast coal..................	2	11		
Clay..................	0	0¼		
Bearing-in coal..............	0	3		
Slate..................	0	0¼		
Brick coal..................	1	3		
Slate..................	0	0¼		
Bottom coal..................	1	3		
			5	8¾

At the mouth of Pigeon Creek the coal is about 50 feet above the water, but it dips below water level within about a mile, and does not again rise above it. About 3 miles above the river it has recently been reached by the shaft of the Hazel Kirke mine at a depth of 85 feet below the flood plain of the creek. It is also reached by shaft by the Ellsworth Coal Company above Bentleyville, several miles beyond the western limit of this territory.

Between Pigeon and Mingo creeks most of the mines are abandoned, presumably on account of the dip of the coal away from the river front. Below Mingo Creek mining operations have been very active and still are continued in some of the large mines, but the coal near the river is almost exhausted and supplies have to be brought from new territory at a considerable distance back. Three detailed sections of the coal were published in Report K[4]. Two, measured in the Courtney mine, are intended to show something of the variation which occurs in the roof division of the coal; they are as follows (see figs. 90 and 91):

Pittsburg coal at Courtney mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Carbonaceous shale..........	1	3		
Coal..................	1	0		
Clay..................	0	3		
Coal..................	0	6		
Slate..................	0	0½		
Coal..................	0	4		
			3	4½
Main clay..................			1	0
Lower division:				
Breast coal..................	3	0		
Slate..................	0	0¼		
Bearing-in coal..............	0	3		
Slate..................	0	0¼		
Brick coal..................	1	0		
Slate..................	0	0¼		
Bottom coal..................	1	3		
			5	6¾

Pittsburg coal at Courtney mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Coal..................	0	3		
Slate..................	0	0½		
Coal..................	0	3		
Slate..................	0	0½		
Coal..................	0	6		
Slate..................	0	0½		
Coal..................	0	7		
Clay..................	0	2		
Coal..................	0	8		
Slate..................	0	0½		
Coal..................	0	1		
Slate..................	0	0½		
Coal..................	0	2		
			2	8⅝
Main clay..................			0	10
Lower division:				
Breast coal..................	3	9		
Slate..................	0	0½		
Bearing-in coal..............	0	3		
Slate..................	0	0½		
Brick coal..................	1	3		
Slate..................	0	0½		
Bottom coal..................	1	6		
			6	10½

The third was measured in the Cliff mine, which was worked out and abandoned a number of years ago. Its section is as follows (see fig. 92, Coal-section sheets):

Pittsburg coal at Cliff mine.

	Feet.	Inches.	Feet.	Inches.
Roof division:				
Black slate..................	0	5		
Coal..................	0	2		
Slate..................	0	0½		
Coal..................	0	2		
Slate..................	0	0½		
Coal..................	0	2		
Slate..................	0	1		
Coal..................	0	4		
Slate..................	0	0½		
Coal..................	0	3		
Clay slate..................	0	2		
Coal..................	0	1		
Clay..................	0	11		
Coal..................	0	8½		
Slate..................	0	0½		
Coal..................	0	7		
Slate..................	0	0½		
Coal..................	0	7		
Slate..................	0	0½		
Coal..................	0	2		
Slate..................	0	0½		
Coal..................	0	2		
			5	1⅞
Main clay..................			0	8
Lower division:				
Breast coal..................	2	11		
Slate..................	0	0½		
Bearing-in coal..............	0	4		
Slate..................	0	0½		
Brick coal..................	1	1		
Slate..................	0	0½		
Bottom coal..................	1	2		
			5	6¾

In a general way the character of the Pittsburg coal deteriorates toward the west, but this change is not great enough to seriously affect the coal in this territory. According to recent developments it has been found that the coal in the Lambert syncline produces coke that compares favorably with that from the Connellsville basin, and the Jones & Laughlin Steel Company produce their own coke from mines back of Allenport and Lucyville. It is not probable, however, that much of the Pittsburg coal in Washington County can be manufactured into merchantable coke. The percentage of ash is too high for this purpose, and the sulphur is also troublesome. Throughout that part of Washington County which is included in the Brownsville quadrangle the coal is well adapted to fuel purposes, and doubtless mines will soon be extended through much of this territory.

Redstone coal.—The Redstone coal lies from 40 to 80 feet above the Pittsburg. It is generally present in the eastern part of Washington County, and it is one of the most promising coals above the great Pittsburg bed. It can not stand in competition with the bed below, but is being counted on as a source of supply when that is exhausted.

Near Fredericktown, in the southwest corner of the Brownsville quadrangle, it is said to be 55 feet above the base of the Pittsburg coal. It is reported to show only 6 inches of coal in a bed of bituminous shale 5 feet thick. This is the condition of the Redstone coal in the territory to the south, but presumably not throughout much of the Brownsville quadrangle. The Redstone coal appears to be somewhat irregular in thickness and distribution in the southern part of the quadrangle, since at various points it is reported absent. In the bend below Coal Center the rocks are well exposed in the river bluff, but the Redstone coal does not appear at its proper horizon, nor has it been identified on Pike Run, where its horizon is exposed for a number of miles. Near Lucyville Professor Stevenson identified the Redstone coal as an 8-inch bed, 20 feet above the Pittsburg coal; but this seems improbable, since wherever it is unmistakably developed the interval is much greater. North of this point it seems to be generally present and to range from 3 to 4 feet in thickness. One mile below Lock No. 4 it is well exposed with the thickness given above (fig. 26). Above the Black Diamond mine it also shows from 3 feet to 3 feet 6 inches thick (fig. 27). Near the mouth of Mingo Creek it has a thickness of 4 feet (fig. 28), as reported from an old air shaft. It also shows near Coal Bluff, about 60 feet above the floor of the Pittsburg coal, with a thickness of 4 feet 6 inches (fig. 29). In this region it usually occurs from 50 to 60 feet above the base of the Pittsburg coal and ranges from 2 to 4 feet in thickness.

In a general way the importance of the Redstone coal appears to increase toward the north, and throughout the northern part of the Brownsville-Connellsville area it is a promising bed. It is, however, frequently disturbed by clay horsebacks and veins, so that its value is not so great as would appear from some of its exposures. In the northern part of the quadrangle the quality is usually good, and it makes very good fuel.

Sewickley coal.—The Sewickley coal bed normally belongs from 120 to 140 feet above the Pittsburg bed and near the base of the Benwood limestone. Throughout this district it is thin, and under present conditions has no commercial value.

In the southwest corner of the quadrangle it occurs about 140 feet above the floor of the Pittsburg coal. At Lock No. 5 it has a thickness of 3 feet (fig. 30), and one mile from Brownsville it shows the following section (see fig. 31):

Sewickley coal west of Brownsville.

	Feet.	Inches.
Coal..................................	3	6
Shale..................................	2	0
Coal..................................	0	8
Total..........................	6	2

It also shows on Gorby Run, where a thickness of 3 feet 6 inches has been reported (fig. 32). North of this point its bloom has been noted at a great many places, but its thickness appears to be not over 2 feet.

Uniontown coal.—The Uniontown coal is of little importance throughout this part of Washington County. It is reported from Krepp Knob, west of Brownsville, with a thickness of 3 feet (fig. 33) and also with the same thickness in the bluff below Coal Center. It occurs about 100 feet below the Waynesburg coal, and consequently ranges from 230 to 260 feet above the Pittsburg bed. North of Coal Center no openings have been observed at this horizon, and it has been noted simply as a bloom, and consequently its thickness has not been determined. It is usually thin, however, and of little value.

Waynesburg coal.—The Waynesburg coal is persistent throughout this district. It ranges from 310 to 360 feet above the base of the Pittsburg bed. In most places it is overlain by coarse Waynesburg sandstone, but occasionally this loses its distinctive characteristics and the bed can be identified only by the general sequence of the rocks associated with it. On Fishpot Run, in the southwest corner of the Brownsville quadrangle, it shows the following section (see fig. 35):

Waynesburg coal on Fishpot Run.

	Feet.	Inches.
Coal..................................	0	10
Sandstone..................................	2	6
Coal..................................	0	4
Clay..................................	0	10
Coal..................................	2	6
Clay..................................	0	1
Coal..................................	0	6
Total..........................	7	7

It is almost invariably broken up by many and thick shale partings, which render the coal practically worthless. In an opening on Krepp Knob west of Brownsville it shows only one clay parting, but the coal benches are correspondingly thin, and consequently the opening does not give much promise (see fig. 36):

Waynesburg coal at Krepp Knob.

	Feet.	Inches.
Coal..................................	0	10
Clay..................................	0	3
Coal..................................	2	6
Total..........................	3	7

On Pike Run and its tributaries the Waynesburg coal has been extensively prospected, especially in the territory near the head of the run and on the west side of the Bellevernon anticline. Most of these country banks are closed at present and in such a condition that it is impossible to measure the coal. Professor Stevenson reports the following sections from four banks in this vicinity (see figs. 39, 40, 41, and 42):

Waynesburg coal on Pike Run,

	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Coal......	1	0	1	0	0	9	0	10
Clay......	1	1	1	1	1	0	1	0
Coal......	3	0	2	8	2	4	2	3
Clay......	0	2	0	1½	0	2	0	4
Brick coal	0	3	0	3	0	3	0	3
Clay......	0	2	.....		0	1	.....	
Coal......	1	6	1	5	1	3	1	4
Totals..	7	2	6	6½	5	10	6	0

The Waynesburg coal has been mined to some extent in the vicinity of Bentleyville, which is on Pigeon Creek about a mile beyond the western boundary of the Brownsville quadrangle. The Pittsburg coal is not available at the surface in this locality, and the Waynesburg has been used to supply local needs. The section of the coal at this place is as follows (see fig. 37):

Waynesburg coal near Bentleyville.

	Feet.	Inches.
Coal	0	10
Clay	1	2
Coal	2	8
Clay	0	2
Coal	1	1
Total	5	11

The uppermost bench of coal is reported to be worthless and is not mined; the lowest bench is also poor, being pyritous and slaty; but the middle bench is good, clean coal. A country bank 3 miles east of Bentleyville affords the following section, which shows that the coal in this region is remarkably regular in the number and thickness of its benches (see fig. 38):

Waynesburg coal 3 miles east of Bentleyville.

	Feet.	Inches.
Coal	0	10
Clay	1	2
Coal	2	8
Clay	0	2
Coal	1	1
Total	5	11

North of this point the Waynesburg coal has not been so extensively used as on Pike Run. It caps the hills on the east side of Pigeon Creek in Fallowfield and Carroll townships, and in the latter locality it is reported to hold a thickness of about 4 feet, but it is probable that this thickness includes the customary shale partings. In the vicinity of Ginger Hill the Waynesburg coal has been opened at several places, but the coal is generally inaccessible. Professor Stevenson reports the following sections from the western part of Fallowfield Township, west of Pigeon Creek, which show the conditions of the Waynesburg coal in this region (see figs. 43 and 44, Coal-section sheets):

Waynesburg coal west of Pigeon Creek.

	Feet.	Inches.	Feet.	Inches.
Coal	0	11	1	0
Clay	1	2	1	3
Coal	2	10	2	8
Parting, thin.				
Coal	1	1	1	0
Totals	6	0	5	11

The coal is present in the northwest corner of the Brownsville quadrangle under the Waynesburg sandstone, which caps the hills in this vicinity, but the part remaining uneroded is so small that it has little value except for local consumption.

In a general way the Waynesburg coal bed contains a large amount of fuel, but it is so broken by partings and the coal itself is generally so impure that the bed is comparatively worthless.

COKE.

Almost all the coal mined in the Uniontown and Latrobe synclines is converted into coke. Besides this main field, coke is produced in Stickel Hollow south of Perryopolis, on Redstone Creek, at Smock and Grindstone, on Youghiogheny River at the Euclid, Port Royal, and Waverly No. 1 mines, and also from the coal of the three Vesta mines, in the vicinity of Allenport and Wood Run. The coal of the Vesta mines is manufactured into coke at the furnaces in the vicinity of Pittsburg.

The coke industry in this district has reached wonderful proportions, although its development is limited almost entirely to the decade just passed. Some coke was made as early as 1860, but there were then only 70 coke ovens in use in the Connellsville district. From this small beginning the plants have grown steadily in size and number, until at present there are approximately 25,000 ovens in constant use in the Connellsville basin and the Lambert syncline. About 10,000 of these ovens are in the Brownsville and Connellsville quadrangles.

In the Latrobe and Uniontown synclines the coal is soft and easily mined; it breaks up in mining into small particles and is delivered to the ovens in the best possible form for coking. The coal is high in fixed carbon and low in sulphur and phosphorus, and has only a moderate percentage of ash. These characteristics make it the typical coking coal of this country.

The essential points in a coke for furnace use are hardness of body, well-developed cell structure, purity, and uniform quality. The average composition of Connellsville coke, according to Mr. A. S. McCreath, is as follows:

Average composition of Connellsville coke (McCreath).

	Per cent.
Water	.300
Volatile matter	.460
Fixed carbon	89.576
Sulphur	.821
Ash	9.113
Phosphorus	.014
Total	100.284

The average of a number of analyses made in 1893 and reported by the H. C. Frick Coke Company shows the following composition:

Average composition of Connellsville coke (Frick Company).

	Per cent.
Water	.070
Volatile matter	.880
Fixed carbon	89.509
Sulphur	.711
Ash	8.830
Total	100.000

The future extension of the coking field is now a most interesting question, since on the supply of coke depends largely the production of iron. Development in the Connellsville basin has been so rapid and the output is so great that the operators are beginning to look forward to the time when the coal from this basin shall be exhausted. This time is variously estimated at from thirty-five to seventy-five years, but it seems probable that these figures are extreme estimates, and that a mean of fifty or sixty years would more properly represent the life of the industry in the basin.

Within the last four years the area of coking coal has been extended southwest in Fayette County to Monongahela River, so that it now includes most of the Lambert syncline. It is possible that this field may be extended into Greene County, but the most of the coal is so deeply under cover that its quality can not be told until shafts are sunk. Only a little of this newly developed field lies in the Brownsville quadrangle, but it seems probable that the whole northern part of the Lambert syncline may become coke-producing territory.

NATURAL GAS.

By Myron L. Fuller.

No important gas wells have yet been drilled in the Connellsville quadrangle. In the Brownsville quadrangle, however, gas has been produced in considerable quantities for more than 15 years—since 1887—and the wells have included several of exceptional volume and pressure. Almost all the wells lie west of a diagonal line drawn from the extreme northeast to the southwest corner of the area, but they may be grouped into three rather well-defined fields. The Bellevernon field, which is the largest, extends in a southwesterly direction from the vicinity of Smithdale, on Youghiogheny River, to the South Branch of Maple Creek, in southern Fallowfield Township, Washington County, the width varying from a mile or less in the northeastern portion to 3 miles or more west of Monongahela River. The field second in importance is that represented by the somewhat scattering wells in the southern portion of Forward Township, Allegheny County. It measures about 2½ miles from east to west and 2 miles from north to south. The third and smallest field lies southwest of East Bethlehem, in Centerville Township, Washington County. It measures only about a mile in diameter. Besides the wells of the fields or pools mentioned, there are a number of scattering wells, not readily referred to groups, occurring at intervals, usually of several miles, along the western border of the Brownsville quadrangle.

All the fields of the area appear to possess a close and definite relation to the geologic structure, Almost without exception the wells are near the crests of the anticlines or far up on their flanks. The relationship is especially striking in the Bellevernon field, in which the wells occur without exception either along the crest of the arch or within three-quarters of a mile on either side.

Natural gas is not confined to a single horizon, but may occur at a number of levels, even in a single well. The Big Injun, Fifty-foot, and Gordon sands are the most productive in Forward Township. In the Bellevernon field the Big Injun, Gantz, and Fifty-foot sands are the principal producing strata. In the Centerville field nearly all the gas is from the Fifty-foot sand. The Elizabeth sand also has produced gas in a few wells in the Bellevernon and Centerville fields. The average depth to the Big Injun is not far from 1450 feet; to the Gantz sand, 2050 feet; to the Fifty-foot, 2100 feet; and to the Elizabeth, 2775 feet. The depths to the pay streak, coals, and gas sands are given for many of the wells in the accompanying table.

BELLEVERNON GAS FIELD.

The first productive well in this field was drilled by the Bellevernon Light and Heat Company. It was located on the John B. Carson farm, in Washington County, at a point not far from Maple Creek and about a mile above its mouth, and was completed in September, 1887. Gas was obtained from several beds, the main supply apparently being from the Fifty-foot sand at a depth of from 2040 to 2060 feet, or a little over 2000 feet below the Pittsburg coal. The sand is extremely hard and close, and although the rock pressure was 860 pounds the minute pressure reached only 125 pounds.

The success of this well produced considerable excitement and led to active drilling. About 20 wells, most of them good producers, were sunk in the following 7 months. The largest was the B. L. Parson well, also owned by the Bellevernon Light and Heat Company. Gas appears to have been encountered in the Salt sand and again in the Gantz, but the main supply was from the Fifty-foot. The gas escaped for a month before it was shut in, the roar being audible for from 10 to 20 miles under favorable conditions. In a 5⅝-inch casing it showed an open pressure of 15 pounds per square inch, and in a 4-inch casing an open pressure of 25 pounds. On shutting it in at the end of a month a minute pressure of 585 pounds and a rock pressure of 800 pounds was obtained. Another well of the same company gave a minute pressure at the start of 620 pounds and a rock pressure of 850 pounds.

The drilling continued in the Maple Creek district until 50 or more wells had been sunk, nearly all being good producers with minute pressures of from 200 to 500 pounds. The average life of the wells, however, was only 5 or 6 years, and in 1894 the supply had decreased to such an extent that "wild-catting" was begun in search of new fields. The first well east of Monongahela River was the Wilson well, sunk in 1894 or 1895. It showed a minute pressure of 300 pounds and led to a marked revival of drilling, which has continued until the present time. The wells are owned mainly by the Bellevernon Light and Heat Company, the Greensboro Natural Gas Company, and T. L. Daly & Co. About 80 per cent have been successful. The average minute pressure has been about 200 pounds and the rock pressure about 600 pounds. The later wells appear on the whole to be a little less powerful than the earlier, the relative efficiency being probably about 60 per cent. The last well drilled by the Bellevernon Light and Heat Company showed a minute pressure of 360 pounds.

At the present time 24 of the wells of the Bellevernon Company are reported to be producing, and it is probable that there are nearly as many more producing wells owned by the Greensboro Natural Gas Company, T. L. Daly & Co., and others. The best of the present wells are the Samuel Finley, about a mile southeast of Webster, and the J. J. Wilson, some 2 miles northeast of the same place. The rock pressure in the Maple Creek district is down to about 60 pounds, but wells drilled 8 years ago are still being used. The pressure in the portion of the field east of the Monongahela River is probably nearly 3 times as great.

Probably 50 per cent or more of the wells get their supply from the Big Injun sand, while others obtain gas from the Gantz, Fifty-foot, or even the Elizabeth sand, the depths below the Pittsburg coal averaging about 1250, 1925, 1950, and 2717 feet, respectively. The following detailed sections of the B. L. Parson well in the Maple Creek district and of the T. L. Daly No. 3 well north of Gibsonton show the succession of beds as recognized by the drillers.

B. L. Parson well.—Located on the South Branch of Maple Creek, Fallowfield Township, Washington County, three-quarters of a mile northwest of its southeast corner. Drilled in 1888 by the Bellevernon Light and Heat Company. Authority, S. F. Jones (Second Geol. Survey Pa., Rept. I[5], p 303). Altitude, 945 feet.

Record of B. L. Parson well.

	Thickness in feet.	Depth in feet.
Drive pipe	13	13
Sandstone	80	93
Slate	244	337
Coal	10	347
Slate	174	521
Sandstone	44	565
Slate	135	700
Sandstone (gas)	15	715
Slate	40	755
Sandstone	50	805
Slate	15	820
Sandstone (water)	40	860
Sandstone	65	925
Coal	8	933
Sandstone	67	1000
Slate (bottom of casing)	10	1010
Limestone	10	1020
Red rock	25	1045
Slate	30	1075
Sandstone	25	1100
Slate	10	1110
Limestone	40	1150
Sandstone, yellow	60	1210
Limestone	15	1225
Sandstone, white	30	1255
Sandstone, black	25	1280
Sandstone, white	30	1310

ELEVATIONS AND DEPTHS TO COALS AND PRODUCING SANDS IN THE GAS WELLS OF THE BROWNSVILLE QUADRANGLE.

[Compiled from information furnished by the owners.]

No. of well on map.	Approximate elevation above sea.	Name of well.	Owners.	Producing sand.	Depth to pay streak.	Depth to Pittsburg coal.	Depth to Upper Freeport coal.	Depth to Salt sand.	Depth to Big Injun sand.	Depth to Gantz sand.	Depth to Fifty-foot sand.
1	1070	Hamilton	Bellwood & Monongahela Natural Gas Co.	....	....	325	....	....	....	....	....
2	1080	Hamilton	Bellwood & Monongahela Natural Gas Co.	....	....	325	....	....	....	....	....
3	990	Lamont	Bellwood & Monongahela Natural Gas Co.	....	....	285	....	....	....	....	....
5	1160	J. K. Long	American Window Glass Co.	Gantz	2236	305	....	....	....	2216	....
6	1005	Jesse Wahl	Philadelphia Co.	....	2585	300	....	1225	1660	2190	2263
13	1170	Stephen Applegate	American Window Glass Co.	Big Injun.	....	415	1050	....	1659	2330	2385
14	1040	Wonderly, No. 1	American Window Glass Co.	....	....	250	....	....	1500	2150	2240
15	1000	Stephen Wahl, No 2	American Window Glass Co.	Big Injun.	1565	235	850	....	1485	2100	2155
				Gordon	2510	...	....	....	....	....	....
16	905	Stephen Wahl, No. 1	American Window Glass Co.	Fifty-foot.	2055	50	....	....	1305	1965	2030
				Gordon	2325	...	....	....	....	....	....
24	1140	R. Maxwell	Bellevernon Light & Heat Co.	Big Injun.	1645	290	935	1100	1525	2195	2215
				Thirty-ft.?	2080	...	....	....	....	....	....
26	1160	B. F. Stoneman	Bellevernon Light & Heat Co.	Big Injun.	1680	320	950	1100	1560	2230	2250
27	1085	Noah Haden	Bellevernon Light & Heat Co.	Big Injun.	1525	215	....	1000	1460	2121	2150
				Gantz	2121	...	....	....	....	....	....
28	1045	Mrs. Moore	Bellevernon Light & Heat Co.	Big Injun.	1530	180	....	....	1430	2130	2170
29	1070	J. Wilson	Bellevernon Light & Heat Co.	Big Injun.	1500	190	825	1010	1445	2110	....
30	1060	J. & B. F. Beazell	Bellevernon Light & Heat Co.	....	....	199	835	990	1465	2110	2130
31	1100	Wm. Beazell	Bellevernon Light & Heat Co.	Elizabeth.	2760	243	....	....	1455	2149	2226
36	930	Rankin No. 2	Bellevernon Light & Heat Co.	....	....	60	....	....	1310	1960	1995
38	870	Mrs. Martin	Bellevernon Light & Heat Co.	Big Injun.	1340	...	....	835	1250	1915	1935
41	1165	Tom Finley	Bellevernon Light & Heat Co.	Fifty-foot.	2255	260	....	1030	1515	2185	2225
43	1070	John Rankin, No. 4	Bellevernon Light & Heat Co.	....	1440	235	880	1065	1500	2130	2170
49	1050	Johnson	Bellevernon Light & Heat Co.	....	....	...	....	....	1400	2060	2105
53	975	Gibson No. 3	T. L. Daly & Co.	....	....	*20	640	....	....	1960	....
54	860	John Irons, No. 2	T. L. Daly & Co.	Black slate	748	*135	....	....	....	....	....
				Black sand	1200	...	....	....	....	....	....
				Loose sand	1872	...	....	....	....	....	....
60	980	John Wilson	Monongahela Natural Gas Co.	Gantz	....	215	850	1150	1550	2165	....
64	1185	Lickman	Philadelphia Co.	....	....	123	....	....	....	2080	....
73	945	B. L. Parson	Bellevernon Light & Heat Co.	Fifty-foot.	1915	*70	....	....	....	1820	1915
74	970	No. 317	Philadelphia Co.	Gantz	....	...	....	....	....	1920	2010
76	1095	Mitchell	Greensboro Natural Gas Co.	....	....	330	....	....	1545	....	2270
77	1080	Mrs. E. Morris	Philadelphia Co.	....	....	139	778	....	1350	2125	....
78	1035	Mrs. E. Morris	Philadelphia Co.	....	....	...	....	900	1280	2050	....
80	1175	J. I. Cleaver	Monongahela Natural Gas Co.	Fifty-foot.	....	260	....	1160	1500	....	2260
81	1185	S. M. Cleaver	Philadelphia Co.	Big Injun.	1600	247	....	....	1506	1926	2247
				Fifty-foot.	2275	...	....	....	....	....	....
				Elizabeth.	2772 to 2797	...	....	....	....	....	....
82	1000	John Williams	Monongahela Natural Gas Co.	Fifty-foot.	....	130	....	1120	1380	....	2140
83	1170	Mahlon Linton	Monongahela Natural Gas Co.	Fifty-foot.	....	300	....	....	1500	2235	2280
84	960	T. W. Hill	Ten Mile Natural Gas Co.	Fifty-foot.	....	67	....	970	1291	....	2015
85	950	O. M. Linton	Ten Mile Natural Gas Co.	Fifty-foot.	2026	50	....	915	1270	1984	2012

*Distance of well-head below Pittsburg coal.

	Thickness in feet.	Depth in feet.
Slate	20	1330
Sandstone, white	110	1440
Slate	45	1485
Sandstone, white	130	1615
Slate	20	1635
Sandstone	15	1650
Slate	160	1810
Red rock	10	1820
Sandstone, black (gas) [Gantz sand]	60	1880
Slate	35	1915
Sandstone [Fifty-foot sand], strong gas	35	1950

T. L. Daly & Co.'s gas well No. 3.—On Gibson farm, three-quarters of a mile north of Gibsonton, Rostraver Township, Westmoreland County. Completed May 12, 1902. Authority, T. L. Daly. Approximate altitude, 975 feet. Well starts 20 feet below Pittsburg coal.

Record of T. L. Daly & Co.'s gas well No. 3.

	Thickness in feet.	Depth in feet.
Clay	6	6
Slate	14	20
Limestone	10	30
Slate	105	135
Black slate	60	195
Red rock	25	220
Slate	35	255
Red rock	25	280
Black slate	35	315
Limestone	10	325
Slate	25	350
Sandstone	15	365
Slate	20	385
Black slate	40	425
Sandstone	30	455
Slate	50	505
Black slate	45	550
Slate	30	580
Sandstone	60	640
Coal	6	646
Black slate	30	676
Slate	75	751
Black slate	34	785
Coal	4	789
Slate	30	819
Sandstone	45	864
Slate	40	904
Sandstone	155	1059
Slate	40	1099
Sandstone	41	1140
Slate	58	1198
Red rock	30	1228
Slate	32	1260
Sandstone	50	1310
Slate	40	1350
Sandstone	180	1530
Slate	40	1570
Sandstone	160	1730
Slate	140	1870
Red sandstone	20	1890
Slate	70	1960
Gantz sand	30	1990
Slate	10	2000
Sandstone	35	2035
Slate	15	2050
Sandstone	40	2090
Slate	15	2105
Red slate	20	2125
Slate	25	2150
Red slate	30	2180
Slate	45	2225
Red slate	50	2275
Red sandstone	30	2305
Red slate	40	2345
Slate	20	2365
Red slate	35	2400
Slate	125	2525
Sandstone	10	2535
Slate	30	2565
Sandstone	10	2575
Slate	40	2615
Sandstone	15	2630
Slate	3	2633

As has been stated previously, the wells of the Bellevernon fields are either along the crest or a little to one side of the axis of the Bellevernon anticline. This anticline enters the Brownsville quadrangle from the northeast at a point about three-quarters of a mile northwest of Marchand. From this point to Smithdale the anticline is rather broad and flat and somewhat irregular, and has not yet afforded much gas. The crest becomes sharp near Salem Church, and maintains this form for from 2 to 3 miles. This part is marked by a considerable number of good gas wells, mainly along a line parallel to the anticlinal axis but a half mile or so farther east. In the vicinity of Fells Church the anticline broadens out and becomes less productive; but it narrows again a little east of the mouth of Turkey Run (three-quarters of a mile south of Webster), where it affords a good supply of gas. From here to the mouth of the small run just east of Sheppler the crest of the anticline lies aling the east bank of the Monongahela. Although the anticline is well developed and has a sharp crest, but little gas has so far been obtained. North of Bellevernon the anticline is broader and has afforded a number of wells. The axis crosses the river near the mouth of Maple Creek. Beyond this point the anticline rises rapidly to a pronounced dome, the central point of which is between the two branches of Maple Creek, about a mile northwest of the old B. L. Parson well, or some 2 miles southwest of Charleroi. The largest wells of the field were obtained either on the southeast flanks of this dome or near the crest. At the dome the axis of the anticline makes a bend to the south, passes near the office of the Philadelphia Company on the South Branch of Maple Creek, continues with minor swings through East Bethlehem, and leaves the quadrangle about a mile north of Riverville.

WELLS OF FORWARD TOWNSHIP.

The wells of this township have nearly all been drilled since the beginning of 1900, the success of the wells of the Bellevernon field and the increasing value of the gas being the probable causes of the drilling. Most of the wells are owned either by the American Window Glass Company, of Pittsburg, or by the West Monongahela Natural Gas Company, of Monongahela. The wells did not meet with such uniform success as those of the Bellevernon field, though volumes of from 500,000 to 3,000,000 cubic feet are reported from several of them.

Gas is obtained from the Big Injun, Gantz, Fifty-foot, Gordon, and Sixth sands, the approximate intervals below the Pittsburg coal being 1325, 1925, 2000, 2275, and 2525, respectively. The Gordon appears to be the best producer, followed in order by the Sixth, Gantz, Fifty-foot, and Big Injun.

STEPHEN APPLEGATE WELL NO. 1.

Located near headwaters of Sunfish Run, Forward Township. Owned by American Window Glass Company. Completed Oct. 22, 1901. Authority, M. M. Wally, contractor. Approximate altitude, 1170 feet.

Record of Stephen Applegate well No. 1.

	Thickness in feet.	Depth in feet.
Unrecorded	295	295
Limestone	25	320
Black slate	30	350
Mapletown coal	4	354
White fire clay	10	364
Gray limestone	11	375
White slate	10	385
Gray sand, loose and open	25	410
Black slate	5	415
Pittsburg coal	6	421
Fire clay	8	429
Gray limestone	12	441
White fire clay [shale ?]	59	500
Red clay	5	505
White clay	95	600
Red clay	40	640
White clay	60	700
Red clay	60	760
White clay	40	800
Red clay	40	840
White slate	40	880
Gray sand	40	920
Black slate	50	970
White sand	60	1030
Coal	4	1034
Gray sand (gas show at 1180)	270	1304
Black slate	10	1314
Gray sand	50	1364
White slate	20	1384
White sand	30	1414
White slate	25	1439
Gray sand	75	1514
White slate	10	1524
Red clay	75	1599
Limestone	60	1659
Big Injun sand (close and hard) (gas)	245	1904
Slate and shale	70	1974
Dark sand	120	2094
Slate and shale	236	2330
Gantz sand, dark shale	25	2355
Gantz sand, black slate	30	2385
Third sand, close and white	40	2425
Black slate	35	2460
Thirty-foot sand	25	2485
White slate	15	2500
Blue Monday sand, dark	50	2550
Slate and shells	55	2605
Red slate	20	2625
Black slate	35	2660
Red slate and shale	20	2680
Gordon sand	10	2690
Slate and shale	80	2770
Fourth sand, dark and hard	20	2790
Unrecorded	40	2830
Fifth sand, dark, shelly (show of oil)	25	2855
Red slate	20	2875
White slate	50	2925
Sixth sand	18	2943
Unrecorded	17	2960

The wells of the Forward field are on the crest or the slopes of the Peters Creek anticline, which is here rapidly subsiding and soon completely disappears. The fold is rather broad and irregular, as will be seen from the contours of the structure map. The wells east of Perry Mill Run are nearly on the crest of the main anticline. The more southerly of the wells along Sunfish Run appear to be near the crest of a subordinate eastward branch of the anticline. The wells near the head of the run are on the flanks of the anticline.

WELLS OF THE CENTERVILLE FIELD.

This small field contains only a few wells, most of which are owned by the Monongahela Natural Gas Company of Pittsburg and the Ten Mile Natural Gas Company of Waynesburg. In every case the gas was obtained from the Fifty-foot sand, the depths varying from 1960 to 2010 feet below the Pittsburg coal. Some of the wells gave large amounts of gas.

The wells of the Centerville pool lie near the crest of the Bellevernon anticline, which at this point is rather broad and pitches rapidly to the southwest. The more northerly of the wells are on the northwest slope of the anticline, one-half mile or so from the crest. The southern wells are on the very crest.

OTHER WELLS.

In addition to the wells of the fields described above, there are a few scattering wells near the western border of the quadrangle. They are owned mainly by the Bellwood and Monongahela Natural Gas Company, the Philadelphia Company, the Greensboro Natural Gas Company, and the Monongahela Natural Gas Company. Gas is obtained from various horizons. The wells are on an average smaller producers thanthose of the Bellevernon and Forward fields.

The well at Baidland is near the center of the Pigeon Creek syncline, the Ginger Hill wells are near the crest of a small anticline, and the Charleroi wells are on the slopes of the Bellevernon anticline. The remaining wells lie on the west flank of the Bellevernon anticline, most of them well down towards the bottom of the Pigeon Creek syncline.

A few test wells have been drilled in the Connellsville quadrangle, but so far little or no gas has been obtained. Most of the drilling in this region has been done south of Sewickley Creek, from Hunkers to Emmonston. These wells were put down several years ago in search of brine, which was used for a number of years in the manufacture of salt. The wells were all shallow, the brine being obtained from the Pottsville and Pocono sandstones, and consequently the lower rocks were not tested for oil or gas. Since that time scattered test wells have been drilled in many places—several in the vicinity of Walts mill and Bells mill; one at Reagantown; one at Layton, on the Youghiogheny River; and one or two on Mounts Creek in the vicinity of Connellsville.

POSSIBLE EXTENSION OF THE GAS FIELDS.

From the large amount of drilling which has been done in the Brownsville quadrangle it is not probable that the fields already described will be appreciably extended. Most of the favorable territory has been tested, and it seems extremely unlikely that any new fields will be discovered in this region, unless upon the minor anticlinal rolls, in which case the fields will doubtless be small and probably of little importance.

So far as geologic structure is concerned (and in this region there seems to be a close relation between the gas fields and the anticlinal structures), the Connellsville quadrangle offers more promising territory for the development of new fields than can be found in the Brownsville area. All the test wells which have been drilled in the former quadrangle are upon the flanks of the Fayette anticline or well down in the adjacent synclines. So far as is known no test wells have been drilled on the axis of the anticline except the shallow salt wells on Sewickley Creek heretofore mentioned. Since the maximum development of this anticline occurs where it is crossed by Jacobs Creek, this locality is most favorable so far as structure is concerned, but whether the sands are of such character as to retain the gas or whether the gas is present can be told only by sinking the drill.

For some reason not well known the large anticlinal folds toward the east are generally not so productive as the folds of medium magnitude along Monongahela River, and it is possible that the Fayette anticline in this region belongs to the larger folds of the east rather than to the other class. There has been developed, however, a fairly productive gas field on the Fayette anticline northwest of Uniontown, and it seems quite possible that this field may be extended to the northeast, into the Connellsville quadrangle.

DISPOSAL OF THE GAS.

The greater portion of the gas, including that from the wells of the Bellevernon Light and Heat Company, T. L. Daly & Co., and the Greensboro, West Monongahela, and Bellwood and Monongahela Natural Gas companies, is piped to the towns along the Monongahela River and used for domestic and minor manufacturing purposes. The Ten Mile Natural Gas Company pipes its gas north to Centerville (East Bethlehem post-office) and south to the Vandergrift Distillery, Fredericktown, Millsboro, and Rices Landing, on the Monongahela River, and to Jefferson, in Greene County. The American Window Glass Company pipes its gas by several 8-inch mains to Monongahela, where the entire supply is used in its glass factory. Both the Philadelphia Company and the Monongahela Natural Gas Company pipe their gas to Pittsburg. The latter has 12, 16, 20, and 30-inch pipe lines, and supplies most of its gas to manufacturing establishments about the city.

LIST OF GAS WELLS IN BROWNSVILLE QUADRANGLE.

(Letters in parenthesis refer to owners. See list below.)

1. Hamilton (c).
2. Hamilton (c).
3. Lamont (c).
4. Joe Lytle (j).
5. J. K. Long (a).
6. Jesse Wahl (g).
7. Jesse Wahl No. 2 (j ?).
8. Jesse Wahl No. 1 (j ?).
9. Jesse Wahl No. 3 (j ?).
10. Jos. Lytle (j).
11. Sam Hindman (j).
12. John Applegate heirs (h).
13. Stephen Applegate (a).
14. Wonderly No. 1 (a).
15. Stephen Wahl No. 2 (a).
16. Stephen Wahl No. 1 (a).
17. Robertson (e).
18. ? (e).
19. Jesse Friese (e).
20. Pierce (e).
21. Nichols (e).
22. Hayden No. 1.
23. Hayden No. 2 (e).
24. R. Maxwell (b).
25. Weddell (e).
26. B. F. Stoneman (b).
27. Noah Haden (b).
28. Mrs. Moore (b).
29. J. Wilson (b).
30. J. and B. F. Beazell (b).
31. Wm. Beazell (b).
32. Unknown.
33. Carnes (e).
34. Martin (b).
35. Carnes No. 2 (e).
36. Rankin No. 2 (b).
37. Guffy No. 1 (e).
38. Mrs. Martin (b).
39. Guffy No. 2 (e).
40. Cunningham (b).
41. Tom Finley (b).
42. Stacy (c).
43. John Rankin No. 4 (b).
44. Not drilled (b).
45. John Smock (b).
46. Taylor Wilson (b).
47. John Irons No. 5 (d).
48. W. J. Menallen (b).
49. Johnson (b).
50. Jim Carnes No. 3 (b).
51. Jim Carnes No. 2 (b).
52. Jones (b).
53. Gibson No. 3 (d).
54. John Irons No. 2 (d).
55. Baulser (b).
56 McKeen (e).
57. Ryan (e).
58. Ryan (f).
59. John Frye (e).
60. John Wilson (f).
61. John Voorhis (c).
62. Chas. Wilson (g).
63. Labin Winette (b).
64. Lickman (g).
65. Jack Carson (b).
66. Jack Carson (b).
67. Sam Fox (b).
68. Ryder No. 1 (b).
69. Ryder No. 2 (b).
70. Spaure (e).
71. Frye (b).
72. Spaure (b).
73. B. L. Parson (b).
74. No. 317 (g).
75. Unknown.
76. Mitchell (e).
77. Mrs. E. Morris (g).
78. Mrs. E. Morris (g).
79. G. W. Deems (g).
80. J. I. Cleaver (f).
81. S. M. Cleaver (g).
82. John Williams (f).
83. Mahlon Linton (f).
84. T. W. Hill (i).
85. O. M. Linton (i).
86. Mary Thistlewaite (g).

Owners of wells.

(a) American Window Glass Company.
(b) Bellevernon Light and Heat Company.
(c) Bellwood and Monongahela Natural Gas Company.
(d) T. L. Daly.
(e) Greensboro Natural Gas Company.
(f) Monongahela Natural Gas Company.
(g) Philadelphia Company.
(h) John A. Snee.
(i) Ten Mile Natural Gas Company.
(j) West Monongahela Natural Gas Company.

CLAY.

The clay interests in the Brownsville and Connellsville quadrangles are of considerable importance. The manufacture of fire brick and forms for use in steel works, in which the more refractory clays are used, is especially prominent. With 10,000 coke ovens in this territory there is a large demand for fire-brick for repairs and for construction of new ovens. Aside from the works using highly refractory clays there are also a number of plants producing ordinary red brick, vitrified paving brick, and pottery ware.

The clays of this district may be divided into two classes. The first class is made up of regularly bedded deposits such as usually occur in association with beds of coal. These have received the general designation of fire clays, although they vary greatly in their refractoriness, or, in other words, in their ability to withstand intense heat. The second class is made up of residual surface clay and of deposits in the present and the abandoned channels of Monongahela and Youghiogheny rivers. Residual clay is common on the uplands, being produced by the weathering of the underlying rocks. So far as known this clay is not utilized in the quadrangles. Most of the red building bricks manufactured in this territory are made from the river alluvium. Plants using such material are in operation at West Newton, Monongahela, and California.

Clay deposits occur in many of the abandoned valleys along both rivers, but they are generally so mixed with sand as to be useless. In the vicinity of Perryopolis, however, fine white clay occurs which strongly resembles that from New Geneva on Monongahela River, which has been used in the manufacture of pottery for the last 50 years. Clay pits have been opened about one-fourth mile east of Perryopolis, where 14 feet of white clay may be seen overlying 22 feet of sand and bowlders extending to the bottom of the pit. A test hole a little nearer the side of the valley is reported to have passed through 40 feet of fine clay before reaching rock bottom. Originally these pits were opened for glass sand, but lately the clay has been utilized in a small way, and from its excellent quality it seems probable that it will grow in favor. According to the owner of these pits fossil leaves occur in pockets in the clay. None of these have been collected and none were visible at the time the pits were examined.

The bedded clays are largely confined to the Allegheny formation. They occur at several horizons, and the thickness and quality of the clay beds are such as to make them of great economic importance.

The lowest horizon at which an important clay bed has been developed is directly beneath the Brookville-Clarion coal in the Chestnut Ridge region. This bed was not seen in the Connellsville quadrangle, but in the region to the south it has been extensively worked back of Mount Braddock for the manufacture of fire brick at that place. In these pits, which are on the summit of Chestnut Ridge, the clay has a thickness of from 8 to 10 feet. It is an excellent flint clay, and from its refractoriness is well adapted to the manufacture of fire brick. As is usual in such deposits, the clay is very irregular in thickness, and it is possible that it is not present north of Youghiogheny River.

Throughout western Pennsylvania the Lower Kittanning coal is underlain by a bed of fire clay which is remarkably persistent in occurrence and very regular in thickness. Its best development is in the Ohio and Allegheny valleys, but it occurs as far east as this quadrangle. It was not noted on Chestnut Ridge, but it is dug about 1½ miles above Layton, on the east side of the stream. In the pits it shows a thickness of 12 feet, and it is immediately overlain by the lower Kittanning coal, 2 feet thick. The clay dug here is shipped to various points along the Baltimore and Ohio Railroad. This is the only place where the Lower Kittanning clay is known to exist in this quadrangle, but it seems probable that so persistent a bed as this has proved to be in the Allegheny Valley will be found at other points where its horizon comes to the surface.

The most important bed of fire clay in this region is the Bolivar clay, which occurs a short distance below the Upper Freeport coal bed. This clay has been worked for a number of years at Bolivar on Conemaugh River and it is generally known by the name of that place. It is a flint clay, ranging in the type locality from 6 to 25 feet in thickness, and occurring from 10 to 20 feet below the coal. It is present on the west flank of Chestnut Ridge, and also along Youghiogheny River, where it cuts the Fayette anticline.

The manufacture of fire brick is an important industry at Connellsville. Much of the clay is shipped in from pits up the river in the vicinity of Ohiopyle, but a large plant at Moyer is supplied from pits near Heminger Mills. A section at these pits shows that the Upper Freeport coal is underlain by 3 or 4 feet of shale, and this in turn by the flint clay, from 10 to 15 feet thick. The clay contains considerable iron. Along the weathered outcrop this is segregated into concretions or "ore balls" which can be removed by hand, but in the unweathered portion of the bed the iron is disseminated through the clay and can not be separated. For this reason only the weathered part of the bed is available, and when this is removed new pits must be opened. The outcrop of the bed of clay is marked almost all along Chestnut Ridge by old pits that for this reason have been abandoned.

The same bed has been mined at Layton on Youghiogheny River. The works are not in operation at the present time, but the clay is reported to be very refractory and to have been used for glass pots. The clay bed is about 200 feet above railroad grade and a few feet below the horizon of the Upper Freeport coal. The coal bed is not visible, but fragments mark its outcrop and it is reported to have shown when the pits were worked.

The Bolivar clay appears formerly to have been worked on Jacobs Creek about 3 miles above its mouth, but the pits are abandoned and the thickness and quality of the clay can not be determined. It is also present on Meadow Run, but no attempts have been made to develop it there.

This bed of clay shows below the Upper Freeport coal in its outcrop on Sewickley Creek. It is mined below Hunkers and manufactured into fire brick by the Westmoreland Fire Brick Company. In one exposure in this vicinity the flint clay is very irregular, ranging from 0 to 6 feet in thickness. Both flint and plastic clays are used at this plant, and both are derived from this bed.

At Layton a bed of flint and plastic clay is utilized, which occurs about 130 feet above the Upper Freeport coal. This is worked at the brick works about half a mile below the depot. At the mouth of the mine the flint clay has a thickness of about 2 feet, but it is said to increase to 5 feet in the mine. This is underlain by plastic clay, the whole having a thickness of from 6 to 20 feet. This bed is well exposed on the west side of the river where it is pierced by the tunnel on the Washington Run Railroad at the west end of the bridge. At this point the following section was measured:

Clay bed on Washington Run Railroad, west of Youghiogheny River.

	Feet.
Sandstone, coarse	25
Shale and thin sandstone	10
Flint clay	$3\frac{1}{2}$
Greenish shaly clay	12
Sandy shale and thin sandstone to Pittsburg and Lake Erie railroad grade	25

At two points in the Connellsville quadrangle, Courtney and Manown, the main clay parting of the Pittsburg coal is utilized in the manufacture of clay forms for open hearth and Bessemer steel plants. In this region the clay is about 8 inches in thickness, and at first sight it seems strange that so small a bed could supply crude material for such extensive works; but the coal mines have been in operation for a great many years and a large amount of this material has accumulated. This industry was established about 1890. It has thrived so well that doubtless the clay from this coal bed will generally be used in the future.

Shale is also used in the manufacture of building and paving brick. A plant producing ordinary red building brick from shale is located near Lock No. 4, north of Charleroi. The shale used here is quarried back of the works and belongs to the upper part of the Conemaugh formation.

About a mile north of Fayette City is another brick-making plant, which manufactures ordinary red brick from shale found in the hillside, and some fire brick from the clay parting in the Pittsburg coal. The shale used for brick has a thickness of about 35 feet and lies about 20 feet above the Pittsburg coal.

Other plants using shale in the manufacture of brick are located in Connellsville and below Dickerson Run.

BUILDING STONE.

Except sandstone hardly any rock suitable for building is found in this territory, and while sandstone is abundant, not all the beds can be used for this purpose. As a rule the Coal Measures sandstones are only suitable for rough masonry, and very few are regular enough in their bedding to supply dimension stone.

The only beds which have been quarried in a commercial way are those of the Conemaugh formation. The Connellsville sandstone is reported to have been quarried at one time, but no trace remains of such operations. The Saltsburg sandstone has been more extensively quarried than any other bed in this territory. It is particularly hard and massive along the Fayette anticline from Flatwoods to Paintersville, and it has been used in a number of places. A quarry was once operated on the plateau on the south side of Youghiogheny River west of Virgin Run, and the stone was lowered by an inclined tramroad to railroad level. Near Fort Hill much good stone has been removed from this bed, but the quarries had no railroad connection and have been abandoned. The only quarry at present active is southeast of Hunkers. The sandstone at this point is even bedded and quarries to good advantage, giving large blocks for rough masonry.

The Homewood sandstone would doubtless afford large blocks where it is massive, as at many localities on Chestnut Ridge, but its outcrop is generally inaccessible and the stone has not been utilized.

GLASS SAND.

Considerable glass sand has been obtained in this territory, but at present the industry seems to be on the decline.

Sand for this purpose is obtained from deposits in the abandoned river valleys and by crushing the white quartzose sandstone of the Pottsville formation.

The river sand has been obtained from the terrace opposite Bellevernon and from the old valley back of the same town. The latter deposit is not operated at the present time and the former is worked only in a small way. The sand at Perryopolis is of similar character and origin and is handled in the same manner. Here the clay is attracting more attention and the sand pits are no longer used.

There is only one sandworks in this territory at which rock is crushed, and this is on the east side of Youghiogheny River about a mile above Layton. The heavy ledge of Homewood sandstone back of the mill is quarried, and after crushing and washing the sand is shipped to various points for glass manufacture. So far as known the Homewood is the only sandstone in this territory pure enough for glass making.

ROCK BALLAST.

The crushing of rock for ballast is an important industry along Chestnut Ridge, but the works are all in the gaps, so that none of them occur within this area. The siliceous limestone lying at the top of the Pocono sandstone is the rock used, and it is quarried extensively in the gorge of the Youghiogheny a few miles above Connellsville.

LIMESTONE.

Limestone is fairly abundant in this region and is used rather extensively in fertilizing the land. The Monongahela formation carries the largest beds, and since this formation has a greater area of outcrop than the others, limestone may be said to be generally present west of Chestnut Ridge, except on the Fayette anticline, where the Conemaugh formation is the surface rock. Limestone beds are of so common occurrence that it is unnecessary to describe them in detail.

On Chestnut Ridge the rocks are generally sandy, but the Greenbrier limestone affords the purest lime in the quadrangle. It is quarried in many places along its outcrop, but since the quarrying is usually done by farmers for the purpose of burning it into fertilizer, it is done in a desultory way. The quarries are soon abandoned and remain simply as scars on the hillsides. The siliceous limestone has not been much used for burning purposes, being too impure. It is said, however, to form an excellent natural mortar when burned, having enough siliceous matter without the addition of sand.

At Uniontown the limestone occurring near the horizon of the Uniontown coal has been manufactured into cement and largely used on the Government locks on Monongahela River, but the works have been abandoned and cement is not manufactured at any point in this region. Many of the limestone beds in the area under consideration would probably make cement, but the quality could not be determined except by a practical test.

In the early days of the iron industry much limestone was quarried in this region and used as flux in the local furnaces, but with the advent of high-grade ores and modern methods a better limestone was necessary. For this reason the local quarries were abandoned, and at present almost all the limestone used in the furnaces is shipped in from other parts of the country.

July, 1902.

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

STATE OF PENNSYLVANIA
GEORGE W. MC NEES, SIMON HARROLD,
FRED D. BARKER, COMMISSIONERS

TOPOGRAPHY

PENNSYLVANIA
BROWNSVILLE 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

Lakes and ponds

CULTURE
(printed in black)

Roads and buildings

Private and secondary roads

Trails

Railroads

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Ferries

Fords

Dams and locks

County lines

Township lines

City, village, and borough lines

Triangulation stations

Bench marks

H. M. Wilson, Geographer in charge.
Control by Sledge Tatum and Arthur C. Roberts.
Topography by Frank Sutton, J. H. Wheat, W. N. Morrill, and T. G. Basinger.
Surveyed in 1899-1900 in cooperation with the State of Pennsylvania.

B
Morrill
Wheat

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1902

Edition of Oct. 1902.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR
STATE OF PENNSYLVANIA
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AREAL GEOLOGY

PENNSYLVANIA
BROWNSVILLE QUADRANGLE

LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles)

PLEISTOCENE

- **Pal** — Alluvium *(in flood plains of present streams)*
- **Pcm** — Carmichael clay *(clay, sand, and bowlders on terraces and in abandoned channels of the larger streams)*

SEDIMENTARY ROCKS

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

CARBONIFEROUS

Permian series ?

- **Cd** — Dunkard formation *(sandy shale, coarse sandstone, some thin limestone, and beds of coal, many of workable size)*

Pennsylvanian series

- **Cm** — Monongahela formation *(shale, limestone, and occasionally coarse sandstone; Pittsburg coal at the bottom, Waynesburg coal at the top, and coal beds of local importance between)*
- **Ccm** — Conemaugh formation *(sandstone, shale, small amount of limestone, and a few small coal beds)*

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Edition of Feb. 1903.

Geology by Marius R. Campbell.
Assisted by L.C. Glenn,
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Surveyed in 1891.

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ECONOMIC GEOLOGY

PENNSYLVANIA
BROWNSVILLE QUADRANGLE

LEGEND

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⚒ Coal mines and sand pits
● Wells drilled for gas

Known productive formations

Cm — Most important coal (Monongahela formation contains the Pittsburg, Waynesburg, and other coal beds)

Cd — Coal (Dunkard formation includes the Washington and other coal beds of local importance)

Ccm — Coal (Conemaugh formation contains thin coal beds)

Contour lines showing lay of Pittsburg coal bed (elevation above sea level shown by figures on contour lines; contour interval is 20 feet)

Coal outcrops (continuous lines represent coal beds of probable workable thickness; long dashes, thin beds of doubtful value; short dashes, outcrops covered by surficial deposits)

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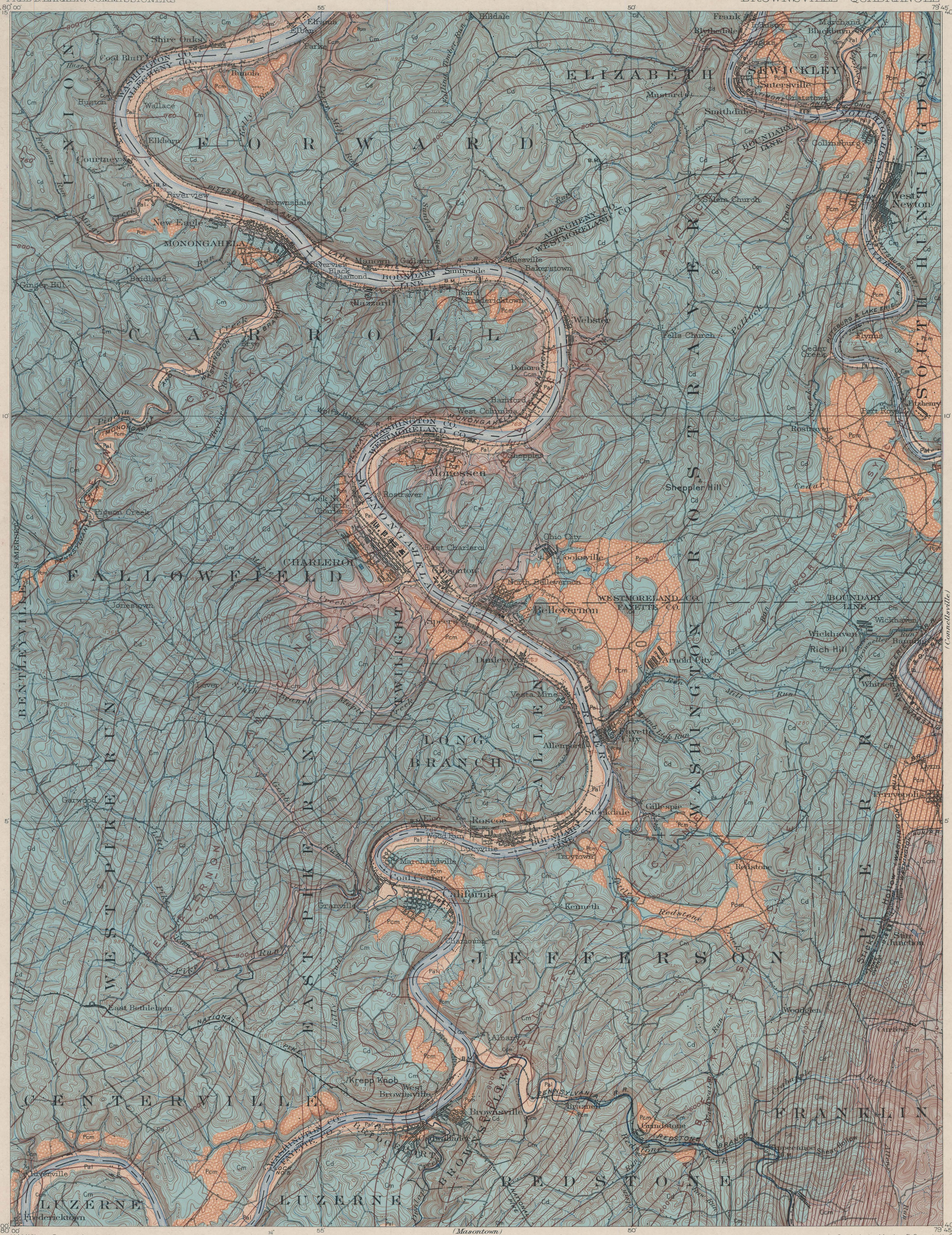
GEOLOGIC STRUCTURE

PENNSYLVANIA
BROWNSVILLE QUADRANGLE



LEGEND

SURFICIAL ROCKS

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SEDIMENTARY ROCKS

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Ccm — Conemaugh formation (sandstone, shale, small amount of limestone, and a few small coal beds)

900 — *Contour lines drawn upon floor of Pittsburg coal at base of Monongahela formation*

(contour interval is 20 feet except in extreme southeast corner where it is 50 feet. Datum is mean sea level. Where the coal has been removed by erosion the lines are determined by the calculated position of the bed.)

The axes of the folds are represented by heavy broken lines drawn along the lowest parts of the synclines and the highest parts of the anticlines.

H. M. Wilson, Geographer in charge.
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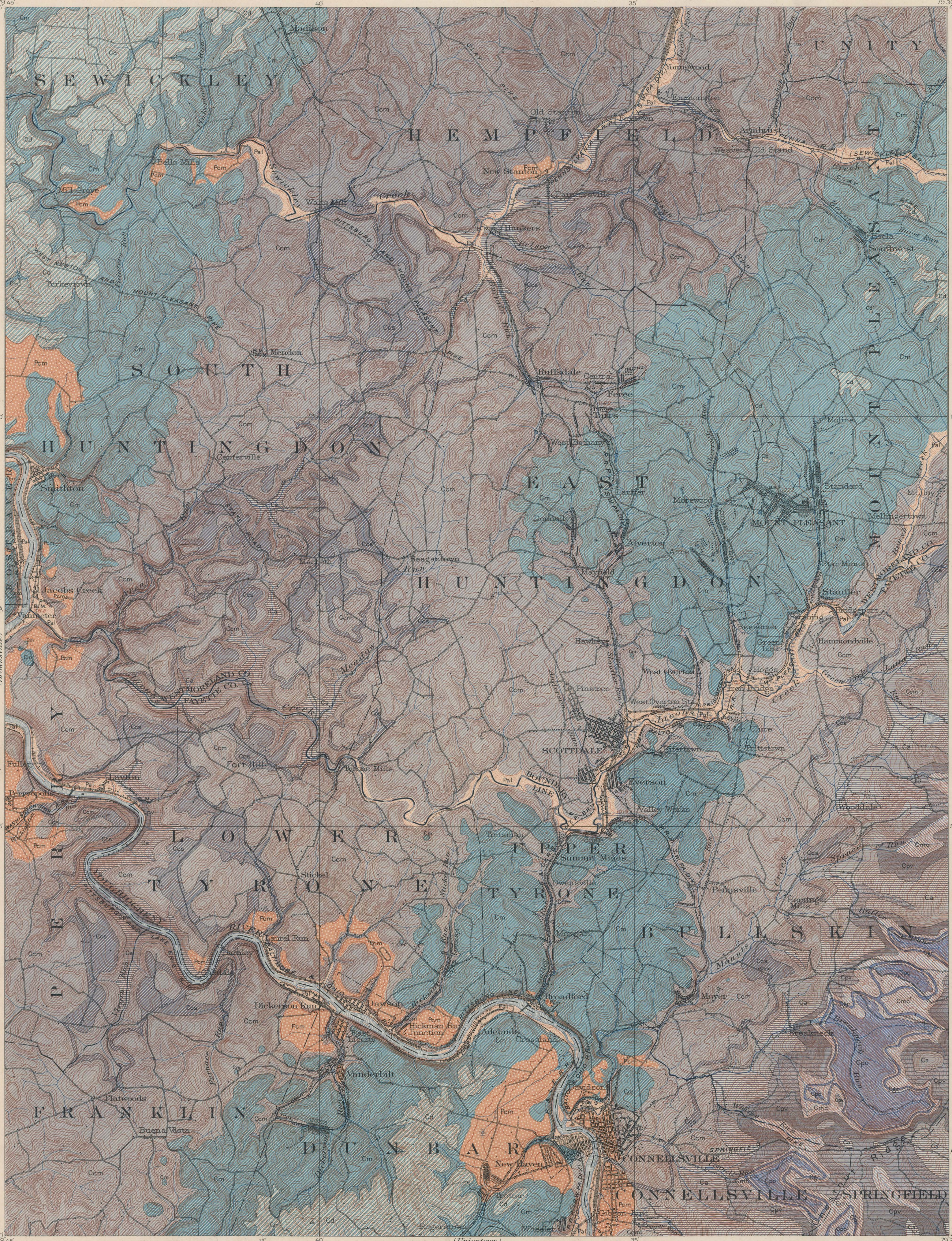
AREAL GEOLOGY

PENNSYLVANIA
CONNELLSVILLE QUADRANGLE



LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles.)

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SEDIMENTARY ROCKS

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CARBONIFEROUS

Permian series ?

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Pennsylvanian series

Cm — Monongahela formation (shale, limestone, and occasionally coarse sandstone; Pittsburg coal at the bottom, Waynesburg coal at the top, and coal beds of local importance between)

Ccm — Conemaugh formation exclusive of the Saltsburg sandstone (sandstone, shale, small amount of limestone, and a few small coal beds)

Ccs — Saltsburg sandstone lentil in the Conemaugh formation (coarse thick-bedded or massive sandstone in the Conemaugh formation)

Ca — Allegheny formation (shale, sandstone, and clay with several workable coal beds; Upper Freeport coal at the top)

Cpv — Pottsville sandstone (coarse massive sandstone or conglomerate with some shale and usually a coal bed at the middle)

Mississippian series

Cmc — Mauch Chunk formation exclusive of the Greenbrier limestone (red and green shale and thin-bedded green sandstone)

Cgr — Greenbrier limestone lentil in the Mauch Chunk formation (thin blue fossiliferous limestone in the Mauch Chunk shale)

Cpo — Pocono sandstone (coarse sandstone grading into very sandy limestone at the top and usually containing sandy shale)

Section

A — A

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ECONOMIC GEOLOGY

PENNSYLVANIA
CONNELLSVILLE QUADRANGLE (Latrobe)

H. M. Wilson, Geographer in charge.
Control by Walter R. Harper and A. C. Roberts.
Topography by Frank Sutton, J. H. Wheat, T. G. Basinger, and H. C. Frick Coke Co.
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Cpo — Pocono sandstone *(coarse sandstone grading into very sandy limestone at the top and usually containing sandy shale)*

⚒ *Coal mines, quarries, clay and sand pits*

Section

Known productive formations

Cm — *Most important coal* *(Monongahela formation contains the Pittsburg, Waynesburg, and other coal beds)*

Cd-Ca — *Coal* *(Dunkard formation includes the Washington and other coal beds of local importance; Allegheny formation contains the Freeport and Kittanning coal beds)*

Ccm-Cpv — *Coal* *(Conemaugh formation and Pottsville sandstone contain thin coal beds)*

Contour lines showing lay of Pittsburg coal bed *(elevation above sea level shown by figures on contour lines; contour interval is 20 feet)*

Coal outcrops *(continuous lines represent coal beds of probable workable thickness; long dashes, thin beds of doubtful value; short dashes, outcrops covered by surficial deposits)*

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GEOLOGIC STRUCTURE

PENNSYLVANIA
CONNELLSVILLE QUADRANGLE

LEGEND

SURFICIAL ROCKS

SHEET SYMBOL

PLEISTOCENE

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

Pcm — **Carmichael clay** *(clay, sand, and bowlders on terraces and in abandoned channels of the larger streams)*

SEDIMENTARY ROCKS

SHEET SYMBOL / SECTION SYMBOL

CARBONIFEROUS

Permian series ?

Cd — **Dunkard formation** *(sandy shale, coarse sandstone, some thin limestone, and beds of coal, many of workable size)*

Pennsylvanian series

Cm / Cm — **Monongahela formation** *(shale, limestone, and occasionally coarse sandstone; Pittsburg coal at the bottom, Waynesburg coal at the top, and coal beds of local importance between)*

Ccm / Ccm — **Conemaugh formation exclusive of the Saltsburg sandstone** *(sandstone, shale, small amount of limestone, and a few small coal beds)*

Ccs — *Included in Conemaugh formation on section* — **Saltsburg sandstone lentil in the Conemaugh formation** *(coarse thick-bedded or massive sandstone in the Conemaugh formation)*

Ca / Ca — **Allegheny formation** *(shale, sandstone, and clay with several workable coal beds; Upper Freeport coal at the top)*

Cpv / Cpv — **Pottsville sandstone** *(coarse massive sandstone or conglomerate with some shale and usually a coal bed at the middle)*

Mississippian series

Cmc / Cmc — **Mauch Chunk formation exclusive of the Greenbrier limestone** *(red and green shale and thin-bedded green sandstone)*

Cgr — *Included in Mauch Chunk formation on section* — **Greenbrier limestone lentil in the Mauch Chunk formation** *(thin blue fossiliferous limestone in the Mauch Chunk shale)*

Cpo / Cpo — **Pocono sandstone** *(coarse sandstone grading into very sandy limestone at the top and usually containing sandy shale)*

DEVONIAN

(green and red shale and green sandstone)

900 — *Contour lines drawn upon floor of Pittsburg coal at base of Monongahela formation* *(contour interval is 20 feet except on Fayette anticline where it is 50 feet. Datum is mean sea level. Where the coal has been removed by erosion the lines are determined by the calculated position of the bed)*

1000 — *Contour lines drawn upon upper surface of Pottsville sandstone, approximately 900 feet below the Pittsburg coal horizon* *(contour interval is 100 feet. Datum is mean sea level. Where the sandstone has been removed by erosion the lines are determined by the calculated position of the formation)*

The axes of the folds are represented by heavy broken lines drawn along the lowest parts of the synclines and the highest parts of the anticlines.

H. M. Wilson, Geographer in charge.
Control by Walter R. Harper and A. C. Roberts.
Topography by Frank Sutton, J. H. Wheat, T. G. Basinger, and H. C. Frick Coke Co.
Surveyed in 1900 in cooperation with the State of Pennsylvania.

APPROXIMATE MEAN DECLINATION 1902.

Scale 1/62500

Contour interval 20 feet.
Datum is mean sea level.

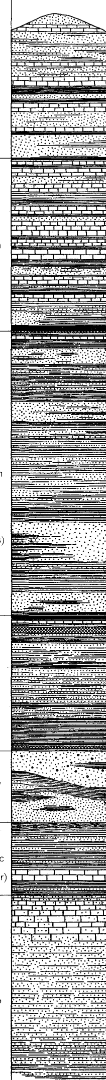
Edition of Feb. 1903.

Geology by Marius R. Campbell
Assisted by L. C. Glenn,
Charles Butts, and L. H. Woolsey.
Surveyed in 1901.

COLUMNAR SECTION SHEET

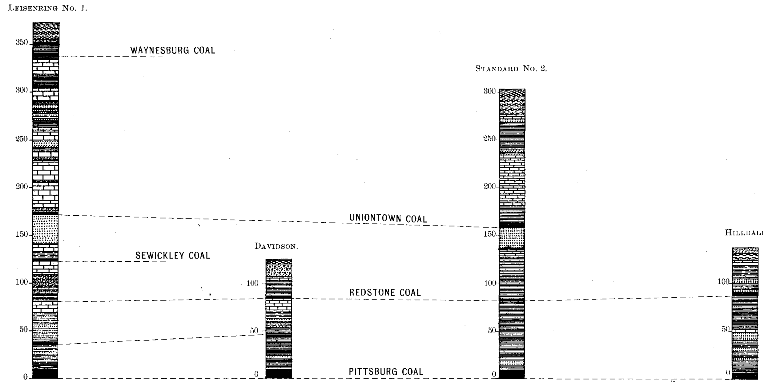
GENERALIZED SECTION FOR THE BROWNSVILLE AND CONNELLSVILLE QUADRANGLES.

SCALE: 1 INCH = 200 FEET.

Period.		Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Names of Members.	Character and Distribution of Members.	General Character of Formation.
CARBONIFEROUS	PERMIAN?	Dunkard formation.	Cd		300+	Washington coal.	Attains a thickness of 8 to 10 feet, but is broken by many shale partings and contains a large percentage of bony coal.	Coarse, friable sandstone and sandy shale; many thin beds of blue or buff limestone; and several beds of coal, mostly thin and only locally workable. The formation is 1000 feet thick in Greene County, but only the lower 300 feet are present in the deepest synclines of this district.
						Waynesburg "A" coal.	Generally thin and valueless.	
						Waynesburg sandstone.	Usually coarse, friable, and mottled by iron stains; sometimes micaceous and flaggy.	
	PENNSYLVANIAN	Monongahela formation.	Cm		310-400	Waynesburg coal.	Ranges in thickness from 3 to 7 feet, but is badly broken by partings. Generally high in sulphur and ash.	Prevailingly calcareous. Massive limestone 140 to 160 feet thick near middle of formation and thin beds of limestone both above and below. Considerable shale interbedded with the limestones. Occasionally coarse sandstone near the top and bottom of the formation. Waynesburg coal at the top and Pittsburg coal at the base.
						Uniontown coal.	Thin and apparently worthless.	
						Benwood limestone.	Hard, blue, non-fossiliferous limestone, interbedded with shale. Makes good lime for agricultural purposes.	
						Sewickley coal.	0 to 3 feet thick. Not mined.	
						Redstone coal.	2 to 4 feet thick, but is disturbed by clay veins and horsebacks. Persistent and of good quality.	
						Pittsburg coal.	7 to 10 feet thick. Remarkably persistent and uniform. Two divisions separated by clay. Lower division only mined.	
		Conemaugh formation.	Ccm		600	Connellsville sandstone.	Generally flaggy and rather persistent. 10 to 20 feet thick.	Shale and coarse sandstone with occasionally thin beds of limestone and coal. Most of the shale is sandy, but there are some prominent beds of green and red, fine-grained clay shale which give a distinct color to the soil on their outcrop. The lower half of the formation is prevailingly sandy, carrying several beds of coarse sandstone or conglomerate.
						Morgantown sandstone.	Coarse and thick bedded, but in places changing into shale and flaggy sandstone. 20 to 40 feet thick.	
						Ames (crinoidal) limestone.	Greenish-gray limestone, 4 feet thick, with many crinoid plates.	
			(Css)			Saltsburg sandstone.	Coarse and thick-bedded, occasionally massive. Changes to shale northward and disappears. 30 to 70 feet thick.	
						Mahoning sandstone.	Flaggy, rather fine-grained sandstone. Coarser and heavier locally.	
		Allegheny formation.	Ca		280	Upper Freeport coal.	3 to 7 feet thick. Fair quality.	Shale, sandstone, fire clay, and coal beds. Shale predominates. Sandstone is generally thin bedded and shaly, but in places is coarse and massive. Coal beds are promising but at present are not developed. Fire clay is generally present and of great value.
						Bolivar fire clay.	Valuable flint and plastic clays. 0 to 20 feet thick.	
						Lower Freeport coal.	Generally thin.	
						Upper Kittanning coal.	Thick coal east of Chestnut Ridge, but little known west of that line.	
						Middle Kittanning coal.	Generally thin and unimportant.	
						Lower Kittanning coal.	Regular in thickness and persistent. 2 to 4 feet thick.	
						Brookville-Clarion coal.	Thin and unimportant.	
		Pottsville sandstone.	Cpv		150	Homewood sandstone.	Coarse, white, hard, siliceous sandstone. Generally massive and sometimes conglomeratic.	Coarse, siliceous sandstone or conglomerate, sometimes massive, with intermediate shale carrying iron ore and coal.
						Mercer coal group.	But little known. Associated with iron ore.	
						Conoquenessing sandstone.	Coarse, irregularly-bedded sandstone or conglomerate.	
	MISSISSIPPIAN	Mauch Chunk formation.	Cmc		150			Red and green shale with green, flaggy sandstone. Blue, fossiliferous limestone near the base.
			(Cgr)			Greenbrier limestone.	Blue, highly fossiliferous limestone. Burns to lime of excellent quality. 20 to 30 feet thick.	
		Pocono sandstone.	Cpo		400+	Siliceous limestone.	Blue, siliceous limestone, grading downward into sandstone.	Coarse gray sandstone; grades at the top into siliceous limestone and at the base is interbedded with sandy shale.

SECTIONS OF MINE SHAFTS.

SCALE: 1 INCH = 100 FEET.

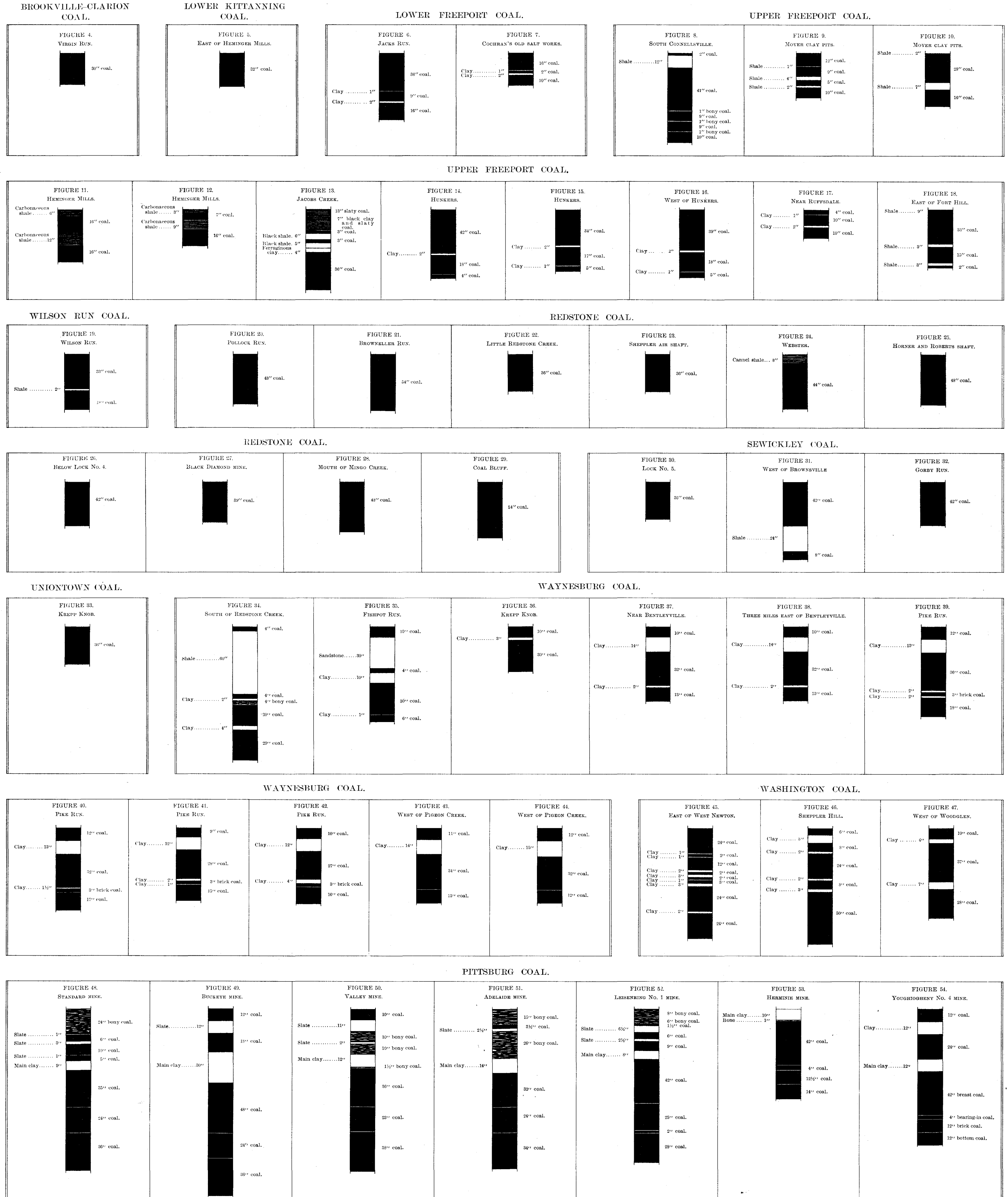


MARIUS R. CAMPBELL,
Geologist.

COAL-SECTION SHEET 1

SECTIONS OF COAL BEDS IN THE BROWNSVILLE AND CONNELLSVILLE QUADRANGLES.

SCALE: 1 INCH = 5 FEET.

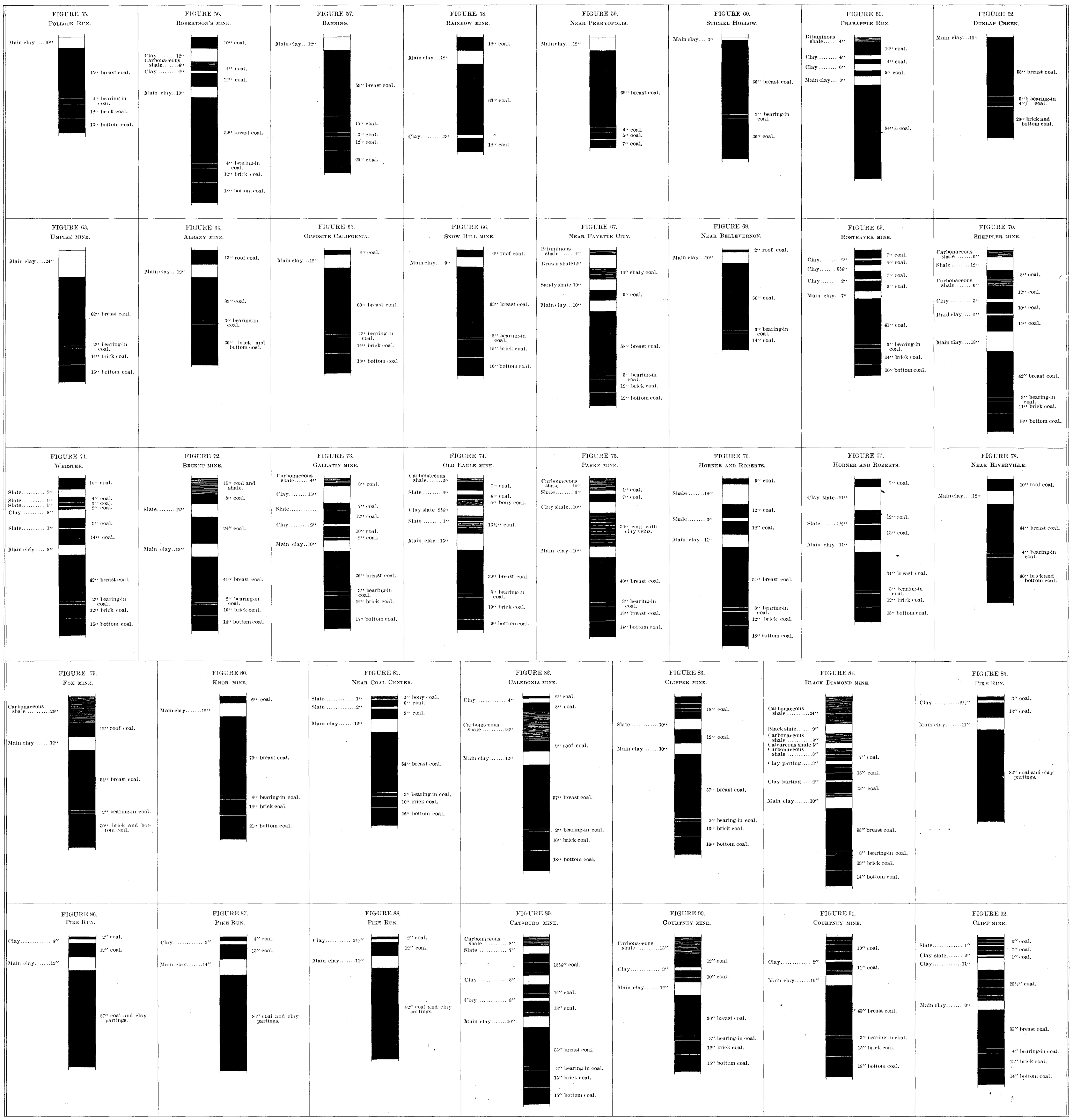


COAL-SECTION SHEET 2

SECTIONS OF COAL BEDS IN THE BROWNSVILLE AND CONNELLSVILLE QUADRANGLES.

SCALE: 1 INCH = 5 FEET.

PITTSBURG COAL.



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

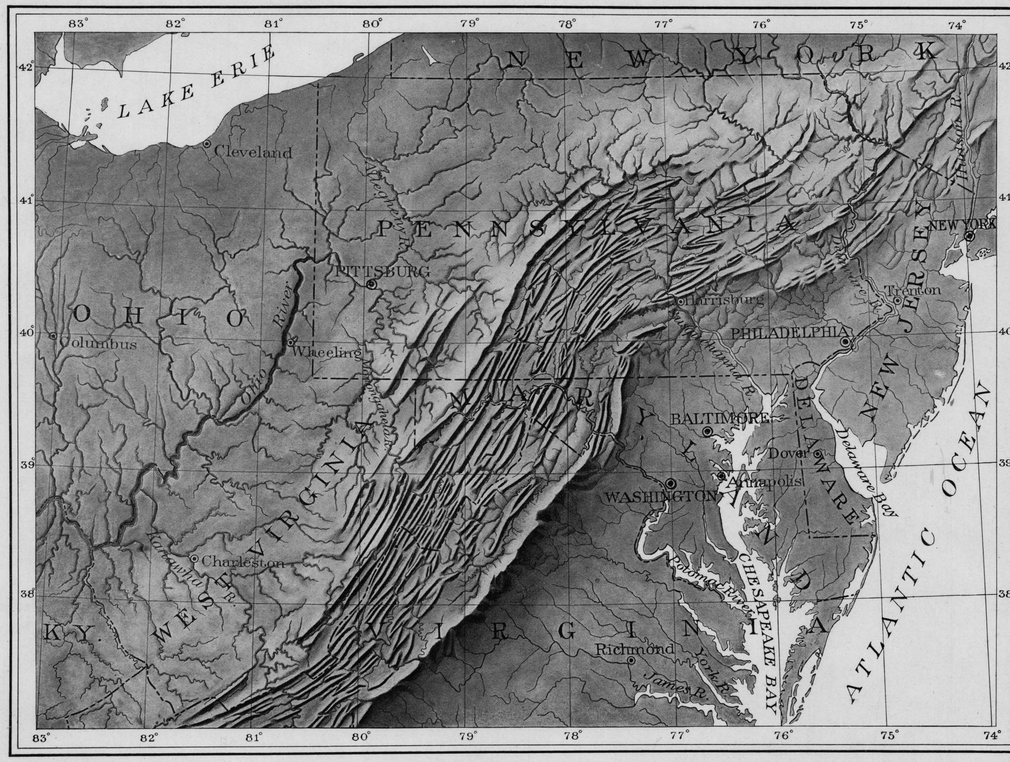

Fig. 93.—RELIEF MAP OF THE NORTHERN APPALACHIAN MOUNTAINS.

The Brownsville and Connellsville quadrangles are situated on the plateau west of the belt of valley ridges, in the southwestern part of Pennsylvania.

Fig. 94.—MAP SHOWING THE EXTENT OF THE NORTHERN PART OF THE APPALACHIAN COAL FIELD.

The position of the Brownsville and Connellsville quadrangles within the coal field is shown by rectangles.

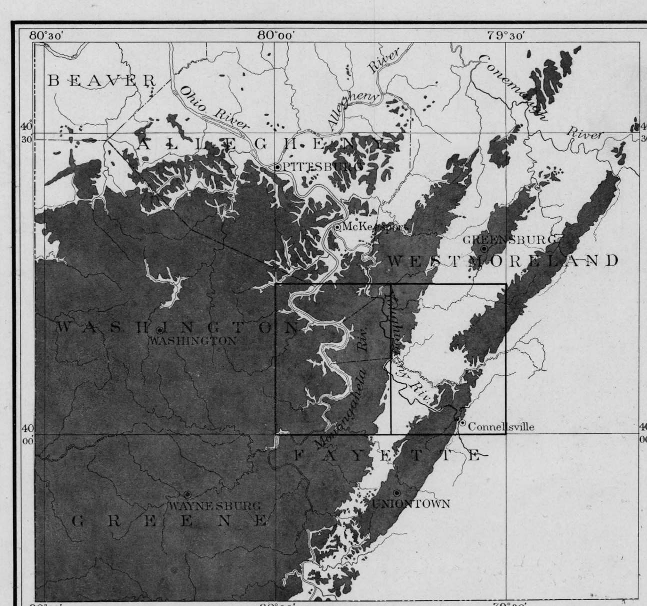

Fig. 95.—MAP SHOWING THE AREA OF THE PITTSBURG COAL IN PENNSYLVANIA.

The Brownsville and Connellsville quadrangles are situated at the eastern border of the Pittsburg coal area, as shown by the rectangles.

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