DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

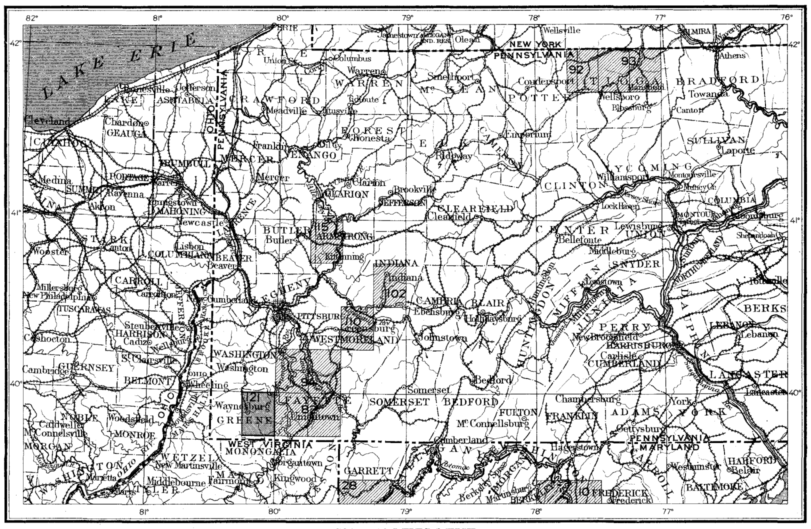
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS OF THE UNITED STATES

WAYNESBURG FOLIO

PENNSYLVANIA

INDEX MAP



SCALE: 40 MILES=1 INCH

WAYNESBURG FOLIO

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

1905

OHIO STATE UNIVERSITY

GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES.

The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic 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 outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the altitudinal interval represented by the space between lines being the same throughout each map. These lines are called *contours*, and the uniform altitudinal 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).

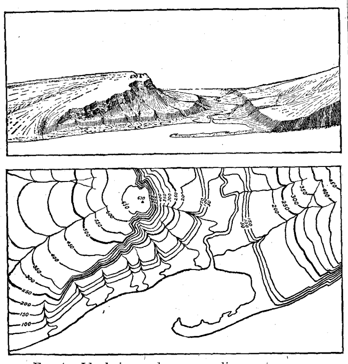


FIG. 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay 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, forming a precipice. Contrasted with this precipice is the gentle slope from its top toward 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 a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above sea; along the contour at 200 feet, all points that are 200 feet above sea; and so on. In the space between any two contours are found 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 all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. These 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 altitudinal 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 serviceable for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If a stream flows the entire year 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, are printed in black.

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

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 about 1 square mile of earth surface; on the scale $\frac{1}{125,000}$, about 4 square miles; and on the scale $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles in English inches, by a similar line indicating distance in the metric system, and by a fraction.

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

The atlas sheets, being only parts of one map of the United States, disregard political boundary lines, such as those of States, counties, and 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 map.—On the topographic map are delineated the relief, drainage, and culture of the quadrangle represented. It should portray to the observer every characteristic feature of the landscape. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property; save the engineer preliminary surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

THE GEOLOGIC MAPS.

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

KINDS OF ROCKS.

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

Igneous rocks.—These are rocks which have cooled and consolidated from a state of fusion. Through rocks of all ages molten material has from time to time been forced upward in fissures or channels of various shapes and sizes, to or nearly to the surface. Rocks formed by the consolidation of the molten mass within these channels—that is, below the surface—are called *intrusive*. When the rock occupies a fissure with approximately parallel walls the mass is called a *dike*; when it fills a large and irregular conduit the mass is termed a *stock*. When the conduits for molten magmas traverse stratified rocks they often send off branches parallel to the bedding planes; the rock masses filling such fissures are called *sills* or *sheets* when comparatively thin, and *laccoliths* when occupying larger chambers produced by the force propelling the magmas upward. Within rock inclosures molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. When the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks thus formed upon the surface are called *extrusive*. Lavas cool rapidly in the air, and acquire a glassy or, more often, a partially crystalline condition in their outer parts, but are more fully crystalline in their inner portions. The outer parts of lava flows are usually more or less porous. Explosive action often accompanies volcanic eruptions, causing ejections of dust, ash, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs. Volcanic ejecta may fall in bodies of water or may be carried into lakes or seas and form sedimentary rocks.

Sedimentary rocks.—These rocks are composed of the materials of older rocks which have been broken up and the fragments of which have been carried to a different place and deposited.

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

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

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in 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, with reference to the sea, over wide expanses; and as it rises or subsides the shore lines of the ocean are changed. As a result of the rising of the surface, marine sedimentary rocks may become part of the land, and extensive land areas are in fact occupied by such rocks.

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

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

From time to time in geologic history igneous and sedimentary rocks have been deeply buried and later have been raised to the surface. In this process, through the agencies of pressure, movement, and chemical action, their original structure may be entirely lost and new structures appear. Often there is developed a system of division planes along which the rocks split easily, and these planes may cross the strata at any angle. This structure is called *cleavage*. Sometimes crystals of mica or other foliaceous minerals are developed with their laminæ approximately parallel; in such cases the structure is said to be schistose, or characterized by *schistosity*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are important exceptions.

FORMATIONS.

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

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

AGES OF ROCKS.

Geologic time.—The time during which the rocks were made is divided into several *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by naming the time interval in which it was formed, when known.

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

(Continued on third page of cover.)

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

Stratified rocks often contain the remains or imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. When two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains found in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it.

Similarly, the time at which metamorphic rocks were formed from the original masses is sometimes shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not of their metamorphism.

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

Symbols and colors assigned to the rock systems.

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

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea or in lakes. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin.

The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system. The symbols by which formations are labeled consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters. The names of the systems and recognized series, in proper order (from new to old), with the color and symbol assigned to each system, are given in the preceding table.

SURFACE FORMS.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—This map 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 colored pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any 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 formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—This map represents the distribution of useful minerals and rocks, showing their relations to the topographic features and to the geologic formations. The formations which appear on the areal geology map are usually shown on this map 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 mine symbol is printed at each mine or quarry, accompanied by the name of the principal mineral mined or stone quarried. For regions where there are important mining industries or where artesian basins exist special maps are prepared, to show these additional economic features.

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 term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks, and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface, and can draw sections representing the structure of the earth to a considerable depth. Such a section exhibits 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:

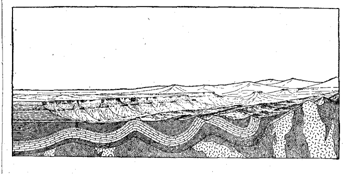


Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate 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:

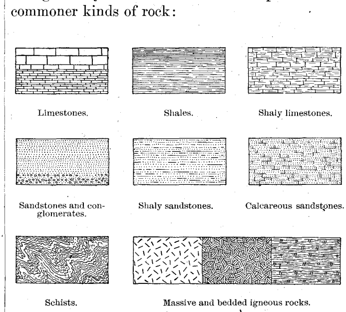


Fig. 3.—Symbols used in sections to represent different kinds of rocks.

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 the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

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

Strata are frequently curved in troughs and arches, such as are seen in fig. 2. 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 proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in fig. 4.

On the right of the sketch, fig. 2, 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

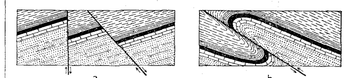


Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

The section in fig. 2 shows three sets of formations, distinguished by their underground relations. The uppermost of these, seen at the left of the section, is a 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 been raised 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 rocks thus rest upon an eroded surface of older rocks 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 the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum 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 sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness of each 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 at the bottom, the youngest at the top.

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

CHARLES D. WALCOTT,

Director.

Revised January, 1904.

DESCRIPTION OF THE WAYNESBURG QUADRANGLE.

By Ralph W. Stone.

INTRODUCTION.

LOCATION AND AREA.

The Waynesburg quadrangle is located in the southwestern part of Pennsylvania, as will be seen by reference to the key map on the cover of the folio. It extends from latitude 39° 45′ on the south to 40° on the north, and from longitude 80° on the east to 80° 15′ on the west. It includes, therefore, one-sixteenth of a square degree of the earth's surface, and has an area of 229.2 square miles.

The quadrangle is largely in Greene County, but it extends into the southern part of Washington County, and includes a small portion of Fayette County on the east side of Monongahela River. It extends to within 2 miles of the north line of West Virginia and 15 miles of the east line of Ohio. It is named from the largest town within its borders, the county seat of Greene County.

RELATION TO APPALACHIAN PROVINCE.

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

Appalachian province.—With respect to topography and the attitude of the rocks, the Appalachian province may be divided into two nearly equal parts by an eastward-facing escarpment called the Allegheny Front. From Pennsylvania to Alabama this separates the Allegheny Plateaus on the west from the Greater Appalachian Valley on the east. It is not a well-developed feature along the whole line, but is especially prominent in parts of Pennsylvania and Tennessee (see fig. 1).

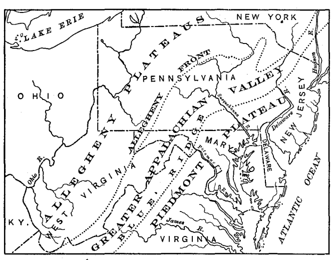


FIG. 1.—Diagram of northern portion of the Appalachian province, showing physiographic divisions.

The general topographic features of the northern part of the province are well illustrated by fig. 6 (illustration sheet). East of the Allegheny Front the topography consists of alternating ridges and valleys, designated the Greater Appalachian Valley, and of a slightly dissected upland like the Piedmont Plain of eastern North Carolina and Virginia. West of the Allegheny Front are more or less elevated plateaus broken by a few ridges where minor folds have affected the rocks, and greatly dissected by streams. In contradistinction to the lowlands of the Mississippi Valley still farther west and the regularly alternating ridges and valleys of the Appalachian Valley, this part of the province has been called by Powell the Allegheny Plateaus. The Waynesburg quadrangle is within the western portion of the Allegheny Plateaus.

The Allegheny Plateaus are characterized by distinct types of geologic structure, surface features, and drainage arrangements. In order to present a clear idea of the physiography and geology of the quadrangle and its relations to the surrounding country, a description of the principal features of the larger province is given below.

ALLEGHENY PLATEAUS.

GEOGRAPHY OF THE PLATEAUS.

Drainage.—The drainage of the Allegheny Plateaus is almost entirely into Mississippi River, but the northeastern end of the region drains in part into the Great Lakes and in part through the Susquehanna, Delaware, and Hudson into the Atlantic.

In the northern part of the province the arrangement of the drainage was largely determined by conditions during the Glacial epoch. Before that time it is supposed that all of the streams north of central Kentucky flowed to the northwest, 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.

Surface relief.—As the name Allegheny Plateaus implies, the surface of this division of the province is composed of a number of plateaus. The highest and most extensive plateau lies along the southeastern margin of the division, and extends throughout its length. It is very old, and consequently is so greatly dissected that its plateau character is not always apparent. Its surface rises from beneath the Cretaceous cover in central Alabama at a height of 500 feet above sea level. From this altitude it ascends to 1700 feet at Chattanooga, 2400 feet at Cumberland Gap, 3500 feet at New River, and probably reaches 4000 feet at its culminating point in central West Virginia. From this point it descends to about 2800 feet on the southern line of Pennsylvania and 2300 to 2400 feet in the central part of the State. The plateau is widely developed in the northern counties of Pennsylvania and throughout southern New York, and ranges in altitude from 2000 to 2400 feet.

This surface is best preserved in Alabama and Tennessee, where it constitutes the Cumberland Plateau. North of Tennessee it doubtless was once well developed, but now is difficult to identify. In northern West Virginia and northern Pennsylvania there are a few remnants of high, level land which appear to be parts of the original surface of this plateau, but it is generally so dissected that only the hilltops mark its former position. In Pennsylvania the remnants of this plateau, which is tentatively correlated with the Cumberland Plateau, are known as the Schooley peneplain.

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

The surface of the high Cumberland Plateau slopes to the west, but it is usually separated from the next lower or Highland Plateau by a generally westward-facing escarpment. This escarpment is most pronounced in Tennessee, where it has a height of 1000 feet. Toward the north the height of the escarpment diminishes to 500 feet. In central Kentucky and north of Ohio River it is so indistinctly developed that it has not 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 uppermost plateau is so greatly dissected that it can be recognized only with difficulty. Toward the central part of the State the plateau surfaces that are usually separated by this escarpment seem to approach each other and the escarpment is lost in a maze of irregular hills which represent all that remains of the higher plateau.

The Highland Plateau is well developed as a distinct feature in Tennessee and Kentucky. In the latter State it is known as the Lexington Plain. It slopes to the west, but along its eastern margin it holds throughout these States a constant altitude of 1000 feet above sea level. In the territory north of Ohio River this plateau is developed on harder rocks than in Kentucky and Tennessee, and the result is that the surface is less regular and its exact position is more difficult to determine. It appears to rise from an altitude of 700 or 800 feet in Indiana to 1000 feet in Ohio, 1200 to 1300 feet in southwestern Pennsylvania, and probably about 2000 feet throughout the northern part of the State and the southern part of New York. A plateau which is recognized in Pennsylvania and known as the Harrisburg peneplain is correlated tentatively with the Highland Plateau or Lexington Plain.

The surface features of this plateau are variable, but there is not so much diversity as in the higher plateau. In Kentucky and Tennessee it is preserved in 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.

West of the Highland Plateau there is a third plain which is developed in the Central Basin of Tennessee and in the western parts of Kentucky and Indiana.

GEOLOGY OF THE PLATEAUS.

Geologic structure.—The structure of the Allegheny Plateaus is simple. The strata lie nearly flat, and their regularity is broken only by small faults and low, broad folds. 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 Cincinnati. From this point the axis of the anticline passes due south to Lexington, Ky., and there curves to the southwest parallel with the Appalachian Valley as far as Nashville, Tenn. This anticline reaches its maximum development in the vicinity of Lexington, where the Trenton limestone is exposed at an altitude of 1000 feet above sea level. In Tennessee it swells out into a dome-like structure, which is exposed in the topographic basin of central Tennessee.

The Cincinnati anticline divides the Allegheny Plateaus into two structural basins, which are best known from the coal fields which they contain. The western basin extends far beyond the limits 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 includes the Appalachian coal field. The Waynesburg quadrangle is situated entirely within the Appalachian coal field, and hence a somewhat detailed description of this field is necessary in order to present a clear idea of the geologic features of the quadrangle.

Structure of Appalachian coal field.—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. The deepest part of this trough lies along a line extending southwest from Pittsburg across West Virginia to Huntington, on Ohio River. Toward this line the rocks dip from both sides of the trough. About the canoe-shaped northern end the rocks outcrop in a rudely semicircular line and at all points dip toward the lowest part of the trough. In Pennsylvania the deepest part of the trough is situated in the southwest corner of the State, and the inclination of the rocks is generally toward that point.

The regularity of the dip near the southeastern margin of the trough is interrupted in Pennsylvania and West Virginia by parallel folds, which in many cases give 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. These minor folds are a constant feature along the southeastern margin of the basin from central West Virginia to southern New York. They make the detailed structure somewhat complicated and break up the regular westward dip, so that at first sight the structure is not apparent. Close examination, however, shows that west of the Allegheny Front each succeeding trough and each successive arch is lower than the one on the east, until the rocks which are over 2000 feet above sea at the Allegheny Front extend below sea level in the central part of the basin. Across the northern extremity of the basin the minor folds are developed in large numbers and extend at least halfway across Pennsylvania near its northern boundary. In the southern part of the State there are only six pronounced anticlines, two of these disappearing near the West Virginia line. Farther south the number is less, until on Kanawha River the regular westward dip is interrupted by only one or two folds of small proportions.

STRATIGRAPHY.

The rocks which are exposed at the surface in the Allegheny Plateaus belong entirely to the Carboniferous system. They include the Pocono, Mauch Chunk, Pottsville, Allegheny, Conemaugh, and Monongahela formations and the Dunkard group. These will be described in the order of their age, beginning with the lowest.

Pocono formation.—In this province the Pocono formation forms the basal division of the Carboniferous system. Its name is derived from the Pocono Mountains, in the eastern part of Pennsylvania, where the formation consists largely of sandstone and is over 1000 feet thick. It rests upon the red rocks of the Catskill formation, the uppermost member of the Devonian system. Although the lower limit of the Pocono can not be determined definitely from well records, it is believed that in the Waynesburg quadrangle the formation is only about 300 feet thick. Over a large area in Pennsylvania the top is well marked by a calcareous and sandy stratum, known as the Loyalhanna (Siliceous) limestone. (Charles Butts, Kittanning folio, No. 115, p. 5.) Where this stratum is absent the top of the formation is not well defined. On the eastern margin of the coal field sandstone predominates. The Pocono contains, however, beds of gray sandy shale and occasional beds of red shale which, though usually thin, may be of considerable thickness. In southwestern Pennsylvania the formation is generally under cover, but is penetrated in drilling deep wells for oil and gas. In the southeastern part of the Appalachian field, in Virginia and West Virginia, the formation contains workable beds of coal of limited extent, and in parts of Pennsylvania it includes thin worthless beds.

Mauch Chunk formation.—This formation overlies the Loyalhanna (Siliceous) limestone in the Allegheny Front, along Conemaugh River east of Blairsville, and along Chestnut Ridge in Fayette County. It takes its name from Mauch Chunk, in the anthracite coal region, where it is over 2000 feet thick in the deep synclines and where it is described as being composed largely of red shale (Second Geol. Survey Pennsylvania, Final Rept., vol. 3, pt. 1, p. 182). In the Allegheny Front it is made up of about 150 feet of heavy grayish to greenish sandstone at the bottom, and 100 feet of soft red shale. It has this character along the Conemaugh between South Fork and Johnstown, but where it is exposed on Chestnut Ridge the sandstone beds are less conspicuous. The formation here is composed of red shale overlying the Loyalhanna limestone, the Greenbrier limestone member, which is not known to occur north of this point, and an upper red shale. The Greenbrier limestone represents the extreme edge of the great Mississippian limestone mass of the Mississippi Valley. In the Waynesburg quadrangle the Mauch Chunk is represented by red shale, sandstone, and a limestone at least 50 feet thick, the total thickness of the formation varying from 125 to 250 feet.

Pottsville formation.—This formation derives its name from Pottsville, in the southern anthracite region. At the type locality it is 1200 feet thick and is composed mainly of a coarse heavy conglomerate, which carries in part of the field several workable coal seams. In the eastern part of the bituminous coal field of Pennsylvania the formation consists of two sandstone members separated in general by a bed of shale, and often includes several thin coals. The upper sandstone member is known as the Homewood and the lower as the Connoquenessing. In places the shale contains a coal bed of workable thickness and in some places a valuable bed of fire clay. A bed of limestone is also locally developed. The three beds occurring together in the shale are known as the Mercer coal, clay, and limestone, because they are well developed in Mercer County. Along the western border of Pennsylvania a third sandstone member occurs below the Connoquenessing and is separated from it by another shale bed which contains a coal seam that is locally of workable thickness. The sandstone is called the Sharon sandstone or conglomerate, and the coal bears the same name, from their great development at Sharon, Mercer County. In most parts of the bituminous coal field of the State the thickness of the Pottsville formation is probably from 125 to 300 feet.

Allegheny formation.—The Allegheny formation, which is named from the river along which it outcrops in typical form, overlies the Pottsville. It is rather more variable in character than the lower formations of the Carboniferous. It is especially distinguished by the fact that in the bituminous coal field it contains a greater number of workable seams than any of the lower formations. On that account it was called by the older writers the Lower Productive measures. In addition to its coal seams, it bears valuable beds of fire clay, limestone, and iron ore. These are separated by strata of sandstone and shale. Nearly all the coal mined in the State north of Pittsburg and east of Connellsville and Blairsville is taken from this formation. The clay and shale beds of the formation form the basis of important industries in several localities.

Conemaugh formation.—The name Conemaugh, taken from the river along which the rocks outcrop, is applied to the formation which was formerly known as the Lower Barren measures on account of its stratigraphic position and the absence in it of workable coals. In some parts of Pennsylvania workable coals of limited extent do occur, however, and sometimes they are accompanied by thin limestones. The great mass of the formation is composed, however, of a succession of shale, mostly sandy, and sandstone strata. A large part of the shale, perhaps the greater part, is sandy. The sandstone strata are variable in thickness and occurrence. In some regions there may be scarcely any sandstone from the bottom to the top of the formation. In such cases the formation is composed almost wholly of shale without any distinctive and traceable beds whatever. The total thickness of the formation varies from 600 to 700 feet.

Monongahela formation. — This formation is named from the river along which it is typically exposed. It overlies the Conemaugh formation in the southwestern part of the State, and extends from the bottom of the Pittsburg coal below to the top of the Waynesburg coal above. Its thickness varies from 310 to 400 feet. It contains several workable coal beds, of which the Pittsburg is by far the most valuable and best known. It is much less sandy and shaly than any of the other Carboniferous formations, but contains, on the other hand, far more limestone, which constitutes more than one-third of its thickness. The formation underlies an oval-shaped area that extends from Pittsburg, Pa., to the vicinity of Huntington, W. Va., and includes considerable portions of Ohio and West Virginia adjacent to Ohio River.

Dunkard group.—This group of rocks was formerly known as the Upper Barren measures and later as the Dunkard formation. It lies above the Monongahela formation and includes the highest rocks of the Carboniferous system found in this area. It has a thickness in the southwest corner of Pennsylvania of about 1100 feet, and consists mainly of shale and sandstone, though it contains beds of coal and limestone. Some of the coals are locally workable, but they are generally worthless. In this quadrangle the group may be divided into two formations, the Washington formation and the Greene formation. In the Washington are included the rocks between the Waynesburg coal and the Upper Washington limestone, and in the Greene all higher rocks. It is doubtful whether the divisions can be carried beyond the boundaries of Pennsylvania, so that in Ohio and West Virginia these rocks will probably be known simply as the Dunkard formation. They occupy an area in southwestern Pennsylvania and along Ohio River in West Virginia and Ohio similar in shape to that of the Monongahela formation, but of less extent.

TOPOGRAPHY OF THE QUADRANGLE.

GENERAL RELATIONS.

There are a few hilltops and small flat areas in the northeast corner of the quadrangle close to Monongahela River which have an altitude of between 1200 and 1300 feet. These are thought to be remnants of an old peneplain surface which is found on Monongahela River at an elevation of about 1250 feet above tide in the Masontown, Brownsville, and Connellsville quadrangles and on both sides of Ohio River from Beaver, Pa., to Wheeling, W. Va. This dissected plateau is known as the Harrisburg peneplain, and as mentioned above is correlated tentatively with the Highland Plateau which occurs farther south. Elsewhere in the quadrangle, however, traces of this peneplain are lacking, for the reduction of the hills to this general level did not take place. Elevations of 1500 feet are common. It may be suggested that this area was not reduced because the cycle of erosion which brought so much of the country to a common level did not continue long enough to reduce all the more distant interstream areas.

The geologic age of the peneplain 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 epoch.

DRAINAGE.

Monongahela River is the largest stream in the Waynesburg quadrangle. About 2 miles of its course are included within the boundaries. Under ordinary conditions the river would not be navigable, but by means of a series of locks and dams the depth of water has been increased so that steamboats ply between Pittsburg and Morgantown, W. Va. Slack-water navigation is possible to beyond the West Virginia line at any season of the year, except when prevented by ice. That portion of the river between Millsboro and Rices Landing, which lies within this quadrangle, is a part of Pool No. 5. The altitude of the surface of the water in this pool is 746.41 feet above tide.

The entire drainage of the quadrangle flows into Monongahela River. The main streams are Tenmile, Muddy, Whiteley, and Dunkard creeks. Tenmile Creek carries away the water of fully one-half of the territory. The South Fork of Tenmile Creek flows across the quadrangle and joins the main stream 3 miles from Monongahela River. It is the longest stream within the area, and its valley contains the largest villages, and affords the main line of travel between east and west.

The upper courses of Muddy and Whiteley creeks drain the east-central part of the quadrangle. The area drained by Muddy Creek is largely in Jefferson and Cumberland townships. The catchment basin of Whiteley Creek is much larger than that of Muddy Creek and extends west as far as the high ridge which forms the boundary between Whiteley Township on the east and Wayne and Center townships on the west.

Dunkard Creek flows through the southern portion of the quadrangle for a short distance, and receives the south-flowing waters of Dunkard, Perry, and Wayne townships.

As the surface has been cleared of a large amount of its original covering of timber, and the slopes generally are steep, all the streams are subject to floods and at such times carry a large quantity of water. Crops growing on flood plains are in danger of being damaged or completely destroyed by high water. These high stages appear quickly, but are of short duration.

A noticeable feature of the drainage of this quadrangle is that besides flowing east, all of the main streams have longer tributaries on the north than on the south. In other words, the streams do not lie midway between the divides, but crowd the south side of the drainage basins. In the basin of Ruff Creek, for instance, Boyd and Craynes runs head at the divide 4 miles away and flow in almost straight courses to the creek, while on the south side the laterals are scarcely more than a mile long. This same relation is very pronounced in the valley of Whiteley Creek, where, in the eastern part of Whiteley Township, the divide on the north is distant from the creek $4\frac{1}{2}$ miles, and that on the south $1\frac{1}{4}$ miles. This characteristic is less conspicuous in the South Fork of Tenmile Creek, about Waynesburg, where the long, straight course of Smith Creek, flowing from the south, is an exception.

No adequate explanation of this lack of symmetry in the drainage basins has yet been found. This unsymmetrical arrangement occurs in several counties in southwestern Pennsylvania. It can not be ascribed to present structure of the rocks, because it disregards anticlines and synclines alike. South Fork of Tenmile Creek passes from the Waynesburg syncline across the axis of the Bellevernon anticline, and then, swinging to the northeast, recrosses the same axis twice in the vicinity of Clarksville. Whiteley Creek has its source near the crest of the Bellevernon anticline, crosses the Whiteley syncline, and meets the flank of the next anticline on the east at a right angle. Likewise, Dunkard Creek, in its course along the State line 2 miles south of the southern boundary of this quadrangle, passes across several minor structural axes. Furthermore, its position does not seem to be due to the composition of the rocks. So far as the character of the rocks is concerned the tributaries on both sides of the streams should be of equal length.

SURFACE RELIEF.

The surface of this quadrangle is decidedly hilly in all parts. The highest altitudes are along the northern, western, and southern boundaries, from which there is a slope toward Monongahela River in the northeast corner. By reference to the topographic map it will be seen that the elevations vary from 750 feet on the river to 1620 feet in the western part of Perry Township. Fifty hilltops reach an altitude of 1500 feet or more, while the flood plains of the main streams are less than 1025 feet above tide. Morgan and Jefferson townships, by reason of their proximity to Monongahela River, have the lowest average altitude; Morris, Wayne, and Perry have the highest.

The most striking topographic features in the Waynesburg quadrangle are the flat upland areas in the northeast corner and the broad floors of Ruff, Muddy, and Whiteley creeks. The level plain at Racine, the flat-topped ridge east of Black Dog Hollow, and the flat hilltops along Monongahela River are all at about the same elevation, which is from 1120 to 1140 feet above tide. A striking agreement in altitude is afforded by the divide at the head of Bush Run and also by spurs in the eastern part of Morgan Township. Along Monongahela River in the Masontown and Brownsville quadrangles, this level is represented by a great many spurs and principal divides. It seems probable that these points which have so near the same altitude mark approximately a base-level of erosion.

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 the Tertiary level recognized at an altitude of about 1250 feet the land was elevated nearly 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. They had a width of from 2 to 3 miles and were bordered by gentle slopes leading by easy stages to the residual uplands farther back.

Below the 1120-foot level just described the streams cut rather steep slopes for 150 to 200 feet. Though these slopes are steep compared with those above 1120 feet, they are not so steep as those bordering the modern streams. In the smaller valleys the bottom of the intermediate slope is not clearly defined, but along Monongahela River the line is marked by a series of rock shelves and abandoned valleys. For a description of these reference should be made to folios Nos. 82 and 94. Two of these rock shelves are seen in this quadrangle on either side of the mouth of Tenmile Creek at an elevation of about 950 feet. Before the streams had cut down to the 950-foot level there was an interval of no movement when South Fork of Tenmile Creek seems to have turned to the east near Jefferson, and to have joined the Monongahela at Rices Landing. These conditions lasted long enough for the stream to cut a wide valley with a broad, flat floor, which is now represented by the level area between Rices Landing and Jefferson. This area is covered with stream-deposited material. It is possible that the broad, gently sloping fields between the mouth of Ruff Creek and Browns Run are a part of this same floor. They are underlain by heavy Waynesburg sandstone, but no river deposits were found on the surface.

The long level stretch on which Jefferson is built is underlain by Waynesburg sandstone, but probably it owes much of its character to terrace cutting and deposition of clay and sand on the rock floor. A series of rock shelves or terraces at an elevation of 950 to 980 feet above tide, denoting a later substage in erosion, extends up South Fork of Tenmile Creek to the western border of the quadrangle. The broad valley floors of Ruff, Muddy, and Whiteley creeks are due probably to ponding of the streams and filling of the channels with silt. This subject is discussed under the heading "Carmichaels formation."

Streams reach all parts of the territory, the rainfall is carried off quickly, and erosion is going on rapidly because of the great extent of moderately steep slopes. The main streams have cut down so far that further deepening is slow. Stream valleys in general are narrow, but the divides are not flat topped. The topography is in a state of maturity.

RELATION OF TOPOGRAPHY TO MAN'S ACTIVITIES.

The earliest settlements in this region were naturally in the valleys of main streams. Their sites were determined by available water power or the presence of level ground wide enough to accommodate a village. Flood plains offered the most accessible and promising land for cultivation. Even now all post-offices, with two exceptions (Castile and Gump), are in valley bottoms. Settlement advanced along the main creeks and up the tributaries, later extending along the tops of the ridges. The presence of a workable coal seam may have been a factor in the growth of Jefferson, Whiteley, and Davistown, and had its effect on Waynesburg and Clarksville.

As the stream valleys are narrow, the slopes steep, and the hill tops have no extensive levels, the areas of land positively desirable for cultivation are small.

The valley bottoms and lower slopes and the gently rounded uplands are cultivated, while the intervening steeper slopes are used for pasturage. The nature of the soil, the abundance of running water and springs, and the evenness of the climate fit this country admirably for the raising of cattle, sheep, and poultry, and the production of butter and cheese. For many years the principal and most profitable employment in this region was that of sheep raising, and the wool had a national reputation. During the last twenty years, however, the industry has fallen off and is now but a small fraction of its former proportions.

DESCRIPTIVE GEOLOGY.

STRUCTURE.

The rocks of the Waynesburg quadrangle are bent into a number of parallel wrinkles or folds which have a northeast-southwest trend. 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 an anticline and toward which they dip in a syncline.

METHOD OF REPRESENTING STRUCTURE.

There are in current use two methods of representing geologic structure. The first is by means of cross sections which show the various strata as they would appear if cut across by deep ditches. This method is effective only where the dip of the rocks is perceptible to the eye. In the Waynesburg quadrangle the rocks lie so nearly horizontal that the slight anticlines and synclines would not be apparent on such sections; besides, the sections illustrate the structure only along certain particular lines and do not give the shape of the arches and basins, which are of the greatest importance in the commercial development of the field, as regards both the mining of coal and the exploitation of oil and gas.

A second method of representing structure has been used in the folios in which the bituminous coal field of western Pennsylvania is described. It consists in the representation, by means of contour lines, of the position of some particular stratum which is known through its wide exposure in outcrop, its exploitation by mines, its relation to some other bed above it, or its use as a key stratum by the drillers for oil or gas. These contour lines show the form and size of the folds into which the stratum selected has been thrown and its altitude above sea level at practically all points.

In this quadrangle the Pittsburg coal bed is the best known stratum and is the one used by the drillers as a key rock in determining the position of the oil- and gas-bearing sands. This great bed lies far below the surface of the greater part of the quadrangle, but in the northeast corner it is exposed for a short distance along Tenmile Creek. The floor of the coal has been selected as the surface by which to represent the geologic structure of the quadrangle.

Where the Pittsburg coal shows in natural outcrop its altitude has been determined at a number of points. Where it occurs below the surface its existence and position are known through the records of the many gas wells of the region. After its altitude has been determined at a great many places, points of equal altitude are connected by contour lines; for example, all points having an altitude of 500 feet above sea level are connected by a line, which then becomes the 500-foot contour. Similarly, all points having an altitude of 550 feet are connected by the 550-foot contour line, and in like manner contour lines are drawn representing vertical distances of 50 feet throughout the area mapped. These lines are printed on the structure and economic geology map, and show, first, the horizontal contours of the troughs and arches; second, the dip of the beds; and third, the approximate height of the Pittsburg coal above sea level.

The depth of the reference stratum below the surface at any point is obtained by subtracting its elevation, as shown by the structure contour lines from the elevation of the surface at the same point. Suppose, for instance, the position of the Pittsburg coal is desired at the mill a half mile west of Waynesburg. It will be seen by the map that the elevation of the surface at this point is 950 feet, and that the mill is halfway between the 350- and 400-foot structure contour lines. The Pittsburg coal, therefore, is here about 950 minus 375 feet, or about 575 feet, below the surface.

As a rule these structure contours are generalized, and are only approximately correct. They are liable to error from several conditions. Being estimated on the assumption that over small areas the rocks maintain a uniform thickness, the position of a contour will be out by the amount by which the actual thickness varies from the calculated thickness. It is well known that in some places the interval between two easily determined strata will vary many feet in a short distance. Such cases make the determination of the position of the reference stratum difficult when it lies some hundreds of feet below the surface. In parts of the bituminous coal regions of Pennsylvania, however, records obtained in drilling for gas and oil give the changes in the interval and thus indicate the structure and the position of the reference stratum.

Another cause of error is that, being measured from the altitude of the observed outcrops, the position of the contour is uncertain to the degree that the altitude is approximate; while in many instances topographic altitudes are determined by spirit level, in most cases geologic observations are made with aneroid barometers. The aneroids are checked as frequently as possible against precise bench marks, and the instrumental error is probably slight, though it may be appreciable. Finally the observations of structure at the surface can be extended to buried strata only in a general way. The details probably escape determination. The errors may accumulate or may compensate one another, but in any case it is believed that their sum is probably less than one contour interval; that is to say, in any part of this quadrangle the altitude of the reference surface will not vary more than 50 feet from that indicated. Over much of the area the possible variation from the altitude will not be more than 20 feet, and the relative altitudes for successive contours may be taken as a very close approximation to the facts.

DETAILED GEOLOGIC STRUCTURE.

The general structural features of the Brownsville, Masontown, and Waynesburg quadrangles are shown in fig. 2. In the Waynesburg quadrangle these have the same northeast-southwest strike that characterizes the whole Appalachian province. The most pronounced features shown by contour lines on the structure and economic geology map are three anticlines and two synclines lying between them. These are described in the order in which they occur from east to west.

Fayette anticline.—The floor of the Pittsburg coal, and therefore the rock strata, in the southeast corner of the quadrangle dip sharply to the west along Dunkard Creek and in the vicinity of Davistown. This is the western flank of the Fayette anticline, a fold which is strongly developed across Fayette and Westmoreland counties. A north-south course is given to the contours between Davistown and Whiteley by the Brownsville anticline, which cuts off the Lambert syncline and joins the Fayette anticline 2 miles east of Whiteley village, near Willow Tree.

Whiteley syncline.—This syncline lies between the Fayette and Bellevernon anticlines, as does the Port Royal syncline in the Brownsville quadrangle. The Port Royal syncline, however, loses its basin-like character in the vicinity of Fayette City on Monongahela River, and the axis does not seem to be continuous with the axis here described. In order to have a convenient appellation for this basin the name Whiteley syncline will be used in this report. It is taken from the township in which the basin is broadly developed.

Deep weathering of the rocks which form the surface and absence of traceable beds make a determination of the slight irregularities in structure which probably exist almost impossible. In the area of this syncline between Muddy Creek on the south boundary of Jefferson Township and Dunkard Creek on the Pennsylvania–West Virginia State line, an area of more than 60 square miles, there are only five deep well borings which give any light on the depth of the Pittsburg coal below the surface. Two of these are in Whiteley Township and the other three in the Blacksville quadrangle. With so meager data there is a possibility of error in the structure contours of this basin.

The shape of the Whiteley syncline, therefore, is not well determined. It is broad and shallow, deepening toward the south. The axis of the trough probably lies about on a line through Khedive, Fordyce, and Kirby. Near the southern edge of the quadrangle it turns almost due south and crosses Dunkard Creek near the dam three-fourths of a mile west of Pentress. The trough may be more pronounced in West Virginia, but the indications on Dunkard Creek in the Blacksville quadrangle are to the contrary. There seems to be a slight dome on the eastern flank of the syncline between Hobbs and Calvin runs in Perry Township, as indicated by the depth of the Pittsburg coal in a gas well on the Hester Delaney farm on Shannon Run below the mouth of Hobbs Run.

Bellevernon anticline. — Professor Stevenson named this axis the Waynesburg anticline in his report on Greene County published in 1876. The first detailed work of the present Survey on this anticline was in the Brownsville quadrangle, which joins the Waynesburg quadrangle on the northeast. The axis crosses Monongahela River at Bellevernon, and the anticline was named from that place, there being some doubt at the time as to its continuity with the anticline supposed to exist at Waynesburg. The survey of this quadrangle has proved the continuity of the fold, but the anticline is so far east of the village of Waynesburg, and has decreased so much in size in this quadrangle, that the name Bellevernon seems more appropriate and hence is retained.

The Bellevernon anticline is the most pronounced and important structural feature in the Waynesburg quadrangle. From the northeast corner of the quadrangle it has a direct southwest course for 14 miles to the head of Dyers Fork. Here it turns south and crosses the southern boundary of the quadrangle between Roberts and Rudolph runs. The crest of the anticline falls gradually from Racine to Spraggs, with the exception of a slight rise where it crosses South Fork of Tenmile Creek. The fall from the northern to the southern boundary is about 400 feet. Where the Bellevernon anticline crosses Monongahela River, near Charleroi, the Pittsburg coal is at an elevation of 1000 feet above sea level. Well records from the vicinity of Blacksville on the Pennsylvania–West Virginia State line show that the same coal is little more than 400 feet above tide. Probably the fold disappears soon after entering West Virginia.

The eastern slope of the Bellevernon anticline in Jefferson Township is short and gentle. From the crest near the mouth of Braden Run to the bottom of the syncline at Fordyce or Khedive there is a fall of scarcely more than 200 feet. From the crest at the same point to the axis of the syncline on the west the Pittsburg coal descends nearly 400 feet. The western flank of the Bellevernon axis is a regular slope, as is shown by contour lines on the structure sheet.

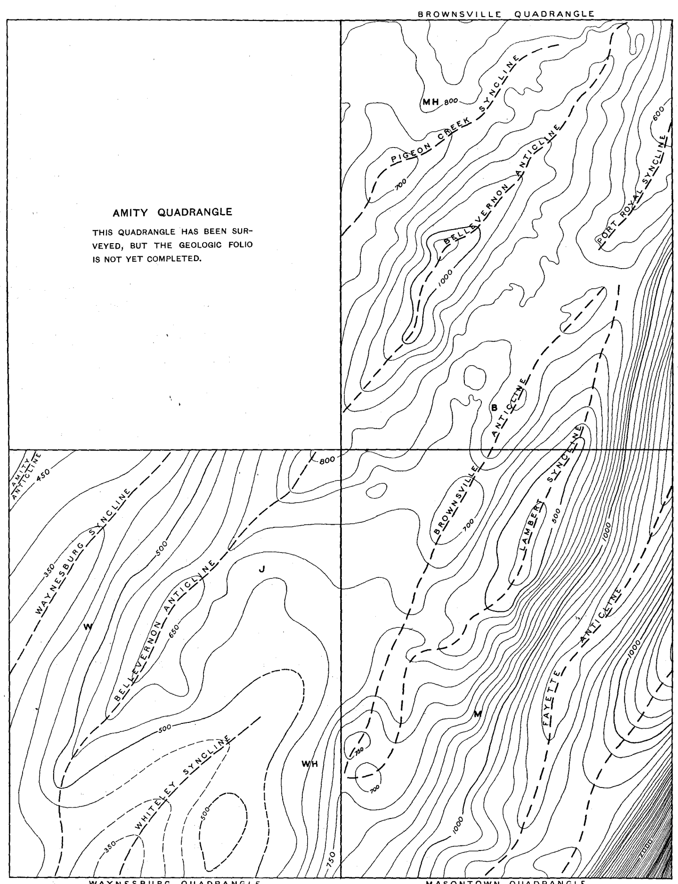


Fig. 2.—Sketch map of Waynesburg, Brownsville, and Masontown quadrangles showing geologic structure by means of contour lines drawn on the floor of the Pittsburg coal. Contour interval, 50 feet.
W, Waynesburg; J, Jefferson; WH, Whiteley; MH, Monongahela; B, Brownsville; M, Masontown.

The southwestern termination of the Bellevernon anticline is somewhat obscure. The axis is fairly well marked as far as Spraggs, in Wayne Township, but south of this place it has not been detected even along Dunkard Creek, where the rocks are well exposed. If the axis were extended in a direct line from the southern margin of the Waynesburg quadrangle it would cross the creek a short distance west of Blacksville, but no fold is apparent at this place, and the rocks seem to rise gently but steadily down the stream for at least 2 miles above Blacksville. A short distance east of the village a low anticline crosses Dunkard Creek, but this does not seem to be connected in any way with the Bellevernon axis. It appears more like the northern extremity of a fold which may have some prominence in West Virginia, but which disappears soon after entering Pennsylvania. Even at the State line its development is so slight that it seems to have no effect upon the structure of the Waynesburg quadrangle.

Waynesburg syncline. — The structural basin which lies west of the Bellevernon anticline was called the Waynesburg syncline by Professor Stevenson. He located the axis somewhat farther east than the present Survey finds it, but the basin is essentially the same as that described by him, and hence the name is retained. The axis falls in line with and seems to have the same relations as the Pigeon Creek syncline in the Brownsville quadrangle (Brownsville–Connellsville folio, No. 94). At the time that quadrangle was surveyed it was recognized that the Pigeon Creek and Waynesburg synclines might be one and the same, but mine data in the vicinity of Bentleyville, Washington County, seemed to indicate cross structure, and so the basin was given the local name of Pigeon Creek syncline. On Pigeon Creek the Pittsburg coal is 700 feet above tide, while on Wisecarver Run in this quadrangle it is at least 400 feet lower. Although this fall may be continuous from one point to the other, it is not known to be so, and it seems best to use the local term.

The axis of the Waynesburg syncline crosses the Washington–Greene county line about a mile west of Castile; it crosses Ruff Creek near the mouth of Boyd Run, and Browns Creek at Rees Mill, 2 miles west of Waynesburg. Continuing in a southwesterly direction, it crosses South Fork of Tenmile Creek half a mile above the mouth of Pursley Creek and passes beyond the western boundary of the quadrangle.

In this part of the quadrangle the structure has been ascertained from the records of several deep wells which show the position of the Pittsburg coal and from the elevation of the Upper Washington limestone. It is possible that the basin is somewhat deeper than is represented on the structure map. The Pittsburg coal was found in a deep well on the Wisecarver farm (17) on Wisecarver Run, about 285 feet above sea level, but the evidence was not sufficient to warrant drawing a 300-foot contour line on the coal.

Amity anticline.—From Ruff Creek and Rees Mill the rocks rise to the west more gradually than to the east, and a low anticline crosses the northwest corner of the quadrangle, in Morris Township, through the Fonner oil field. This fold was called the Pinhook anticline by White and Stevenson in their reports (Second Geol. Survey Pennsylvania, Rept. K, p. 27). The name was taken from a burlesque appellation of the little village in Amwell Township known as Pleasant Valley or Lone Pine, and for that reason is not suitable for geologic nomenclature. Furthermore, their description of the location of this axis in Greene County does not agree with the accompanying map. During the present survey the axis was traced from the northwest corner of this quadrangle northward across Tenmile Creek at Hackneys and close to the village of Amity, in Washington County. The name Amity seems preferable and was applied for the first time by the writer in a brief report entitled "Oil and Gas Fields of Eastern Greene County, Pa." (Bull. U. S. Geol. Survey No. 225, p. 405).

According to well records the Pittsburg coal is about 460 feet above sea level on the crest of the Amity anticline where it crosses the northern boundary of this quadrangle. Its elevation is 420 feet at the road forks in the extreme northwest corner of the quadrangle, and from 400 to 420 feet in the wells on the Dunn farms a half mile farther north. On the crest of the anticline at Hackneys, a little over 3 miles due north of Hope, the elevation of the coal is 495 feet. The rocks dip to the east, so that the same coal was found 430 feet above tide in a diamond-drill hole at Bissell, on Tenmile Creek. For this reason the 450-foot contour line is shown swinging strongly to the east near Hope, so as to pass close to Tenmile village.

The sketch map, fig. 2, shows the relation of the geologic structure in the Waynesburg quadrangle to that in the Brownsville and Masontown quadrangles; and the accompanying cross section, fig. 3, drawn normal to the strike of the structure in Greene and Fayette counties, shows that the anticlines and synclines which are such strong features in so limited an area as one quadrangle are only small undulations in a greater structural feature, the Appalachian basin.

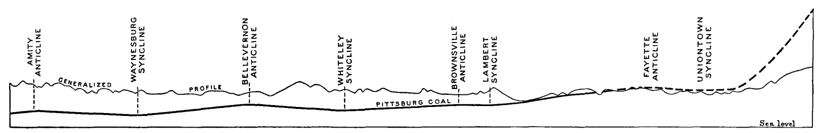


Fig. 3.—Cross section from northwest corner of Waynesburg quadrangle to southeast corner of Masontown quadrangle. Horizontal scale, 1 inch—3¾ miles; vertical scale, 1 inch—3000 feet.

STRATIGRAPHY.

The discussion of the rocks in this quadrangle divides itself naturally between those which are not exposed at the surface and those which outcrop. The former are known from the records of deep wells sunk for gas or oil; the latter can be studied directly.

ROCKS NOT EXPOSED.

Sources of knowledge.—Gas and oil companies and private individuals operating in this county usually require the drillers to keep a record of the thickness of strata passed through in sinking wells. It is from this source that information is obtained concerning the underground structure and stratigraphy. Records are always more or less inaccurate when measurements are made by counting the turns of the cable on the bull-wheel shaft, and the observers are not trained geologists. Another source of error is the difficulty of identifying rocks by the relative ease with which the drill penetrates them or by the drillings brought up in the sand pump. Furthermore, records are rarely complete, often showing only the gas and oil sands, thus leaving great intervals of which nothing is known but the thickness. Too frequently beds geologically important, such as red rock and limestone, are overlooked or not recorded. An interpretation and correlation of the records of nine wells which lie in a north-south line across the quadrangle are given on the columnar section sheet.

In discussing the character and relation of the beds which lie under the Pittsburg coal, the lowest rock exposed in the quadrangle, the usual order of description, from older rocks to younger, will be reversed and the description proceed in the order in which the various strata are penetrated by the drill.

CONEMAUGH FORMATION.

The Conemaugh formation extends from the floor of the Pittsburg coal down to the roof of the Upper Freeport coal. Underneath this quadrangle it is from 570 to 600 feet thick and is composed of sandstone, limestone, and shale. Many of the records of wells drilled in Greene County give no details of this formation. It is known, however, that limestone is encountered about 50 feet below the Pittsburg coal. This limestone is underlain by a massive sandstone, the Connellsville sandstone, which sometimes is 50 feet thick. Another heavy sandstone is met at a distance of 150 to 200 feet below the coal. The interval between these two sandstones is occupied by shaly sandstone or red shales. This second sandstone is not named in the records of this region, but is known elsewhere as the Morgantown. The shale which underlies the Morgantown sandstone often is red.

Red beds.—These beds of red shale in the upper part of the Conemaugh probably are continuous throughout the quadrangle, but the records are so incomplete that this can not be positively asserted. Red rock is noted in many of the wells in Monongalia and Marion counties, W. Va. In the Brice Wallace well in Marion County (West Virginia Geol. Survey, vol. 1, p. 238) red rock is recorded as extending through an interval of nearly 300 feet. Several well records from Franklin Township, Greene County, indicate the presence of a considerable thickness of red beds under this part of the quadrangle. Red rock is noted in the Fonner field, in Morris Township, 250 feet below the Pittsburg coal, and also in Amwell, Hopewell, and Franklin townships, Washington County.

Dunkard oil sand.—According to identifications by different drillers, the top of the Dunkard oil sand is from 425 to 575 feet below the Pittsburg coal. Some drillers find a break in this thick sandstone and name the upper and lower divisions the Little and Big Dunkard.

The lower 150 feet of the Conemaugh is composed of massive sandstone and sandy shale. This part of the formation is variable, being recorded sometimes as a continuous mass of sandstone, and again as two beds separated by shale. No two records are exactly alike in this respect. Judging from the outcrop of this horizon in other counties, the Dunkard oil sand is composed of two beds, known as the Saltsburg and Mahoning sandstones. In some places these form an almost continuous mass of heavy strata, 150 feet thick, with few or no breaks, but in other localities either one or both of the members are shaly. It would seem, then, that a sand lying between 425 and 500 feet below the Pittsburg coal is the Saltsburg, and that one found more than 500 and less than 570 feet below the coal is the Mahoning. It is probable that a sand reached in Franklin Township at a depth of 575 feet below the Pittsburg coal and called Dunkard by the driller is the sandstone which lies below the Upper Freeport coal at the top of the Allegheny formation.

ALLEGHENY FORMATION.

A series of coal-bearing strata from 350 to 375 feet thick constitutes the Allegheny formation. As a whole the data regarding its character here are meager and unreliable. It is rare that drillers recognize or record any coals below the Pittsburg. Having reached this well-known horizon, they look only for productive sands and often note nothing else, or hundreds of feet of strata are lumped as shale or shaly sandstone. In the record of the Sayers well (F), which was drilled at the pump station 2 miles east of Waynesburg, the one item, "black shale 370 feet" is all the account that was kept of the entire Allegheny and Pottsville formations. The Johnstown cement rock and Vanport (Ferriferous) limestone are noted in one or two records. The Clarion sandstone near the base of the formation sometimes reaches a thickness of 30 to 50 feet, in which case it has in a few instances been called the Gas sand. Probably it is not always present.

POTTSVILLE FORMATION.

The Pottsville formation is about 150 to 180 feet thick, and generally it is composed of two heavy sandstones separated by shale. The upper is the Homewood and the lower the Connoquenessing sandstone. The records sometimes show these sandstones merged into one continuous bed from 100 to 170 feet thick. There is a possibility that this represents the true condition of the beds, but a separation by a belt of shales in the midst of the formation is more common.

Gas sand.—The porous, sandy rock which is found in this territory at an average depth of 765 feet below the Pittsburg coal and commonly known as the Gas sand correlates in a majority of cases with the Homewood sandstone. In a few records the position of this sand is such that it seems to be the Clarion sandstone, near the base of the Allegheny formation, rather than the top member of the Pottsville. In other wells it has been put as high as the Kittanning sandstone, and sometimes is not noted at all. The recorded thickness ranges from 15 to 140 feet.

Salt sand.—At an average distance of 165 feet below the top of the Gas sand, or 932 feet from the Pittsburg coal, the Salt sand is reached. According to the well records its thickness varies from 15 to 175 feet. When the recorded thickness is small the bed of sand which produced salt water has been given the name; when it is over 100 feet the whole Pottsville formation has been called Salt sand and the Gas sand is either in the Allegheny or not noted at all. When the Gas sand corresponds with the Homewood sandstone the Salt sand probably is the Connoquenessing sandstone. Likewise, when the Gas sand is not noted and the Salt sand is only moderately thick the Salt sand is equivalent to the Connoquenessing sandstone. When the Salt sand is recorded as being extremely thick, however, it usually coincides with the whole Pottsville formation and may include the upper part of the Mauch Chunk.

MAUCH CHUNK FORMATION.

Red rock and limestone are the components of the Mauch Chunk formation in this quadrangle. In Monongalia and Marion counties, W. Va., this formation has a thickness of over 250 feet, including some shaly sandstone. Well records in West Virginia, just south of this quadrangle, show 50 to 150 feet of red shale, and a considerable thickness is found in the southern townships of Greene County. The red shale thins out to the north and west, however, and probably disappears, so that in Washington and Morris townships red rocks rarely are found at this horizon.

The Greenbrier limestone, commonly known to Greene County drillers as the Big Lime or Mountain Lime, is persistent throughout this area and shows almost as great thickness in Washington County as it does over the State line in West Virginia. In the northern townships, where red rock is not found in the Mauch Chunk, the Connoquenessing sandstone rests on the Greenbrier limestone or is separated from it by only a thin bed of shale or shaly sandstone.

The thinning of the Mauch Chunk formation decreases the interval between the Pittsburg coal and the top of the Pocono formation in a northwesterly direction. It also points to an unconformity at the base of the Pottsville. So far as shown from well records, this might be an unconformity due to non-deposition or to erosion. From evidence in other localities where these formations outcrop it seems to be an erosional unconformity.

POCONO FORMATION.

A massive sandstone which has a thickness of 250 to 300 feet and which is found about 1225 feet below the Pittsburg coal is known as the Big Injun sand. It lies immediately under the Greenbrier limestone or Big Lime of the Mauch Chunk and is easily recognized. It constitutes the upper part and perhaps all of the Pocono formation.

The interval between the Pittsburg coal and the top of the Pocono decreases northwesterly by the disappearance of the Mauch Chunk red shale. In each township northwest of Perry Township it becomes smaller and in Morgan Township is 100 feet less than in Perry Township. Further evidence is given by the wells to the north and south of this quadrangle. Nine wells in Monongalia and Marion counties, W. Va., give an average distance of 1313 feet to the top of the Big Injun. The recorded intervals in these wells range from 1276 to 1338 feet, and are considerably greater than those in the southern townships of Greene County. In Washington County, Pa., the interval continues to decrease, the top of the Big Injun being 1145 feet below the Pittsburg coal in a well on the Meloy farm near West Amity station, Amwell Township, and 1130 feet in a well on A. Sprowl's farm on Robinsons Fork, West Finley Township.

This sandstone is remarkably persistent and regular in thickness in the southwestern part of the State. Where it is seen in outcrop the top is an arenaceous limestone which downward becomes more sandy and grades into calcareous sandstone. The change from arenaceous limestone to nearly pure siliceous beds is gradual and accounts in part for considerable variations in the thickness of the limestone in the lower part of the Mauch Chunk, as shown in the records of deep wells. Allowance must be made for this when the rocks can not be seen, and part of a large interval of lime and shale is sometimes considered as the top of the Big Injun instead of being all Big Lime, as recorded by the driller.

There is some difference of opinion as to the thickness of the Pocono and the position of the base of the Carboniferous rocks in western Pennsylvania. The lower part of the formation is usually less massive than the upper. For this reason the bottom of the formation is not always easily recognized.

In his report on the geology of West Virginia (West Virginia Geol. Survey, vol. 1, p. 205), I. C. White gives the Pocono a thickness of 560 to 600 feet, and includes in it the Big Injun and Squaw sands and 380 feet of underlying shales and sandy beds. The Big Injun sand in his section is 150 feet thick. He classes a series of sands and shales 571 feet thick, extending from the bottom of the Pocono, which he places just above the Gantz sand, to the bottom of the Elizabeth or Sixth sand, as Catskill, and calls the gray and dark shales with an occasional "shell" which lie below the Sixth sand Chemung. On the other hand, M. R. Campbell, in the Masontown-Uniontown folio, No. 82, describes the Pocono as being 300 feet thick and equivalent to the Big Injun sand of the drillers. He classes the sands and shales below the Big Injun sand as Devonian.

During the present survey of Pennsylvania, fossils were collected in Fayette County on the National Pike about 50 feet below the base of the Pocono sandstone and were identified by George H. Girty as of Chemung age. The Pocono in this locality is approximately 300 feet thick and is composed almost entirely of sandstone which varies from thin-bedded, flaggy rocks to massive conglomerate. Professor Stevenson states in one of his papers (Am. Jour. Sci., 3d ser., vol. 15, 1878, pp. 423–430) that he found a number of species which, according to Professor Hall, are typical Chemung forms. These were found within 18 inches of the base of the Pocono sandstone, and clearly show that, from a paleontologic standpoint, no formation can be present at that point between the Chemung shale and the Pocono sandstone. The presence of Chemung fossils, however, does not preclude the possibility that the rocks containing them are Pocono in age. They may be long-lived Devonian forms which have persisted into the Carboniferous.

That there may be a zone of merging between Devonian and Carboniferous faunas, with no distinct boundary, has been shown by Charles Butts (Rept. New York State Paleon. 1902, pp. 990–995). He finds that in the Olean quadrangle in southern New York a few distinctively Devonian forms persist and are associated with forms which belong in the Mississippian series and with other forms which have Carboniferous aspects. Mississippian fossils have not been found below the Pocono sandstone in the Chestnut Ridge region, and although search has not been made, it seems probable that they are not there.

Below the Big Injun sand the drill passes through a series of interbedded shales and sandstones about 1000 feet thick. There is something like a definite succession of beds, as exhibited by well records, throughout the quadrangle, but sandstone and shale replace each other so that the section in one well may be unlike that in another near by. The rocks here discussed may be divided into three parts: (1) shale, "slate and shells," 300 feet thick, underlying the Big Injun; (2) gas sands and interbedded red shale, 600 feet thick, and (3) slate and shells to the bottom of the deepest well.

These red beds in (2) appear in the wells in the Waynesburg quadrangle about 700 or 800 feet below the top of the Pocono, the uppermost being near the horizon of the Gantz sand. They are supposed to be Catskill and of Upper Devonian age.

It is admitted that the 300 feet of slate and shells composing (1), as described above, and those of the gas sands in (2), which are above the red shale, may belong to the Pocono formation. If they are Pocono, then the top of the Devonian is represented by the so-called Catskill red shales, which, in the Josephus Bowers well (H) in Whiteley Township, occur through a distance of over 300 feet. If these rocks between the Big Injun sand and the top of the red beds are not Pocono they are either Chemung or a transition series above the Chemung.

Whether the Pocono extends down to the red beds or is only 300 feet thick and equivalent to the Big Injun sand is a question which can not be settled by the evidence of deep-well records alone. As a matter of convenience the beds below the Big Injun sand are here discussed with the Devonian.

DEVONIAN ROCKS.

The first 250 to 300 feet of strata below the Big Injun sand, as shown by the records of wells in this quadrangle, are composed largely of shale and thin, hard, sandy layers known as "shells." Three or more sandstones of varying thickness are sometimes recorded; but they do not seem to be persistent, and do not yield gas or oil. The second division of the rocks, noted above as found below the Big Injun, begins with the Thirty-foot sand and extends to the bottom of the Elizabeth sand.

Gas sands.—In this distance of approximately 600 feet eight well-known sand rocks occur, in the following order: Thirty-foot, Gantz, Fifty-foot, Gordon, Fourth, Fifth, Bayard, and Elizabeth. These sands have varying thicknesses and are separated from one another by beds of shale. A detailed statement regarding these sands appears under the heading "Natural gas."

A study of the relation of the Big Injun and Fifth sands to each other and to the Pittsburg coal is not without interest from a stratigraphic point of view.

The following table shows the average distance from the Pittsburg coal to the Fifth sand in the Waynesburg quadrangle.

Distance from Pittsburg coal to Fifth sand.

Township.	Number of wells.	Least distance.	Greatest distance.	Average distance.
		Feet.	*Feet.*	*Feet.*
Franklin	44	2258	2355	2308
Morgan	5	2292	2365	2314
Washington	4	2275	2345	2310
Wayne	12	2270	2336	2303
Whiteley	5	2282	2325	2302

These figures seem to indicate that the Fifth sand is very nearly parallel with the Pittsburg coal. The difference between the least and greatest intervals in the quadrangle is barely more than 100 feet, while the average distance in five townships varies only 23 feet.

The following table shows the relation of the Fifth sand to the Big Injun.

Distance from top of Big Injun to top of Fifth sand.

Township.	Number of wells.	Least distance.	Greatest distance.	Average distance.
		Feet.	*Feet.*	*Feet.*
Morgan	5	1075	1150	1109
Washington	4	1075	1129	1101
Franklin	39	1015	1200	1084
Whiteley	11	1020	1060	1045
Wayne	12	970	1101	1044

The average intervals in these five townships show a decrease from north to south. The distance from the top of the Pocono to the Fifth sand is more than 50 feet greater in the northern part of the quadrangle than it is in the southern. It is shown in the table for the Pocono formation, given below, that the interval from the Pittsburg coal to the Big Injun sand in these same townships decreases in the opposite direction.

The relation of the Big Injun sand to the Pittsburg coal and the Fifth sand is shown in the following table:

Average distances from top of Big Injun sand to Pittsburg coal and Fifth sand.

Township.	Pittsburg.	Fifth.	Total.
	Feet.	*Feet.*	*Feet.*
Wayne	1259	1044	2303
Whiteley	1257	1045	2302
Franklin	1224	1084	2308
Washington	1209	1101	2310
Morgan	1205	1109	2314

The total of average distances for each township shows again the remarkable parallelism between the Pittsburg coal and Fifth sand.

Catskill red beds.—Near the horizon of the Gantz sand is where the red beds usually appear in the wells drilled in this quadrangle. The red color is found in both sandstone and shale, and is believed to indicate the Catskill formation. The Catskill red beds are either at the top of the Devonian or some distance below the top of the Chemung formation, depending on the definition of the base of the Pocono.

The third and lowest arbitrary division of the Devonian rocks as given above extends from the Elizabeth sand to the bottom of the deepest well. According to the record of the Eliza Shape well (6) there is a series of slate and shells for at least 356 feet below the Elizabeth sand. This well has a total depth of 3607 feet and penetrated 2831 feet of strata below the Pittsburg coal.

On the columnar section sheet in the graphic representation of the sequence of rocks in nine deep wells, the position of the gas sands is shown and their relation as well as that of the formations is indicated by correlation lines. The disappearance of the Mauch Chunk red beds in the northern part of Greene County, as the result of an unconformity at the base of the Pottsville sandstone or Salt sand is also shown, as described above.

SURFACE ROCKS.

Carboniferous System.

The surface rocks in this quadrangle belong to the Carboniferous system. Three formations are present, the Monongahela, Washington, and Greene. The Monongahela formation is exposed along Tenmile Creek and its South Fork from Monongahela River to Waynesburg, and on Dunkard and Whiteley creeks; the other two, which form the Dunkard group, cover fully 85 per cent of the area. The Monongahela belongs to the Pennsylvanian series, the Washington and Greene to the Permian. A generalized section for the Waynesburg quadrangle is given on the columnar section sheet.

MONONGAHELA FORMATION.

General statement.—The Monongahela formation extends from the base of the Pittsburg coal to the top of the Waynesburg coal, and in this region is 315 to 390 feet thick. The whole thickness of the formation is seen in this quadrangle only on Monongahela River at the mouth of Tenmile Creek.

According to Mr. I. C. White (Bull. U. S. Geol. Survey No. 65, p. 45), a section measured in the steep hillside one mile below Rices Landing, in this quadrangle, exhibits the following sequence:

Section of Monongahela formation near Rices Landing, Greene County, Pa.

		Feet.	Inches.	Feet.	Inches.
1. Waynesburg coal	Coal	1	0	6	4
	Clay	0	5		
	Coal	1	3		
	Clay	1	2		
	Coal	2	6		
2. Shales		40	0	91	0
3. Limestone, Waynesburg		6	0		
4. Shales and sandstone		45	0		
5. Coal, Uniontown				1	6
6. Limestone, Uniontown		6	0	126	0
7. Shales and sandstone		38	0		
8. Limestone, "Great"		82	0		
9. Coal, Sewickley				1	9
10. Sandstone		40	0	95	0
11. Limestone		25	0		
12. Sandy shale		30	0		
13. Slate, bituminous Redstone coal				1	6
14. Sandstone, Pittsburg, flaggy		15	0	45	0
15. Sandstone, Pittsburg, massive		30	0		
16. Coal, Pittsburg	Roof: Coaly shale	1	0	10	0
	Roof: Coal	1	2		
	Roof: Clay	0	10		
	Main bench	7	0		
Total				378	1

This section shows a total thickness of 378 feet and is the most detailed record that has been obtained in the quadrangle.

The records of 35 deep wells drilled in this quadrangle which give the depth of the Waynesburg and Pittsburg coals prove that the formation does not maintain anything like a uniform thickness throughout the area. The extreme intervals between these two coal beds are 299 and 392 feet. The formation decreases in thickness toward the west so that in several wells near the western boundary it does not measure over 320 feet. A regularity in the thinning of the formation can be determined in a general way. The thickness in Washington Township is less than the average in Franklin Township, and both are much less than the usual thickness in Dunkard Township.

Further evidence of westward thinning is shown by wells in Richhill Township, in the western part of Greene County. Five well records in this township show that the thickness of the Monongahela formation varies from 299 to 309 feet, and averages 297 feet, which is 43 feet less than in Franklin Township, and 76 feet less than in Dunkard Township.

A table showing the thickness of this formation as measured in 35 wells in the Waynesburg quadrangle is given in the next column.

The average thickness of the Monongahela formation in the Waynesburg quadrangle, or, in other words, the mean distance from the Waynesburg to the Pittsburg coal, as shown by these thirty-five well records is 337 feet.

The Monongahela formation is composed of several kinds of rocks, but may be characterized as calcareous. It contains over 100 feet of limestone, some heavy beds of sandstone, shales, and five coal seams (shown in fig. 4). All of the coals are persistent in extent so far as known. The Pittsburg coal, which is at the base of the formation, is the thickest seam, is probably the least variable, and has the shortest outcrop line of all the coals in the quadrangle. The Waynesburg coal, at the top of the formation, and the Mapletown coal, about one-third way from the bottom, are of workable thickness. The Redstone and Uniontown are too thin to be of value.

Thickness of Monongahela formation as shown by deep-well records.

Well number.	Name.	Township.	Waynesburg coal to Mapletown coal.	Mapletown coal to Pittsburg coal.	Waynesburg coal to Pittsburg coal.
			Feet.	*Feet.*	*Feet.*
59	Lot McClure, No. 3	Dunkard	.....	.....	378
58	Pride, No. 1	do	.....	.....	375
57	Pride, No. 3	do	275	91	366
12	Elizabeth Rush	Morgan	.....	....	369
14	Montgomery, No. 1	do	215	108	323
7	Lewis, No. 2	do	.....	.....	320
43	W. S. Scott, No. 3	Jefferson	.....	.....	322
42	W. S. Scott, No. 1	do	.....	.....	299
49	Eliz. J. Stephens	Whiteley	280	83	363
51	Thomas Mooney, No. 1	do	230	100	330
50	Iseminger heirs, No. 2	do	225	95	320
41	Thomas Bayard, No. 1	do	220	95	315
21	D. R. Pratt	Franklin	286	106	392
37	John Frye, No. 1	do	275	93	368
F	R. A. Sayers, No. 1. 1889	do	229	130	359
34	Gordon heirs, No. 1	do	227	129	356
G	L. M. Carpenter, No 1	do	225	125	350
27	Bonar Land Co., No 1	do	230	115	345
28	E. M. Sayers, No. 1	do	222	116	338
E	Illig, No. 1	do	223	113	336
40	E. and J. Strosneider, No. 1	do	250	82	332
31	Bowlby and Donly, No. 1	do	225	105	330
30	R. A. Sayers, 1901	do	....	.....	330
33	Wm. Rinehart, No. 2	do	217	112	329
18	F. M. Shriver, No. 1	do	.....	.....	327
24	Bowlby	do	220	105	325
22	Adams heirs	do	225	99	324
35	E. M. Sayers, No. 1. 1900	do	220	103	323
23	C. M. Smith, No. 1	do	230	90	320
36	Greenlie	do	224	91	315
38	Isaac Thomas	do	215	99	314
55	Sarah Gump	Wayne	250	90	340
20	Conger	Washington	212	108	320
C	J. W. Closser, No. 1	do	190	124	314
2	Wm. Fonner, No. 5	Morris	.....	.....	337

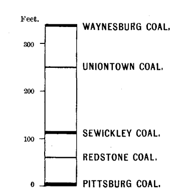


FIG. 4.—Section showing coal beds of the Monongahela formation.

Pittsburg coal.—The Pittsburg coal, at the base of the formation, outcrops along Tenmile Creek between Monongahela River and Clarksville so close to water level that the underlying shale at the top of the Conemaugh formation is below the surface or hidden by the flood plain. From an economic standpoint this coal is the most important member of the formation. In fact, it is more uniform in quality and thickness, and for a given area more valuable than any other bed in the bituminous field of Pennsylvania. The Pittsburg coal occurs in an area 50 miles in length by 50 miles in breadth in the southwest corner of the State. It is found throughout Greene and Washington counties and extends east into Fayette County and north into Allegheny County. It is from 6 to 10 feet thick.

Little is known regarding the character of the coal or section of its bed in the deeper parts of the basin in Greene and Washington counties. Drill records, with three exceptions, attest its presence in all parts of the Waynesburg quadrangle with about the same aggregate thickness that it maintains in outcrop on the edges of the field. The Pittsburg bed lies deep below the surface, but it is only a question of time when it will be reached by shafts. A sandstone about 50 feet thick overlies this coal seam. It is in part rather thin bedded and shaly, and has a dark-gray to brown color, features which do not distinguish it from other sandstones in the region. It is recognized most readily by its geologic position.

Redstone coal.—This bed was first named and described by Prof. H. D. Rogers from a locality near Uniontown, Pa. He assigns to it a thickness of 2 to 3 feet and gives the interval between it and the Pittsburg coal as 50 feet. In the Lemont air shaft, which was sunk in the vicinity of Rogers's type locality, the Redstone bed occurs about 80 feet above the floor of the Pittsburg coal and is 4 feet thick. The coal is closely underlain by the Redstone limestone, which has a thickness of from 11 to 13 feet. This interval of 80 feet and the underlying limestone have been observed in several shafts and diamond-drill holes in Fayette County. Fig. 5 shows the section in the Lemont shaft. Besides the features mentioned above, it is noticed that in this section the Pittsburg sandstone is replaced by shale.

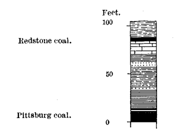


FIG. 5.—Section of Lemont mine shaft near Uniontown, Pa. Scale, 1 inch=100 feet.

In this quadrangle a coal which is from 40 to 70 feet above the Pittsburg bed is seen in occasional outcrops below Clarksville. It shows about half a foot of coal and bituminous shale and is too thin to be of value. This bed, which is commonly supposed to be the Redstone, can not be correlated definitely with the type locality because the interval is considerably lessened and because it can not be said with certainty that there is an underlying limestone on Tenmile Creek.

The well records in Greene County do not show a coal between the Mapletown and Pittsburg coals, and it seems probable that the Redstone has no economic importance in this quadrangle.

Above the Redstone coal are two beds of sandstone separated by a bed of limestone, filling the interval of 50 to 70 feet which intervenes between the Redstone and the next coal above it.

Sewickley (Mapletown) coal.—The Sewickley coal, known in this locality as the Mapletown coal, has its best development in the southeastern portion of Greene County. It is about 120 feet above the Pittsburg coal and underlies a considerable thickness of limestone. Well records in Dunkard Township give various measures for the interval between the Mapletown and Pittsburg coals, the extremes being 91 and 145 feet.

In the Waynesburg quadrangle the Mapletown coal outcrops along Dunkard Creek, passing below water level at the mouth of Meadow Run, where it has a thickness of 5 feet. This coal is seen along Tenmile Creek below Clarksville, where it is from 12 to 22 inches thick. The bed has from one to three thin partings, which detract from its value. It takes its name from the village of Mapletown, in southeastern Greene County, where it has been mined extensively for local use.

Benwood limestone.—The most important member of the Monongahela formation lithologically is the Benwood limestone, which in places attains a thickness of 150 feet, and has its base about 130 feet above the Pittsburg coal. The name is derived from an excellent exposure of this limestone at Benwood, 4 miles south of Wheeling, W. Va. This limestone is commonly known as the Great limestone.

The term Benwood limestone is restricted to the strata occurring between the Mapletown and Uniontown coals. This bed is never solid limestone, being broken up by layers of shale and thin sandstone into two large divisions. The lower division is about 60 feet thick, and is generally composed of alternating bands of limestone and calcareous shale. The limestone beds are usually less than 2 feet thick, although an occasional bed attains three to five times that thickness locally. The upper division of the Benwood limestone is of varying thickness, from 6 to 20 feet, and lies immediately under the Uniontown coal. It is composed of beds a foot or more thick with interstratified thin layers of shale. The lower division is more persistent than the upper and has a larger magnesian content. The analyses which are obtainable indicate that the composition is variable. Certain benches are pure enough for making lime, while others are worthless. The texture varies from very fine to shaly. This limestone has been used in the Monongahela Valley for manufacturing natural cement. The weathered surface of the limestone may be gray, almost white, bluish, or brownish; the fresh stone is dark blue, flesh colored, and drab.

The Benwood limestone is exposed on Meadow Run below Davistown and in the valley of South Fork of Tenmile Creek below Jefferson. Particularly good exposures occur on Castile Run and at the iron bridge across South Fork of Tenmile Creek, 2 miles below Jefferson. The bluff along the river between these two points gives the section of this part of the geologic column and shows the dip of the beds.

Uniontown coal.—At the horizon of the Uniontown coal a small blossom can usually be found in the road. The bed is at the top of the Benwood limestone and 60 to 80 feet below the Waynesburg coal. It seems to be persistent as coal or as bituminous shale, and may be a foot thick in some places. At the west end of the covered bridge over Ruff Creek, near the Childrens Home, about 8 inches of Uniontown coal is exposed in the ditch.

Waynesburg limestone.—The interval between the Uniontown and Waynesburg coals is occupied by sandstone and shales, with a 10-foot bed of limestone 25 feet below the Waynesburg coal. Good exposures of this limestone are seen on the road three-fourths of a mile east of Whiteley post-office, on Braden Run below Kelley's coal bank, and in a number of places between Jefferson and Racine. This bed, which is known as the Waynesburg limestone, is persistent and can be found usually where the road crosses its horizon. It is light colored and fairly heavy bedded.

Above the Waynesburg limestone there is often some shaly sandstone and shale, and the floor of the Waynesburg coal usually rests on shale or fire clay.

Waynesburg coal.—The Waynesburg coal marks the top of the Monongahela formation, and is the highest of the Upper Productive measures. Its outcrop, as shown on the geologic map, extends up the valley of South Fork of Tenmile Creek to within a mile of Waynesburg, up Whiteley Creek to Whiteley village, and along Dunkard Creek and Meadow Run to Davistown.

The Waynesburg coal seam varies in thickness from 5 to 9 feet and is almost universally a double bed. It is divided by a shale parting, which ranges from 3 to 28 inches in thickness. The upper bench of coal is 12 to 36 inches thick, and the lower bench measures from 30 to 48 inches where its lower limit can be seen. The coal is hard and comes out in good-sized lumps, but it frequently contains considerable quantities of sulphur. It is useful for steam and domestic purposes, but the content of sulphur makes it unfit for the manufacture of coke and gas.

Fossils.—The flora of the Monongahela formation is very imperfectly known. According to David White it appears to be characterized by a great abundance of representatives of the types of *Neuropteris scheuchzeri*, and *Neuropteris ovata;* by pecopterids of the large-pinnuled group, and by odontopterids of the type of *Odontopteris brardii.* In this formation the lepidophytes are waning, the genus *Lepidodendron* having nearly disappeared, and the genus *Sigillaria* being represented by the *S. brardii* group. The limestones which fill so much of the interval between the Pittsburg and the Waynesburg coals and which may indicate deep-water conditions, show no marine fossils. The only molluscan forms they contain are a few bivalve crustaceans. The fauna of the whole group seems to be restricted to fresh-water types.

DUNKARD GROUP.

General statement.—Above the Monongahela formation is a series of soft rocks extending from the roof shales of the Waynesburg coal to the topmost beds of the Carboniferous of the Appalachian region. The name of the group is derived from Dunkard Creek, along which the rocks show in outcrop throughout most of its course. It is not known how great the original thickness of this series of rocks may have been.

In the Waynesburg quadrangle the greatest thickness of the Dunkard is about 800 feet. The highest beds are found in the hilltops between Gump and Little Shannon Run, in Perry and Whiteley townships, and on the prominent hill marked by a triangulation station on the eastern boundary of Morris Township.

The Dunkard group contains thick beds of heavy sandstone, a number of thin beds of limestone, and several small coal seams. For the most part, however, it is made up of thin-bedded sandstones and shales. As a whole the rocks are soft and weather easily to considerable depth. For this reason outcrops of the softer beds are limited, and it is extremely difficult to trace any of the higher beds.

For cartographic reasons the Dunkard has been given group value in this folio and is divided into two formations. In Report K of the Second Geological Survey of Pennsylvania Professor Stevenson divided this group into two parts, which he called the Washington County group and the Greene County group, taking the names from the counties in which the rocks are well developed. Unfortunately he defined the base of the "Upper Barren measures" as occurring at the top of the Waynesburg sandstone, and was not consistent in his definition of the dividing line between the two groups named above. This makes it necessary to redefine the limits of the two parts of the Dunkard. To conform with usage which has been general since the publication of Bulletin No. 65 of the United States Geological Survey, the lower part of the Dunkard—Stevenson's Washington County group—is extended to include the Waynesburg sandstone and Cassville shale. The base of his Greene County group is fixed as he sometimes defined it, at the top of the Upper Washington limestone. Stevenson's names are retained after dropping the word county and changing "group" to formation. The two parts of the Dunkard group, therefore, will be described as the Washington and Greene formations. The Washington formation extends from the top of the Waynesburg coal to the top of the Upper Washington limestone. The Greene formation includes all Permian rocks in this area above the Upper Washington limestone.

The division between formations was placed at the top of the Upper Washington limestone because that stratum is the most persistent and easily recognized member of the group. Its horizon is about 400 feet above the Waynesburg coal. The outcrop of this limestone was traced over a large part of this quadrangle, and its elevation was ascertained at numerous points, to determine geologic structure. The limestone occurs near the tops of the ridges, and caps a few isolated hills in the eastern half of the quadrangle. In the western half the syncline and southwestward dip bring the limestone down into the valleys. The rise of the anticline toward the northeast corner has carried the Greene formation so high that it has been eroded. In the vicinity of Davistown, on the flank of the Fayette anticline, it has likewise been removed.

WASHINGTON FORMATION.

The Washington formation includes a number of locally important members, which are described in detail below. The intervals between the members described are occupied by shales, sandstones, and thin beds of limestone. The greatest interval is 180 feet of thin sandstone and shale which is capped by the Jollytown coal. A number of beds of shale are contained within this interval, but outcrops are few on account of the softness of the rocks. Several coal beds are known in the Washington formation, but none of them reach the importance of the coals of the subjacent series. They are too thin or too much broken by partings to be worked until the thicker beds in the Monongahela formation are exhausted.

Cassville shale.—The base of the Washington formation is a bed of shale from 0 to 12 feet thick, which forms the roof of the Waynesburg coal. When this shale is absent, the Waynesburg sandstone rests directly on the coal. This shale always bears fossil plants and is notable for that reason.

Waynesburg sandstone.—This sandstone is a massive bed, from 40 to 70 feet thick, separated into two nearly equal parts by a sandy shale. It is coarse grained, heavy bedded, and shows strong cross-bedding. Its color is usually a dirty gray to buff where massive.

The physical characteristics of the Waynesburg sandstone denote great change in the conditions which had prevailed for a long time previous to its formation. The great thickness of limestone in the Monongahela is evidence of quiet subsidence and slow deposition in a large and deep body of water.

The Waynesburg coal represents a low land area and quiet conditions, which existed until the roof shales were laid down. In the sandstone, however, are evidences of rapid changes. The body of water in which the material settled was shallow and disturbed by strong currents which brought in a vast amount of coarse material.

The sandstone is well exposed just above the coal at Davistown and Whiteley. It can be seen all along South Fork of Tenmile Creek to the mouth of Laurel Run, where it dips rapidly beneath the surface. The plateau at Racine is underlain by this sandstone, and Jefferson is built on it. Bluffs of the rock showing its massive character and cross-bedding may be seen on South Fork of Tenmile Creek at the mouth of Grimes Run and in several places along the creek between this place and Jefferson.

Waynesburg "A" coal.—This is the lowest in the series, and is found 65 to 90 feet above the Waynesburg coal. It is separated from the sandstone described above by a few feet of argillaceous shale. The coal sometimes has a thickness of more than 2 feet, but is seldom of commercial importance. This coal and the Waynesburg "B," which lies 30 feet above it, are persistent though thin. The Waynesburg "B" coal is rarely more than a few inches thick.

Washington coal.—The most conspicuous coal bed, the Washington, occurs about 140 feet above the base of the formation. It has a wide variation in thickness and structure, but is very persistent, and always shows a strong blossom. The bed is so broken by clay parting that its thickness appears to be considerable, but the total amount of coal is small. Sections of this coal, which show a thickness of several feet, are somewhat misleading unless the details are known. For instance, in Buffalo Township, Washington County, the bed has a total thickness of 8 feet, 9 inches, as follows:

Section of Washington coal in Washington County.

	Feet.	Inches.
Coal and shale	0	10
Clay	2	0
Coal and clay	3	1
Clay	0	10
Coal	2	0
Total	8	9

The total of coal is 4 feet, 3 inches; it is of poor quality, containing much sulphur and a great quantity of ash.

In Franklin Township, Greene County, the Washington coal shows two benches, 9 and 5 inches thick, separated by 5 inches of clay. It has no economic value in this quadrangle.

Jollytown coal.—At an elevation of about 375 feet above the Waynesburg coal and on top of a series of sandstones and shales 100 feet thick, which separate it from the Washington coal, is a persistent little member known as the Jollytown coal. Its position is 40 to 50 feet below the Upper Washington limestone, but there is considerable variation in the distance above the Waynesburg coal. The interval is about 300 feet in the northwest part of the quadrangle and 400 in the southeast near Dunkard Creek. The Jollytown coal is important as a horizon marker and guide because it is easily recognized and widely distributed over the quadrangle. In most instances where seen in this area it carries 6 inches to 1 foot of coal and is overlain by iron carbonate nodules. Along Dunkard Creek it is about 20 inches thick and of fair quality. In this region, where other coal beds are not within easy reach, it is of some value. A number of good outcrops can be seen on South Fork of Tenmile Creek above Waynesburg, on Browns Creek, and on Overflowing Run.

The name Jollytown has been used by I. C. White (Bull. U. S. Geol. Survey No. 65, p. 22) for a coal above the limestone he describes as the Upper Washington. In his section on Dunkard Creek he places the Jollytown coal 422 feet above the Waynesburg coal. In this folio the usage of Professor Stevenson, who describes it as being 50 feet below the Upper Washington limestone, is followed.

Jollytown limestone.—Thirty feet above the Jollytown coal and 20 feet below the Upper Washington limestone is a limestone which is exceedingly persistent. It is hard and coarsely brecciated, weathering to dull gray, often tinged with yellow. The surface frequently has a roughened appearance where weathered. Owing to its ability to withstand the weather and to its peculiar surface characteristics it is an important guide in stratigraphy. It is not more than 5 feet thick, but it is so resistant that some trace of it is usually found wherever it has been exposed. Outcrops are numerous. Along South Fork of Tenmile Creek above Waynesburg in particular, and throughout the western half of the quadrangle in general, blocks of the yellow limestone can be found between the Jollytown coal and the Upper Washington limestone.

Upper Washington limestone.—The Upper Washington limestone is by far the most conspicuous and persistent member of the Dunkard group in this quadrangle, and for that reason was chosen as the horizon upon which to subdivide the group into formations. Its position is from 350 to 440 feet above the Waynesburg coal. Where the limestone is known to be present its top, which marks the upper limit of the Washington formation and the base of the Greene formation, is shown on the accompanying maps by a thin black line. Where no outcrops could be found in Whiteley, Perry, and Dunkard townships, the probable horizon of the limestone is indicated on the map by the merging of the patterns of the two formations.

The Bellevernon anticline elevated the rocks so much that the upper part of the Dunkard formation is eroded along the arch from Racine to the middle of Franklin Township. The anticline plunges to the southwest, however, and brings the Dunkard so low that in Wayne Township the Upper Washington limestone outcrops in the bottom of the valleys.

The characteristics of the Upper Washington limestone are so marked in this region that it is easily recognized. In all portions it weathers to a gray-white. This color is in such strong contrast to that of other limestones in this region that it affords a means of certain identification. In case of any doubt the occurrence of the yellow Jollytown limestone at its customary place 20 feet below is conclusive. The Upper Washington limestone in this quadrangle is from 4 to 15 feet thick. It is brittle, rings sharply when struck, and is divided into two or three layers by thin beds of shale. On fresh fracture the rock is blue, almost black, drab, and mottled. Its brittleness and ability to withstand the weather have led to its employment as road metal, and it is often burned for lime.

The greatest thickness of this rock is seen in Washington County. In West Bethlehem Township, just north of the divide at the head of Craynes Run, an excellent exposure was found in the road beside a small run. The limestone is 15 feet 6 inches thick, white on the weathered surface, and mottled gray inside. In the southern part of the quadrangle the bed is thinner, not so white, and outcrops are few.

There is a typical outcrop of the Upper Washington limestone at the road forks on Wisecarver Run 2 miles north of the tin mill at Waynesburg. Also on Purman Run 2 miles north of Waynesburg, the Upper Washington and Jollytown limestones are exposed at the road forks. There are numerous outcrops of this bed along the road up Boyd, Hopkins, and Overflowing runs at an altitude of about 1100 feet, and on the hillsides farther east at greater elevations. The easternmost outcrop in Morgan Township is 2 miles west of Clarksville on a hill 1420 feet high, where the limestone has been quarried 60 feet below the summit. At the head of Dyers Fork, on land owned by Mr. Zimmerman and on S. J. Bradford's farm across the ridge on the south, are good outcrops. In Wayne Township white blocks of Upper Washington limestone outcrop along Roberts Run at elevations of from 1100 to 1150 feet above sea level. An excellent exposure in the road ascending the ridge on the east a mile south of Spraggs shows the usual characteristics. The rocks rise to the east so that a 1400-foot hill near Davistown is lower than the horizon of the limestone. Almost no outcrop of this limestone could be found in the southern half of Whiteley and Perry townships. As a result of deep weathering of the soft sandstones and shales the surface is covered with a mantle of waste that may have hidden the outcrop, but it seems probable that at some places in the southern part of the quadrangle the limestone is absent.

The interval between the Pittsburg coal and the Upper Washington limestone changes from nearly 800 feet at Davistown to 650 feet at Ruff Creek. This is due to a thinning of 50 feet in the Monongahela formation and of 100 feet or more in the Washington formation. Professor Stevenson reported in 1876 that the interval between the limestone and the Washington coal varies from 325 feet on Dunkard Creek to 260 feet on South Fork of Tenmile Creek near Waynesburg and 190 feet on Ruff Creek in the eastern part of Washington Township.

GREENE FORMATION.

Bituminous shale.—Directly above the Upper Washington limestone is a dark shale, more or less bituminous. This shale marks the base of the Greene formation. Often the shale is sufficiently bituminous to show a fracture like that of cannel coal. Under such circumstances it contains bivalve crustaceans and fish scales in abundance, all well preserved. In Washington County there is frequently a little coal a few feet above the limestone, and the shales are without much carbonaceous matter. When such is the case the shales are rich in impressions of leaves and stems.

Sandstone and shale.—In Greene County ferruginous shale occurs above the bituminous shale, but, except within a very small area in Center Township, is so distributed as to be unavailable as ore.

The greater part of the Greene formation in the Waynesburg quadrangle is composed of soft sandstone and shale. These weather so deeply that there are few outcrops in the upper part of the formation. The beds in this part of the geologic column are so variable and so covered by débris that no accurate measurements could be made and only an approximate section can be constructed. Red shale seems to occur frequently in the upper portion of the Greene formation, and about 100 feet above the Upper Washington limestone there is in places considerable fairly heavy sandstone.

In the 400 feet or more of rock which lie between the Upper Washington limestone and the top of the highest hills in the quadrangle there are several small beds of limestone and bituminous shale or coal. The coals are nowhere thick enough to be of value, and because of the softness of the overlying rock are usually covered with débris.

Fossils.—The organic remains of the Dunkard group, according to David White, comprise fossil plants in large numbers and ostracods with occasional occurrences of pelecypods and fish fragments. The flora is characterized by the continuance of the ubiquitous neuropterids noted in the Monongahela; by the presence of a highly varied pecopterid element, some of whose large forms approach, in aspect, the Mesozoic *Cladophlebis;* also by the occurrence of several large obliquely-lobed sphenopterids, and by great quantities of small-leafed *Sphenophylla* of the group represented by *Sphenophyllum filiculum.* Lepidophytes, with the exception of the *Sigillaria brardii* group, appear to have vanished.

Among the plant species having greater value in precise age determination, though often rare in their occurrence, are the following:

Callipteris conferta Sternb.
Callipteris lyratifolia Goepp. var. coriacea (F. & I. C. W.).
Callipteris curretiensis Zeill.
Pecopteris fœminæformis (Schloth.) Sterz. var. diplazioides Zeill.
Pecopteris germari Weiss.
Alethopteris gigas Gutb.
Odontopteris obtusiloba Naum.
Caulopteris gigantea F. & I. C. W.
Equisetites rugosus Schimp.
Sphenophyllum fontaineanum S. A. Miller.
Sphenophyllum tenuifolium F. & I. C. W.
Sigillaria approximata F. & I. C. W.

This flora of the Dunkard is interesting on account of the occurrence of species that are either unique or closely related to forms present in rocks of Mesozoic age. Such are:

Equisetites striatus F. & I. C. W.
Nematophyllum angustum F. & I. C. W.
Pecopteris odontopteroides F. & I. C. W. sp.
Sphenopteris pachypteroides F. & I. C. W.
S. pachynervis F. & I. C. W.
Saportæa grandifolia F. & I. C. W.
Jeanpaulia virginiana F. & I. C. W. sp.
Tæniopteris newberryana F. & I. C. W.

The best localities for making collections of fossils in the Dunkard group are at the type locality, Cassville, W. Va., and on Muddy Creek near Carmichaels, in Greene County, where for nearly half a mile the Cassville shale and Waynesburg coal are finely exposed along the stream.

Below the Washington coal is a sandstone which often bears imperfect leaf impressions and fragments of carbonated vegetable matter. A black carbonaceous shale between the Lower Washington and Washington coals contains bivalve crustaceans and fish scales. This shale is exposed on Purman Run above the covered bridge in the village of Waynesburg.

Parts of the Upper Washington limestone contain bivalve crustaceans. Good specimens can not be obtained because the weathered surface is unsatisfactory and tests are destroyed in breaking the rock. The bituminous shale above the limestone carries some fossils, as mentioned above.

Quaternary System.

PLEISTOCENE DEPOSITS.

CARMICHAELS FORMATION.

The deposits of clay, sand, and gravel made in the valley of the Monongahela during Pleistocene time take their name from the village of Carmichaels, in Greene County. This town is situated in a broad abandoned valley of the Monongahela, which was filled to a depth of 60 feet with gravels and fine silt when a barrier of some sort, probably of ice, obstructed the river at a point 1½ miles below the village and ponded the waters. This is one of the most striking of the numerous abandoned channels along the river.

As the valley was originally occupied by an active stream, the lowest materials in this deposit are always coarse and well rounded. Above this layer of bowlders the deposit is finer, varying with no apparent regularity from gravels to sand and clay. The current passing through the ponded water varied in strength, at times being so strong as to bring in coarse material, and again so weak that finely laminated clay was laid down.

There were several periods at which ponding or retardation of current took place from different causes. In early Pleistocene time, possibly during the Kansan invasion, the river flowed at a higher elevation, and seems to have been ponded so that a deposit of silt was made which mantles valley slopes in some places to an elevation of more than 1060 feet above tide. Whether the valley was filled up to that level, or only a thin layer of silt covered the sides, is not known. The road from Rices Landing to Jefferson crosses a plain, the largest nearly level area in the quadrangle, which is covered with this silt. Here may have been the former outlet of South Fork of Tenmile Creek to the Monongahela. On this plain are places where small quartz pebbles are numerous, and a number of rounded bowlders of hard sandstone, 8 to 12 inches in diameter, were seen. These bowlders are too large to have been rolled to their present position by the currents which carried the fine material on which they lie. South Fork of Tenmile Creek at that time was a small stream flowing on a gently graded floor. It seems likely that these bowlders were carried in by blocks of ice from the Monongahela.

Deposits of clay, sand, and gravel similar in character to those found at Carmichaels and near Rices Landing are seen at various points on the South Fork of Tenmile Creek. The elevation of the rock floor or cut terrace on which these deposits rest is between 960 and 980 feet above tide. These sediments have been mapped at Jefferson, at the bend on Browns Run, between the loops on Ruff Creek, at Waynesburg, and at other points. The rock floor is about 980 feet above tide in the western part of Franklin Township. It rises gently upstream, more slowly than the stream itself, so that terrace deposits and alluvium merge. An excavation for a well near the gristmill at Jefferson showed that the material covering the terrace at that point is an extremely fine, laminated clay. At the brickyard in Waynesburg the rock floor of the old valley, at an elevation of 960 feet above tide, is covered with a thin layer of gravel and several feet of clay on top.

On the road between Jefferson and Waynesburg, a quarter of a mile east of the bridge over Ruff Creek, a cutting in the highway shows a deposit of fine silt containing some well-rounded pebbles. Beyond a doubt this material was dropped here at a time when Ruff Creek flowed at a higher level and a little to the east of its present position. This deposit at an elevation of 960 to 990 feet above tide is a remnant of an extensive filling, like that in Muddy Creek, which extends into Washington Township. The revived stream has cut it all away, except the short stretch at the mouth of Craynes Run.

The rock floor of the larger terrace on the south and west sides of the village of Jefferson is about 950 feet above tide. There is another terrace north and west of the village on both sides of the creek which is at an elevation of 910 feet. The deposits on this lower terrace may be of the same age as those seen between Tenmile Creek and its South Fork at Clarksville at a somewhat lower elevation.

Just south of Clarksville there are river gravels in the highway on a rock floor at an elevation of 820 feet above tide. These are almost too low to correlate with the terrace deposits at Jefferson, and may represent a much later stage of ponding in the main river. During the Wisconsin stage the Allegheny and other rivers flowing from the north were so heavily loaded that they aggraded their channels. This naturally would have raised the mouth of the Monongahela and retarded its flow. These low deposits at Clarksville may owe their origin to this cause.

During the existence of the ice dam below Carmichaels the ponded waters must have extended for some distance up the tributary streams. If this condition existed for any length of time, or was often repeated, deposition must have occurred to an appreciable extent in the side streams. Some of these deposits have been recognized and mapped. If one traverses Muddy Creek or Whiteley Creek from its head toward the mouth, the wide valley bottom appears to be but a normal development of flood plains. If one comes from the east, however, this physiographic feature seems to have a different origin. The deposit in the valley of Muddy Creek to 1½ miles from Khedive is continuous with that which fills the abandoned channel at Carmichaels. The top soil, of course, is true alluvium, but the larger deposit, which gives the narrow valley a broad floor, is Carmichaels clay, and has been mapped as such.

Since the rejuvenation of the drainage, erosion has been very active in removing the soft material deposited in the narrow valleys. Whiteley Creek has succeeded in cutting out the clays as far as the village of Whiteley. For a mile above Whiteley it has cut a trench through them, but from Woods Run to Lanz Run the creek meanders on a broad filling of Carmichaels clay. The width of the valley floor decreases upstream, but it is believed that the flat bottom due to the filling of Carmichaels clay extends up to an elevation of about 1040 feet above tide, which is reached at Cummins on Dyers Fork, and about a mile above Kirby on the main stream. On Dunkard Creek but one small area of terrace deposit remains in this quadrangle at an elevation of 950 to 970 feet above tide. Between this point and the mouth of the creek, in the Masontown quadrangle, there are a few small areas remaining. The stream has cut below them 20 to 60 feet and left only these occasional remnants of the former soft filling of the valley.

RECENT DEPOSITS.

ALLUVIUM.

The valleys of most of the streams in the quadrangle are so narrow that the flood plains are scarcely more than 100 yards wide and are too small to map. Only the larger areas of alluvium are indicated on the areal geology map. The best developments of flood plains are on the inside of the sharp bends of South Fork of Tenmile Creek. The flats just above creek level and a quarter of a mile wide west of Clarksville and southwest of Jefferson are good examples.

It is noticeable that the flood plain of Monongahela River is small in comparison with the size of the stream. It is not so well developed as the flood plains of some of its tributaries. This may be explained by the fact that the wider flood plains of the tributaries survive from a cycle preceding the latest uplift, whereas the river is in a new cycle and is still actively engaged in deepening its channel.

GEOLOGIC HISTORY.[1]

PALEOZOIC ERA.

The sequence of events during Cambrian, Ordovician, and Silurian periods can be inferred only from the character of the rocks in other parts of the country. Such inferences possess little value and will not be undertaken.

Devonian Period.

The account of the geologic history begins, then, with the lowest rocks penetrated by the drill, which are shales and thin interbedded sandstones well down in the Devonian. At the time these rocks were laid down a large part of what is now the continent of North America was covered by water. There was a great inland sea which was bounded on the north by the Archean highlands of Canada and on the east by a land area lying somewhere along the Atlantic slope and apparently crossing New England near its western line. This land extended far to the south, and it seems probable that it reached westward possibly across the lower Mississippi Valley. The great expanse of salt or brackish water in the heart of the United States had access to the open sea, but it did not have a fixed shore line or constant relation to the land for any great length of geologic time.

At the time this history begins the open sea which probably existed throughout most of the Devonian period was receiving great quantities of muddy sediments from land somewhere to the east. These muds were interbedded with layers of sand. This was due probably to slight elevation of the land, which permitted active erosion, or to the reworking of material already deposited. It is possible that different rates of elevation produced the changes from "slate" to "shells."

In the midst of this long-continued deposition of alternating muds and sands, which the deepest well shows to be at least 1362 feet thick, the streams brought to the sea a great quantity of red material, presumably derived from a deeply oxidized land area. These shales and sandstones, prevailingly red in color, which came in toward the close of the Devonian, have a thickness of over 200 feet, as shown by some of the deep wells in this quadrangle. They probably represent the so-called Catskill formation.

The Catskill beds are not to be considered as having been formed in a definite division of geologic time. In northern Pennsylvania there appears to have been a series of oscillations by which at times ordinary marine conditions extended far to the east, and then again red sediments of the Catskill were deposited as far as the western part of the State. The red beds found in the Devonian in this quadrangle are supposed to be the feather edge of beds representing one of these western advances of the conditions which existed through so long an epoch in the eastern part of the State.

After the deposition of this red material the conditions which preceded it were repeated and a succession of sandy sediments was laid down in the sea. The coarser character of the material was due to the shallowness of the sea and the frequent reworkings of the material by the waves, or to the greater elevation of the land and its more active erosion.

Carboniferous Period.

POCONO EPOCH.

Since it is not possible to obtain fossils from the beds which are buried deep below the surface of the Waynesburg quadrangle and are known here only by the records of deep wells drilled for oil and gas, no definite line of separation can be drawn between the Devonian and the Carboniferous. It is believed, however, that the mass of sandstone found in these wells, which has a thickness of 250 or 300 feet and is known as the Pocono sandstone, marks the earlier part of Carboniferous time. The water in which these deposits were spread was for the most part fresh, and the material was derived from the coarse, washed quartzose sediments which had been accumulating in the beaches of the Devonian sea. A tilting of the coastal plain to the west at the beginning of Carboniferous time may have been the cause of the rapid delivery of this sand to the waters of the Appalachian sea. The great variation in thickness of the formation which is found between the Allegheny Front and the central part of the trough of the Appalachian coal field is due to the varying distance from shore.

The Pocono epoch probably was not long, for deposition seems to have been very rapid and accompanied by rapid submergence. Toward the close of this period the changing conditions of deposition produced a calcareous sandstone and introduced a new epoch.

[1] The author has drawn largely on "The Sedimentary Record of Garrett County" in the Maryland Geol. Surv. Rept., by George C. Martin, and on the "Geologic History" in the Latrobe folio of the Geologic Atlas of the United States, by M. R. Campbell, for the material in this section.

MAUCH CHUNK EPOCH.

After the close of Pocono time the sea must have become deeper and clearer, for little or no arenaceous sediments were deposited. Probably the submergence which brought the clear ocean waters into the regions converted the lower courses of the rivers into estuaries in which the coarser part of the land waste was held. The open sea teemed with marine animals, and by the agency of these organisms, aided perhaps by chemical precipitation, beds of limestone accumulated to a thickness of 40 to 80 feet, as represented by the Greenbrier limestone. The period during which this limestone was deposited was of considerable duration and was free from crustal movements.

An elevation of the continent sufficient to quicken erosion and bring the region under discussion within the zone which could receive muddy sediments put an end to the deposition of the Greenbrier limestone. A quantity of mud and sand was brought into the clear marine waters and sandy shales were deposited. The red color of these muds suggests that conditions of Catskill time were repeated. It is supposed that this red material was derived from a deeply oxidized land area in which the material was much like that which to-day prevails in the southern part of the United States.

These sediments thicken greatly toward the east, so it is probable that the land area from which they were derived lay in that direction. The deeply weathered and oxidized soil was swept from the shore westward and carried far out to sea, but the coarser material from the new land area was accumulated in flood-plain and coastal-plain sediments which, after being reworked, were finally deposited under the sea in the next epoch.

POTTSVILLE EPOCH.

The beginning of Pottsville time was marked by the change from deposition of fine oxidized sands and clays to that of much coarser and fresh sands and gravels. The Pottsville formation lies unconformably upon the Mauch Chunk shale. This unconformity is the record of one of the most interesting periods of Appalachian history, so far as it is now known. It records a period of elevation, erosion, and subsequent depression and sedimentation.

Deep wells in the Waynesburg quadrangle show that the Pottsville beneath this area is about 150 feet thick and is composed of two sandstones separated by shale. In the southern anthracite region the formation is 1200 feet thick and composed of sandstone and conglomerate with a number of coal beds, while in Tennessee and Alabama it is more than 5000 feet thick. (David White, Deposition of the Appalachian Pottsville: Bull. Geol. Soc. America, vol. 15, pp. 277.)

Formerly it was supposed that the great difference in thickness of the Pottsville formation in the southern anthracite basin and in the bituminous field of the western part of the State was due to different amounts of material having been supplied to the two areas; in other words, that the thin sections of the western part of the State represent the same epoch of geologic time as the thick sections of the southern anthracite basin. From the work of Mr. David White on the fossil plants (Fossil floras of the Pottsville formation in the southern anthracite field, Pennsylvania: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 751–930), it is now known that in the southern anthracite basin sedimentation was carried on continuously from the close of Mauch Chunk to the beginning of Allegheny time, whereas in the western part of the State the close of the Mauch Chunk epoch was marked by an uplift which raised the main part of the bituminous field above sea level and hence no rocks of corresponding age were deposited. While the field was a land area it must have been subjected to erosion, and probably much of the rock previously laid down was carried away.

After about two-thirds of the formation had been laid down in the eastern trough, the land in northwestern Pennsylvania and Ohio subsided and deposition was resumed in that part of the province. The region along the Allegheny Front, extending westward at least as far as Allegheny River and south for an unknown distance, remained dry land. The most important bed deposited in the newly submerged region is the Sharon conglomerate, which is a prominent feature of the stratigraphy of the Beaver Valley. This bed seems to be absent toward the interior of the basin and is not recognized in the deep wells in this quadrangle.

After the deposition of the Sharon conglomerate and the overlying Sharon coal, the Chestnut Ridge region was depressed and sedimentation was extended entirely across the bituminous field. The Connoquenessing sandstone or Salt sand was deposited in the Waynesburg quadrangle at this time. Thereafter the sequence of events is the same throughout the western part of the State, and the Pottsville formation was completed, after the incursion of a varying amount of muds, by the deposition of the Homewood sandstone over the entire area.

In the interval between the deposition of the Connoquenessing and Homewood sandstones there was a period during which a portion at least of this basin was covered with vegetation and the Mercer coals were laid down. The deep-well records do not indicate their presence beneath this quadrangle nor prove their absence.

ALLEGHENY EPOCH.

The deposition of the Homewood sandstone was succeeded by that of the Allegheny formation. A geologic history of this epoch based on the records of wells in this quadrangle would be incomplete and inaccurate because the drillers give little thought to this part of the geologic column. Some general statements regarding events may be made by inference from the sequence of rocks seen in adjoining territory.

As soon as Pottsville submergence ceased the top of the sand last deposited was covered with a layer of coal. This indicates comparatively quiet, level, and perhaps swampy areas. This coal, the Brookville, if present at all, was now covered with mud and the Clarion coal was laid down. A crustal submergence of broad extent spread the beach and flood-plain sands over the coal marsh and formed the Clarion sandstone. A greater submergence followed, and as a result the region was farther from shore. In this deep water shales were laid down, and then the Vanport (Ferriferous) limestone, which carries a marine fauna. When the shales which include the limestone were built up to water level a rank growth of vegetation developed upon the surface and the Lower Kittanning coal was formed. Whether the formation of coal necessarily means low, marshy land is not yet definitely concluded. The Lower Kittanning marsh, if there was a marsh, included what is now the bituminous coal fields of Ohio, Pennsylvania, Maryland, West Virginia, and probably part of Kentucky. Next followed a slight submergence during which shales and in some places a Middle Kittanning coal were deposited. Rapid sinking brought in abundant sand and filled up the basin, so that another coal, the Upper Kittanning, covered the surface. Accumulations of sand and shale were brought in rapidly and somewhat irregularly when the Upper Kittanning coal sank below water level. The submergence was only moderate and was attended by uplift and increased erosion in the interior. The local occurrence of the Lower Freeport limestone in this interval suggests that these were local deep or quiet places along shore which land detritus did not reach.

The next period of tranquillity, with the basin well filled, is indicated by the Lower Freeport coal. The deposition of this bed probably was less regular in thickness and extent than that of the Lower Kittanning. Variation in amount of submergence and differences in supply of material following the formation of the Lower Freeport coal are shown by the deposits which overlie it. These are in some places shale, and in others sandstone.

A period of quiet succeeded these varying events and deep-water conditions probably existed. Fine sediments were deposited, which consist in some places of limestone, in others of iron carbonate, and in others of fire clay. The Upper Freeport limestone and the Bolivar fire clay were deposited at this time.

Then came widespread uniform conditions favorable for the growth of vegetation, and the Upper Freeport coal was formed. The destruction and burial of this vegetation ended Allegheny time.

CONEMAUGH EPOCH.

The beginning of Conemaugh time is marked by the accumulation of the sands preserved in the Mahoning sandstone. The formation of this thick deposit of sands was brought about by a widespread submergence which carried the Upper Freeport coal below the surface and spread the accumulated sands over the sea bottom. Locally the basin was filled and thin seams of coal were deposited, while in other places subsidence continued for a long time, until the formation reached a thickness of 150 feet of almost continuous sandstone. In general the rest of the Conemaugh consists of shales with occasional heavy beds of sandstone. Coal beds, when present at all, are thin and of small extent. The Ames limestone, which occurs about the middle of this formation, marks another incursion of sea water into this region.

The Morgantown sandstone, which lies above the Ames limestone, indicates a period of marked elevation during which the previously accumulated coastal-plain deposits were transferred into the sea, and the marine and coastal-marsh deposits which had been formed in the time just passed were buried. A series of red shales frequently overlies the Morgantown sandstone and seems to record a period in which a large part of the land lay near base-level. The waste from this deeply oxidized land surface was mostly fine, and filled the sea with mud until another seaward tilting carried in sands and gravels and spread them over the finer deposits. The Connellsville sandstone was deposited during this tilting. There followed a period of submergence and quiet conditions, during which little sand and no gravel passed the shore line. Fine sands alternated with clays and limy muds. Slow sedimentation continued until finally the bottom of the greater part of the basin was brought near water level and the Conemaugh epoch ended.

MONONGAHELA EPOCH.

The Pittsburg coal at the base of the Monongahela formation is the lowest rock exposed in the Waynesburg quadrangle. The geologic history after the deposition of the Pittsburg coal can be inferred from the rocks seen within this area.

At the close of Conemaugh time the Appalachian basin was a level area. Remarkable uniformity in conditions and long duration of rank vegetable growth resulted in the formation of the Pittsburg coal over this broad, level area. Such changes as took place—for example, the interruption of the deposition of carbonaceous material by an influx of mud—likewise extended over wide areas. A widespread submergence put an end to the vegetable growth and covered the Pittsburg coal with shale. An elevation of the land areas brought in material to form the Pittsburg sandstone, but the water soon became clear enough for limestone to form. The limestone is thin and is overlain by Redstone coal.

After the growth and deposition of the Redstone coal vegetation the land sunk, more limestone was deposited, and mud and sand filled up the basin and formed the surface on which the Sewickley vegetation grew. Again there was submergence and for a long time limestone, with a few shales, was deposited, until a thickness of 150 feet had accumulated. Immediately on top of this limestone lies the Uniontown coal. It seems unnecessary to assume very deep water conditions for the accumulation of this lime. The freedom from admixture with land waste suggests that the area in which it was formed was some distance from shore, or that base-level conditions had been reached on shore and very little detritus was being brought to the basin.

After the deposition of the Uniontown coal there was further submergence and shale and sandstone were laid down. Then the water cleared, possibly becoming deeper, and the Waynesburg limestone was formed. After the deposition of more shale the waters became shallow and conditions favored the growth of another covering of vegetation. In this shallow water the Waynesburg coal was deposited. The final interruption of vegetable growth and burial of this swampy area ended Monongahela time.

DUNKARD EPOCH.

The crustal movement which submerged the Waynesburg coal was slight at first and discharged only fine sediments into the basin. After the coal had been buried by several feet of mud, the submergence became more marked and a considerable quantity of sand, which had accumulated on the coastal plain, was washed off shore and spread over the bottom of the basin. The Waynesburg sandstone dates from this time. Toward the top it becomes shaly and is overlain by the Waynesburg "A" coal, showing that the basin had filled again until a surface was formed on which vegetation could develop.

The formation of the Waynesburg "A" coal was interrupted by a gentle submergence which made the waters muddy and deposited a few feet of shale. When the waters became clear limestone formed, but frequent tilting and elevation or depression of the surface characterize this period. Thin coal beds, local in extent, were formed, only to be submerged and buried after a short period.

The Upper Washington limestone, which is about 400 feet above the Waynesburg coal, marks a time when the water in the basin was clear. This limestone has been found only in part of the Waynesburg quadrangle and is limited in extent. Above it there are several hundred feet of rocks which are mostly sandstone and shale, but which contain occasional thin limestones and coals. Sedimentation probably continued until the Appalachian gulf was finally filled. This ended the Paleozoic sedimentary record in this part of the world.

APPALACHIAN REVOLUTION

Since the deposition of the Paleozoic beds here mentioned the region has been subjected to crustal movements which produced great folds in the rocks. These movements were induced by compressive strains. The strain was most severe along the eastern side of the Greater Appalachian Valley, and the rocks were not only thrown into great folds but the pressure was so great that cleavage was induced and in many cases the rocks were completely metamorphosed. Westward from this zone to the Allegheny Front the strain was less severe and the folds were of smaller magnitude. In a measure the Appalachian coal basin seems to have acted as a bulwark against which the rocks were crushed. The folding continued, however, across the basin, but with greatly decreased effect. Some of these low folds are seen in the anticlines and synclines of the Waynesburg quadrangle.

MESOZOIC ERA.

The Appalachian region has been a land area during all of Mesozoic and Cenozoic time. It received no sediment, but was subjected to uplift, folding, and erosion. The final result of the folding is shown in the present geologic structure. The uplift and erosion are evidenced only by the topographic forms. So much erosion has taken place, however, since the close of the Mesozoic era that it is doubtful whether any of the surface forms produced at that time are still recognizable. There are topographic forms in this region which seem to bear some traces of the Mesozoic surface, and which suggest the more important geologic changes that have occurred. The oldest topographic record is supposed to be represented by the even-crested ridges of the central part of the State and by the anticlinal ridges in the bituminous coal field. It is thought that the summits of the ridges once formed part of the surface of an extended peneplain which was produced by subaerial erosion during Cretaceous time. The peneplanation is supposed to have been so extensive as to reduce almost all of the surface to a fairly common level regardless of the character of the underlying rocks. Such a cycle of erosion demands an extremely long period of time, and it is probable that its formation occupied much of the Cretaceous period. From its extensive development in the highlands of northern New Jersey it has been named by Davis the Schooley peneplain.

After its formation, during which the land was brought down to near sea level, the gently undulating surface was elevated and the streams at once proceeded to dissect it. It is not certain that any of the original surface remains, but from the fairly constant altitude of the ridges it is probable either that their summits were once at the surface of this plain or that they have been reduced only slightly below it.

There are no traces of this peneplain itself in the topography of the Waynesburg quadrangle. If the plain be projected across the quadrangle from the areas on the east which seem to represent it, its probable altitude in this part of Greene County would be from 1600 to 1800 feet above sea level, which is considerably higher than any of the hills in the quadrangle.

CENOZOIC ERA.

Tertiary Period.

Following the period of long-continued erosion during which the Schooley peneplain was produced, this region was uplifted not less than 800 feet, and again the crust of the earth remained stationary long enough for the somewhat softer rocks west of Chestnut Ridge to be reduced to a common level. This surface is now represented by the hilltops, which stand at an altitude of from 1200 to 1300 feet above sea level, and is called the Harrisburg peneplain (M. R. Campbell, The geographic development of northern Pennsylvania and southern New York: Bull. Geol. Soc. America, vol. 14, pp. 277–296), from its development about the capitol of the State. Possible remnants of this peneplain are seen in the northeast corner of the Waynesburg quadrangle at an altitude of about 1250 feet.

The date of origin of this surface is not known with certainty. Evidently it is later than the Schooley peneplain and earlier than some of the features which seem to mark the closing stages of the Tertiary period. For these reasons it is provisionally referred to early Tertiary time, and probably to the Eocene.

After the formation of the Harrisburg peneplain the surface was again raised, and again dissection began to destroy the evidence of the existence of a plain. The succeeding stages of development are not well enough marked in the Waynesburg quadrangle to warrant discussion. There are the merest traces of a surface about 100 feet below the Harrisburg peneplain, which may indicate another pause in the movement of the earth's crust and the production of a generally level surface in favorable localities. These traces consist of flat-topped spurs at an elevation of about 1150 feet along the main drainage lines in the eastern part of the quadrangle. The surface formed during this pause is well developed in the Allegheny Valley and is called the Kittanning peneplain (Charles Butts, Kittanning folio, No. 115). Its date of origin can not be assigned definitely, but was probably in the later portion of Tertiary time.

The development of the Kittanning peneplain was interrupted by another elevation of the earth's crust and renewed dissection by the streams. During subsequent short pauses in crustal movement the streams broadened their valleys somewhat, as illustrated by the terraces at Jefferson, and after each period of quiescence the region was again elevated and deeper channels were cut. Peculiar conditions which existed possibly in late Tertiary time and ended in early Pleistocene ponded the main streams, and deposits of land waste were laid down over the valley floors. There is nothing to indicate that the downcutting of channels has not been comparatively continuous since that date.

MINERAL RESOURCES.

COAL.

Coal is the most important mineral resource of the Waynesburg quadrangle. Although the output is small at present, the time may come when the great Pittsburg seam which underlies the entire quadrangle will be reached by shafts and mined on a large scale. In this particular district the coal is worked less now than formerly; not for any lack of it, but because of the abundant production of natural gas.

Of the numerous coal beds outcropping in the Waynesburg quadrangle, three are of workable thickness, the Pittsburg, Mapletown, and Waynesburg. The outcrop lines of the Pittsburg and Waynesburg beds are shown on the geologic maps. The outcrop of the Mapletown coal is shown in part. The geologic structure has been described already, and the position of the Pittsburg coal is shown on the structure and economic geology map by 50-foot contour lines. The importance of an accurate representation of the lay of the coal is understood when it is considered that, for advantageous working of a mine, drifting should be carried up the slope. A mine entry should be so located with relation to the dip of the bed that all mine water will drain out naturally and loaded cars will have a down grade. When a coal mine is worked from a shaft the bottom of the shaft should be at the lowest point on the body of coal to be taken out. From the structure contours drawn on the Pittsburg seam in this quadrangle may be determined the direction in which drifts should be driven from the bottom of any shaft which may be sunk to the coal, in order to get natural drainage to the sump and a favorable grade for moving coal toward the shaft.

In the discussion which follows a few detailed sections of coal beds and some other facts have been taken from previous reports. Special acknowledgment is due to Professor Stevenson for the data thus obtained. The coal beds will be described in order beginning with the lowest.

PITTSBURG COAL.

The most valuable bed of bituminous coal in southwestern Pennsylvania is the Pittsburg. It is well known for its excellent qualities as a first-class steam, gas, and coking coal. Much of this coal bed, as originally laid down, has been removed by erosion, but it still underlies 2000 square miles in this part of the State. Fig. 7, on the illustration sheet, shows its areal extent and also the location of the Waynesburg quadrangle with reference to the Pittsburg coal field. From this map it will be seen that the Waynesburg quadrangle is well within this great coal field.

The Pittsburg coal in this quadrangle does not outcrop for a distance greater than 2 miles, showing only at water level on Tenmile Creek below Clarksville. Well records show that the bed is present throughout the quadrangle. On the outcrop it can be developed by drifting, but through the larger part of the quadrangle it is deeply buried and can be reached only by shafts. It is 500 feet below creek level at Waynesburg, 650 feet at Ruff Creek, 550 feet at Sycamore, 500 feet at Cummins, and 850 feet at Castile. The method of determining the depth of this bed by reading the structure map is explained under the heading "Structure."

Of its quality as a steaming and domestic coal nothing need be said, for it is widely and favorably known. It is a high producer of illuminating gas, containing sometimes 36 to 38 per cent of volatile combustible matter. For the manufacture of coke the Pittsburg has few if any equals in the United States.

The average of a large number of analyses of the coal of the Connellsville basin 20 miles east of this quadrangle, made by H. C. Frick Coke Company, is as follows:

Average of several analyses of Pittsburg coal.

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

Although no shafts or diamond drills have been sunk to this coal where it lies deep below the surface, away from Monongahela River, it is known that the bed is present and has a considerable thickness throughout the quadrangle. It is safe to assume that its quality is good also.

As measured on the outcrop the thickness of the Pittsburg coal in this region is as stated in the following table.

Thickness of the Pittsburg coal.

	Section 1, Monongahela.		Section 2, Tenmile.	
	Feet.	Inches.	Feet.	Inches.
Shale with coal	1	0	0	0
Coal	1	2	1	6
Clay	0	10	1	1
Coal	7	0	6	7
Total	10	0	9	2

The Dilworth Coal Company mines the Pittsburg coal at Rices Landing by means of a shaft 168 feet deep. The bed is below the level of the river. A section furnished by Mr. James Black, the general superintendent, (section 3, coal-section sheet) is as follows:

Section of Pittsburg coal at Rices Landing.

	Feet.	Inches.
Roof coal	0	10
Main clay	0	10
Breast coal	4	2
Bearing-in coal	0	4
Brick and bottom coal	3	4
Total	9	6

The bearing-in coal is poor, but the rest is good and is marketed in Pittsburg. The roof coal is not taken down. At this point the Pittsburg bed is overlain by 3 feet of shale and 66 feet of sandstone. The Sewickley and Redstone coals were not recognized in the shaft.

Two or three small mines on the Pittsburg coal are operated on Tenmile Creek below Clarksville. One at the mouth of Dog Hollow, owned by Mr. Corbett, is said to have produced 75,000 to 100,000 bushels annually. The entry is on the outcrop, but the dip is such that considerable difficulty is experienced with water. Another mine on the south side of the creek is owned by the John Eddy Coal Company of Buffalo and is leased to Mr. David N. Malone. The entry is at the end of the iron bridge over Tenmile Creek, and the coal is reached by a descent of 10 to 15 feet. Water accumulating in the mine is removed by syphon. Mr. Malone mined from 15,000 to 20,000 bushels of coal in 1902. The demand has fallen off during recent years because of the development of the Clarksville gas field. The coal in the mines is nearly 7 feet thick, but the bottom foot of coal carries an excessive amount of sulphur.

The records of three deep wells in the Waynesburg quadrangle do not show the Pittsburg coal. The first of these was sunk by the Waynesburg Gas Company at the mouth of Purman Run (26) in the village of Waynesburg in 1885. (Numbers in parentheses refer to well locations on the structure and economic geology map.) The horizon of the Pittsburg coal is covered in the record (John F. Carll, Ann. Rept. [Second] Geol. Survey of Pennsylvania for 1886, pt. 2, p. 772) by the entry "Slate..90 feet." In eight wells within a radius of half a mile the coal was found.

The second well is at the head of Grimes Run near where the Franklin, Morgan, and Washington township lines join on the Amos Day farm. The Day well (15) was drilled by Mr. A. P. Troutman in 1900 for the Carnegie Natural Gas Company. He reported "Pittsburg coal..none." The Mapletown coal was found at the proper horizon. Within a mile to the south six wells struck the Pittsburg coal.

The third well in which the Pittsburg coal was not recognized is also in Franklin Township. It was drilled by the Carnegie Natural Gas Company on the farm of Mr. H. C. Wood 2½ miles south of Waynesburg and half a mile east of Smith Creek (39). The Waynesburg and Mapletown coals were recorded by the contractor, Mr. Tim Ross, but he reported the Pittsburg as absent. The nearest wells are on the Bell and Hoge farms, distance 1¼ miles in opposite direction; the records of these two wells show the Pittsburg coal at the proper horizon.

In has been observed along Monongahela River, where the Pittsburg coal is exposed at the surface, that in some places the overlying sandstone attains a very massive character and for short distances cuts out the upper bench of the coal. Where contemporaneous erosion was particularly effective the main bench of the coal also is largely or wholly removed and replaced by sandstone. Such occurrences in coal seams are known as "horsebacks." Their shape may be that of a basin or of a channel, but they are usually not of great extent.

It seems probable that these three wells have encountered the horizon of the Pittsburg seam at points where the coal is cut out by horsebacks. If the Pittsburg coal is absent, which is not proved, the areas are small, as shown by the evidence of wells near by.

REDSTONE COAL.

There are some places where the Redstone coal is of workable thickness. The bed as a whole is thin and not very persistent. Near Masontown it has a thickness of more than 3 feet, but in the Buffington shaft near New Salem and in the Dilworth shaft at Rices Landing no trace of it is reported.

In the Waynesburg quadrangle the Redstone coal reaches the surface on Tenmile Creek below Clarksville and on Monongahela River. It shows a blossom in the road at an elevation of 40 to 70 feet above the Pittsburg coal, and seems to be composed of less than a foot of coal and carbonaceous shale. It is too thin to be of value.

SEWICKLEY (MAPLETOWN) COAL.

A bed of coal generally known throughout western Pennsylvania as the Sewickley has a limited outcrop in this quadrangle. It is mined extensively at Mapletown, Greene County, and for that reason is known locally as the Mapletown coal. Since this term is the only one used by well drillers in Greene County to designate the coal seam found about 100 feet above the Pittsburg coal, and is better known among all classes than Sewickley, it is used here in preference to the older term, but not with the intention of supplanting the latter.

At Mapletown the coal seam is 5 to 6 feet in thickness, with 2 to 3 inches of shale near the middle of the bed. It is a free-burning coal that is much prized as a domestic fuel. In fact, by some it is considered superior to the Pittsburg. Its composition at the type locality and on Dunkard Creek is as follows:

Analyses of Mapletown coal at Mapletown and on Dunkard Creek.

	Mapletown.	Dunkard Creek.
	Per cent.	Per cent.
Water	1.500	1.790
Volatile matter	30.428	35.400
Fixed carbon	55.038	56.818
Sulphur	1.406	1.152
Ash	11.628	4.840

Analysis No. 1 was made by S. A. Ford from a sample of the upper bench taken at an opening near the level of Whiteley Creek, 1 mile from Mapletown, Greene County; and No. 2 by D. McCreath from a sample of the coal on Dunkard Creek near the West Virginia line. (Second Geol. Survey Pennsylvania, Rept. K, p. 379.)

The horizon of the Mapletown coal is from 90 to 130 feet above the Pittsburg. It appears at the surface in this quadrangle on Dunkard Creek below Meadow Run and on South Fork of Tenmile Creek below Castile Run. In the southeastern part of the quadrangle the bed is thick enough to mine, showing over 5 feet of clean coal of excellent quality. At Davistown it commands the same price as the Waynesburg and is preferred by some, but the latter coal is used more because it is mined nearer the village.

The openings on the Mapletown coal along Dunkard Creek within the boundaries of this territory were not in condition for measuring a section at the time that locality was visited. Professor Stevenson published his measurements made at the mouth of Meadow Run, where the coal has been mined at water level.

Mapletown coal on Dunkard Creek (section 4).

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

This is a little thinner than at the type locality at Mapletown, where the total thickness of the bed is 5 feet 3½ inches, including 2½ inches of clay parting near the middle of the bed.

On Tenmile Creek the Mapletown bed is much thinner, measuring from 18 to 22 inches, (section 5 on the coal-section sheet), and is not worked because the Waynesburg and Pittsburg seams supply the demand.

In deep wells the presence of this coal throughout the quadrangle is recognized.

UNIONTOWN COAL.

A small coal seam known as the Uniontown lies about 275 feet above the Pittsburg and 80 feet below the Waynesburg coal, and is supposed to be persistent over a considerable area. Although seen in a number of places on South Fork of Tenmile Creek and on Dunkard Creek, it can not be asserted that this coal occurs throughout the quadrangle because the bed is deeply buried everywhere but on these two streams. It is too thin to be recognized by drillers and is not noted in any well records. The small coal bloom seen occasionally in the road gave no opportunity to get the details of the bed, which probably carries 8 inches of coal. At the time of the previous survey of this region this bed was worked on a limited scale on Pumpkin Run, in Cumberland Township. The bed section at this opening is given as follows:

Uniontown coal in Cumberland Township.

	Feet.	Inches.
Coal	1	6
Sandstone	10	0
Coal	1	0

Under present conditions so thin a coal seam as the two combined is not of commercial importance.

WAYNESBURG COAL.

This bed reaches its greatest development in Greene County, and takes its name from a town in this quadrangle. The total thickness of the bed is frequently 6 feet or more, but it is so broken by clay partings and the coal is often so impure that mining is expensive. Usually the coal is overlain by shale, and underlain by shale or fire clay.

The Waynesburg bed yields a hard block coal which has little or no coking value. It is frequently worthless from the high percentage of ash and sulphur. Its average composition is about 50 per cent fixed carbon, from 32 to 36 per cent volatile matter, 1.3 to 3 per cent sulphur, and 11 to 13.5 per cent ash.

Four analyses of this coal published by a previous survey (Second Geol. Survey Pennsylvania, Rept. MM, p. 6) represent fairly well the variations in its composition. The analyses and localities are as follows:

Analyses of Waynesburg coal.

	I.	II.	III.	IV.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	1.265	1.175	1.180	1.235
Volatile matter	34.685	35.615	32.344	36.185
Fixed carbon	49.590	49.725	51.582	46.723
Sulphur	1.270	2.280	1.306	2.972
Ash	13.190	11.205	13.588	12.885
	100.000	100.000	100.000	100.000
Coke	66.315	63.210	66.476	62.580

I. G. C. Sayres, below Waynesburg, Franklin Township.
II. L. L. Minor, near Jefferson, Jefferson Township.
III. A. Groom, near Carmichaels, Cumberland Township.
IV. U. Lippincott, on Ruff Creek, Morgan Township.

The most extensive outcrop of this coal in the Waynesburg quadrangle is along the arch of the Bellevernon anticline. The bed is lifted so high by this arch that it is exposed in the hills along Monongahela River, and is cut away by Tenmile Creek so that it shows at the surface on both sides of South Fork of Tenmile Creek as far as the mouth of Laurel Run. Here the western limb of the anticline carries it rapidly below the surface.

The Waynesburg coal is 200 to 350 feet above the creek on the hillsides below Clarksville, but upstream it dips gradually until it passes under South Fork of Tenmile Creek in the little village of Dodysburg, a mile east of Waynesburg. An inclined shaft was sunk upon it at Dodysburg many years ago, and reached the coal at a depth of 58 feet. It was never worked much, however, on account of water coming in from the creek.

When this area was surveyed by the Second Geological Survey of Pennsylvania, in 1876, the Waynesburg coal was worked extensively to supply local demand. At Jefferson a score of openings in the bluff back of the college grounds produced over 100,000 bushels annually a generation ago. It was estimated that Waynesburg consumed more than 500,000 bushels annually. In recent years, however, the development of a gas field in the immediate vicinity of the village and the production of an immense amount of cheaper fuel has cut off the demand for coal almost entirely. As a result many of the coal banks have been abandoned for years and are now inaccessible. A very few are operated through the winter, and not more than six are worked all the year round to supply rural demand. The usual price of this coal is 3 to 4 cents a bushel at the mine.

Although many old openings have been abandoned so long that they are completely closed, the places where measurements of the bed can be made are sufficiently numerous to furnish data at comparatively short intervals. At present the interior of the bed is most easily reached at tne Fowler, Grandon, and Greene banks on South Fork of Tenmile Creek, the Kelly bank on Braden Run, Burk bank on Ruff Creek, Porter bank on Laurel Run, the Minor and Ross banks at Whiteley, and the Bowermaster bank at Davistown.

The average of 22 measurements made in the eastern part of Greene County, where the bed reaches its best development, is as follows:

Average section of Waynesburg coal.

	Feet.	Inches.
Coal	2	0
Clay	1	2½
Coal	3	0
Total	6	2½

In some openings the bed shows three benches of coal instead of two, with clay partings varying greatly in thickness. Where three benches are recognized neither the coals nor the partings have any constancy in thickness.

The variations in the Waynesburg coal are well illustrated on the coal section sheet, where the sections are arranged to show changes in the coal from the northeast corner to the southern boundary of the quadrangle. The bed where exposed near Burson schoolhouse (section 7) shows three benches of coal, but in the hillside south of Clarksville (section 8) only two benches appear, the upper bench being free from clay bands, while the shale on top of the lower bench reaches its extreme development of 2 feet. North of Clarksville the lower bench of coal increases locally to 4 feet in section 9, and to 5 feet in section 11, while a variation from these sections is shown in section 10. In the latter section a sandstone roof 9 feet or more thick is present, while in section 11, which represents the greatest known thickness (10 feet) of the Waynesburg coal, 8 feet of shale intervene between the top of the coal and the Waynesburg sandstone. The output from this latter bank has been small since the development of the Clarksville gas field. Further variations are shown in section 12 and section 13, the upper bench showing an unusual and local thickness (3 feet) in the second case.

On a little run about a mile below Jefferson the Second Geological Survey of Pennsylvania found a number of openings worked by Mr. John Rex and obtained comparative measurements in five entries. These are published to show the changes in the bed within a few rods, and the breaking of the upper bed of section 12 by a clay parting several inches thick.

Waynesburg coal 1 mile east of Jefferson.

	Section 14.		Section 15.		Section 16.		Section 17.		Section 18.	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Coal	0	9	0	10	0	8	0	11	1	3
Clay	0	3	0	2	0	3	0	2	0	6
Coal	1	11	2	0	1	4	1	11	1	7
Clay	0	8½	0	6	2	2	1	5	1	5
Coal	2	11	2	6	2	10	2	11	2	3
Totals	6	6½	6	0	7	3	7	4	7	0

The overlying shale usually contains streaks of coal. The upper bench of coal consists of alternating bands of coal and shale, each one-half to 1 inch thick, and is not worked. The middle bench is hard and slaty, and contains much pyrite, while the bottom bench is only a fair coal.

The section (19) from one of the abandoned openings in the ravine back of Jefferson College shows all three benches of coal, overlain by a bed of shale and clay containing thin carbonaceous streaks. Here the upper bench, 9 inches thick, is bony, but the middle and lower benches are of good quality.

A mile west of Jefferson, in the bank on Browns Run, owned by Simeon Fowler, the coal is in two benches (section 20), the upper one 30 inches thick and the lower one 33 to 39 inches thick. The parting between these two benches is 13 inches of shale. The coal of the upper bench is preferred for domestic use. It is divided by a parting which occurs irregularly and is in places 5 inches thick. Mr. Fowler and his son work this mine the year round and produce about 25,000 bushels. In the Grandon bank (section 21) the bed of coal is separated from the overlying massive Waynesburg sandstone by 10 feet of fossiliferous shales. The bank is operated only through the winter. In 1901 it produced about 9000 bushels. The character of the coal between Braden Run and Ruff Creek is shown in section 22. At the mouth of Grimes Run the upper bench of the coal is 15 inches, the parting 19 to 20 inches, and the lower bench 3 feet or more thick. The bed has been opened on both sides of the run, but the openings are now abandoned. The coal shows in the run at the first fork in the road. Its character opposite the mouth of Grimes Run is shown in section 23.

The coal is mined by Mr. U. L. Green at the mouth of Grimes Run (section 24). This is one of the largest banks on this seam in the Waynesburg quadrangle, producing 25,000 bushels annually, and is the only one where a horse is used for tramming. The coal comes out in large chunks and presents a good appearance. After a few days exposure to the weather, however, the presence of a high percentage of sulphur shows itself. The coal is free burning and contains much ash. Where the road crosses the creek 2 miles east of Waynesburg, at the pump station, the coal has been worked on both sides of the stream. Measurements made by an earlier Survey (Second Geol. Survey Pennsylvania, Rept. K., p. 148) of two openings here, are as follows:

Section 2 miles east of Waynesburg (section 25).

	Feet.	Inches.	Feet.	Inches.
Bituminous shale	0	0	0	8
Coal	1	6	1	8
Clay	1	3	1	3
Coal	3	8	3	5
Total	6	5	7	0

These are average sections and do not represent conditions which continue for more than short distances in the banks. The upper coal bench may be not more than 1 foot thick in some places; the thickness of both the clay parting and the bottom coal varies from 1 foot to 4 feet. On Braden Run (section 26) the upper bench is a little thicker than at the pump station and thinner than in the Grandon bank, while the lower bench remains nearly the same.

A coal bank on Ruff Creek half a mile below Lippincott supplies fuel to those in the vicinity who do not use natural gas. It is owned by Mr. Will Burk and has an output at present of 35,000 to 40,000 bushels a year. The section (27) was obtained in an abandoned bank under the sandstone bluff at the south end of the village of Lippincott, where the coal goes under the creek.

The westernmost bank of the Waynesburg coal seam which is worked at present is that of Mr. Porter on Laurel Run. A local irregularity in the dip carries the coal under the run, so that the outcrop here is cut off from that on the creek. The output of this bank varies from 25,000 to 40,000 bushels a year. The section here and at Lippincott does not differ materially from the average conditions in other banks in the vicinity. All of the banks show rolls or horsebacks of shale and clay which cut out the coal locally and produce variations in the section.

The Waynesburg coal outcrops along Whiteley Creek as far as the western end of Whiteley village, where it dips gradually below the surface. There are no gas wells in this vicinity and the coal bed is worked to supply fuel for local use. In the bank operated by Mr. Charles Ross, 1 mile east of the village, the coal is 5 feet thick with little or no parting. The output of this bank is 20,000 bushels annually. Sections 28 and 29 show the character of the coal seam in this vicinity.

At Davistown the Waynesburg has been mined somewhat extensively for local use (sections 30 and 31), and sections were obtained by an earlier survey (op. cit., p. 99) at the opening back of the old steam mill. The measurements are only 15 feet apart and exhibit imperfectly the variations. The top bench is well defined throughout the tunnels, and is always of poor quality. The others yield good coal, which, for domestic purposes, rivals the Mapletown at the mouth of Meadow Run.

The Waynesburg coal is worked by Mr. J. B. Bowermaster in a bank above the Valley House (sections 32, 33). The annual output of this mine is about 5000 bushels. The bed dips rapidly to the west and goes under the run half a mile above Davistown.

This coal is opened in several places along Dunkard Creek where it crosses the boundary of the quadrangle, but no sections were obtained.

WAYNESBURG "A" COAL.

This coal bed is persistent throughout Greene County and usually its blossom can be seen in the highway 80 feet above the Waynesburg coal. In the valley of Castile Run its thickness is 16 inches (section 34); in Franklin and Greene townships, 18 inches, and in Cumberland Township it reaches 2 feet (section 35). This coal has a local development on Muddy Run above Carmichaels in the Masontown quadrangle, where a thickness of 3 feet 6 inches induced some one to mine it.

The Waynesburg "B" coal and the Little Washington are thick enough in this quadrangle to form small blossoms in the road, but are too thin to be thought of as a fuel supply. The Waynesburg "B" is about 1 foot thick on Smith Creek (section 36).

WASHINGTON COAL.

This coal is found 140 to 180 feet above the Waynesburg and is seen frequently throughout the quadrangle. It always shows a strong blossom, but the total amount of coal is only a fractional part of the bed. Although this bed is of workable thickness in some parts of Washington County, it does not exceed 18 inches or 2 feet in Greene County and is so broken by clay partings as to be valueless.

In the village of Waynesburg, near the first bridge over Purman Run, the Washington coal is exposed, and the following section was obtained by the Second Geological Survey of Pennsylvania:

Washington coal at Waynesburg (section 37).

	Feet.	Inches.
Coal	0	8
Clay	0	5
Coal	1	3
Total	2	4

Not more than 5 inches of this lower bench is good coal. There are several exposures of the same bed on the Smith Creek road a mile south of Waynesburg station and on Whiteley Creek at the mouth of Frosty Run. The latter is largely black shale, but on Smith Creek the section is as follows:

Washington coal on Smith Creek (section 38).

	Feet.	Inches.
Coal	0	9
Clay	0	5
Coal	0	5
Total	1	7

NATURAL GAS.

GAS DEVELOPMENTS IN GREENE COUNTY.

Drilling for gas in Greene County was begun, so far as records show, at Waynesburg in 1885. In that year a well was sunk by the Waynesburg Gas Company on the north bank of Tenmile Creek at the mouth of Purman Run (26), in the village of Waynesburg, Franklin Township. (Numbers in parentheses refer to well locations on the structure and economic geology map.) The record of this well was published in the Annual Report of the [Second] Geological Survey of Pennsylvania for 1886, pt. 2, p. 172. This well, although favorably located, was not successful, for while drilling in a promising sand with a show of oil at a depth of 2745 feet the cable parted; the drillers were unable to regain the tools and the hole was abandoned. Subsequent drilling in the immediate vicinity shows that if the well had been sunk a few feet deeper a strong flow of gas would, without doubt, have been struck. As it was, several years passed before gas was found in paying quantities in this territory.

Five fields are now known which are located wholly or partly in the Waynesburg quadrangle; they bear the names Clarksville, Zollarsville, Waynesburg, Kneisley, and Roberts Run. The term "field" as used here means a group of producing wells, and does not imply that outside of the field the territory is unproductive. It is probable that within a few years the territory lying between some of these groups of wells will be drilled and found to be productive, and the fields thereby become merged into one large field along the Bellevernon anticline. The positions of these five fields are shown by the locations of the wells on the structure and economic geology map. The relation of these areas to the oil and gas fields of the northern Appalachian region is shown on the illustration sheet, fig. 7.

RELATION TO STRUCTURE.

The relation between the structure of the rocks and the occurrence of gas and oil in the Appalachian field has long been recognized. It has been discovered that gas is most likely to be found well up the flanks or along the axes of anticlines, while oil is generally associated with the flanks of synclines or is found at points on the anticlines where the dip decreases and what might be called structural terraces are formed. Wells drilled in the bottom of synclinal troughs often prove to be dry holes or produce salt water. The relations of liquids and gases to geologic structure are explained by a natural distribution according to gravity which takes place between the loosely fitting particles of sand which make up the reservoir rocks. According to the theory of the accumulation of gas and oil in a folded bed of sandstone which is capped by an impervious cover and is permeated by gas, oil, and water, the heavier water would tend to seek the low-lying troughs of the synclines, while the oil would rest on top of the water, ascending the flanks of the synclines, and the still lighter gas would tend to seek the arches of the anticlines.

The occurrence of gas in the Waynesburg quadrangle conforms in a general way to this theory of accumulation. It is noticeable, from the arrangement of the gas wells shown on the structure and economic geology map with relation to the structure contour lines, that by far the larger number of gas wells are located along the Bellevernon anticline. In a number of cases wells drilled near the synclinal axes have proved unproductive.

GEOLOGIC AGE OF THE GAS SANDS.

Gas in paying quantities has been found at several geologic horizons in the Waynesburg quadrangle. The first important gas sand in this region, commonly known as the Big Injun, is a massive sand at the base of the Carboniferous and is part of the Pocono formation. The other gas sands, from the Thirty-foot to the Elizabeth, are all Devonian.

In this connection the following note should be made concerning the correlation of sands. From the proximity of the fields and the constancy of the intervals between the recognizable rock horizons, it is supposed that the same bed of sandstone which is known as the Fifth sand, for instance, in the Waynesburg field is also the Fifth sand in the Kneisley and Clarksville fields. While the familiar names of gas sands used by the drillers are serviceable, they indicate only approximate geologic position instead of actual identity of sand. It can not be proved that the gas-bearing sands which are given the same name in different fields are continuous beds. In fact, the manner in which heavy sandstone beds showing at the surface sometimes thin out and are replaced by shales or rocks of other character makes it possible that the same conditions exist in the deeper-lying sandstones, and that these gas reservoirs may be large lenses of sandstone rather than continuous beds throughout all the fields here described.

DESCRIPTION OF OIL- AND GAS-BEARING SANDS.

Introduction.—The logs of most of the wells in this territory have been obtained and studied, and measurements in about 100 of them have been compiled and the averages determined in order to construct a generalized section for the region. The Pittsburg coal, which underlies the entire county, is several feet thick and easily recognized, so the drillers use it as a starting point in figuring the depth at which the producing sands will be found. This coal varies in depth from 10 to 1060 feet below the well mouth, according to the location of the well. The intervals between the coal and the tops of eleven well-known sands are shown in the foregoing table, together with the number of well records from which the average of each was computed.

Distances from Pittsburg coal to the gas sands in Waynesburg quadrangle.

From Pittsburg coal to top of—	Number of wells.	Maximum.	Minimum.	Average.
		Feet.	*Feet.*	*Feet.*
Dunkard sand	18	575	425	475
Gas sand	20	856	674	765
Salt sand	32	1035	860	932
Big Injun sand	86	1305	1148	1228
Thirty-foot sand	19	1845	1744	1795
Gantz sand	43	1965	1813	1916
Fifty-foot sand	53	2044	1902	1937
Gordon sand	58	2224	2040	2147
Fourth sand	43	2298	2140	2230
Fifth sand	63	2392	2258	2313
Bayard sand	62	2464	2388	2433

Dunkard oil sand.—A sandstone which is found more than 425 and less than 575 feet below the Pittsburg coal is known as the Dunkard oil sand. The name is taken from Dunkard Creek, near the mouth of which an oil pool was found in 1861. It is this sand which produces oil in the Whiteley Creek field at Willow Tree, and which gave a small showing of oil in a number of wells in this quadrangle.

Gas sand.—The first sand rock which is commonly recognized by the drillers and watched for in order to determine the horizon, is what is known as the Gas sand. Its position varies considerably according to the different drillers, and it seems probable that there may be a number of sandstones at this horizon, any one of which may be taken to be the Gas sand. Its thickness ranges from 15 to 140 feet, the variations being due in part to undoubted changes in the amount of sandstone present at this horizon and in some instances to a tendency on the part of the driller to class everything as sandstone for a considerable distance, when in reality it may be much broken by shale beds.

Salt sand.—This sand is about 932 feet below the Pittsburg coal and, according to the records in hand, varies in thickness from 15 to 175 feet. A small quantity of gas is occasionally encountered in this sand. It should be noted that the Salt sand lies above the Big Injun sand, while in Armstrong County the same name is used for a gas-bearing stratum below the Big Injun.

Big Injun sand.—A sand rock always recognized by the drillers from its thickness and position is the Big Injun, the top of which is about 1225 feet below the Pittsburg coal and the thickness of which is usually from 250 to 300 feet. This average depth is very close to the actual depths of the Big Injun sandstone in Franklin Township. The interval varies, however, from 1275 feet in Dunkard and Perry townships to 1182 feet in Morris Township. In other words, the interval is nearly 100 feet greater in the southeastern part of the quadrangle than it is in the northwestern part.

The Big Injun sand produces oil in the Mount Morris field, Dunkard Township, and it is commonly expected to contain more or less gas wherever it is drilled through. This sand was named the "Big Injun" by some driller in Washington County, Pa., on account of its thickness and hardness.

Thirty-foot sand.—The first sand below the Big Injun which is recognized at all commonly in Greene County is know as the Thirty-foot. Its average distance below the Pittsburg coal is 1795 feet. It is not productive anywhere in this locality so far as known, nor does its name mean much as to its thickness, for in that particular, records show variations from 20 to 60 feet. The horizon of the Thirty-foot is not the same as in Armstrong County, but probably corresponds with what is sometimes known there as the Gas, Butler, or Murrysville sand. Somewhere between the Thirty-foot and the Big Injun there is an occasional development of a sandstone which has been recognized and recorded in a few logs as the Squaw sand. Its presence beneath this territory, however, is not well enough known to be affirmed.

Gantz and Fifty-foot sands.—At an average distance of 1916 feet below the Pittsburg coal in the Waynesburg quadrangle the Gantz sand is struck. This sand takes its name from a well on the Gantz farm, Franklin Township, Washington County, which was drilled in 1885, and was the first paying oil well in the county. The sand was found 1827 feet below the Pittsburg coal, its depth below the Pittsburg coal being less than in the eastern half of Greene County because of the disappearance of the Mauch Chunk red shale toward the northwest.

The Gantz sand is usually 15 to 25 feet thick and produces both gas and oil. It is closely underlain by the Fifty-foot sand, so that the two are frequently recorded as continuous. It is very probable that the shale between them becomes thin in some localities or gives way to shaly sandstone. In some cases the driller records a thickness of 60 to 100 feet for one of the sands and makes no mention of the other. The horizon of these sands is occupied in Armstrong and other counties by a heavy continuous deposit known as the Hundred-foot sand, a term which is little used in Greene County. The Fifty-foot sand produces gas in some fields.

Gordon sand.—A sand which occasionally produces a small amount of gas, and lies at an average distance of 2147 feet below the Pittsburg coal, has a thickness of 15 to 50 feet, and is usually recorded in wells which reach this depth. The Gordon sand is named from the farm near Washington, Washington County, where it was discovered in August, 1885.

Fourth sand.—Another sand which produces only a small amount of gas is the Fourth sand. Its top is at an average distance of 2230 feet below the Pittsburg coal, and its thickness is variously regarded as from 7 to 70 feet. The presence of the Fourth sand is noted almost as frequently as that of the Gordon, which indicates something of its persistence.

Fifth sand.—The great gas producers of the group of sands which are known in Greene County are the Fifth and Bayard sands. By far the larger number of wells in the quadrangle, except those in Dunkard and Morris townships, are sunk to one or both of these horizons. The Fifth sand is at an average distance of 2313 feet below the Pittsburg coal, and, according to various records, ranges in thickness from 10 to 65 feet. A study of the relation of the Fifth sand to the Big Injun and Pittsburg coal was given under the heading "Rocks not exposed."

Bayard sand.—Gas is found more frequently in paying quantities in the Bayard than in any other sand in this field. The distance from the top of the Fifth to the top of the Bayard sand in 60 wells averages 120 feet. The depth of the Bayard below the Pittsburg coal varies from 2388 to 2464 feet, and averages 2433 feet. The thickness of the Bayard sand seems to vary considerably. In a few wells which have passed completely through the sand, it is from 3 to 12 feet, while in other wells, which stopped when the gas was struck and did not go to the bottom of the sand, it is 20 to 30 feet. The Bayard is also known by some drillers as the Sixth sand. The name Bayard was introduced in gas-sand nomenclature in February, 1895, when a successful well (41) was completed on the Thomas Bayard farm, Whiteley Township, Greene County.

Elizabeth sand.—This term is applied to a sand which carries some gas and is found at depths ranging from 100 to 175 feet below the top of the Bayard. Its thickness, as recorded in three wells, is not more than 7 feet. Probably the number of holes sunk to this sand in the eastern half of Greene County is less than 10.

DESCRIPTION OF GAS FIELDS.

Clarksville field.—Twenty or more wells on the Bellevernon anticline between Racine and Jefferson constitute the Clarksville field. These have been drilled by the Carnegie Natural Gas Company, the Philadelphia Company, and the Monongahela Natural Gas Company. The first well in the field was completed on the Aaron Degood farm (11) in July, 1895. Gas is found in 6 of the sands, but the Gantz and Bayard are the largest producers.

The plunge of the Bellevernon axis is shown by the difference in elevation of the Pittsburg coal in the Allen well (9) in East Bethlehem and the Orr well (13) in Morgan Township. These wells are both near the crest of the fold, but the Pittsburg coal in the Orr well is 140 feet lower than in the Allen well. In the Horner well No. 1 (10) a coal seam was found 630 feet below the Pittsburg coal. This probably is the Upper Freeport coal, and is one of the few records of its existence in this region.

Zollarsville field.—The hamlet of Zollarsville, in the Amity quadrangle, gives its name to a belt of gas wells which crosses Tenmile Creek near the mouth of Plum Creek. Nine or ten wells in this belt are in the Waynesburg quadrangle, the southernmost being in Castile Run. This field is on the flank of the Bellevernon anticline west of the Clarksville field and parallel with it. The intervening territory is supposed to be, and probably is, good gas ground, and is being held in reserve by the companies which have it under lease. The Pittsburg coal is about 550 feet above sea level in this group of wells, or 150 feet lower than at Clarksville.

Gas in this part of the Zollarsville field is found mostly in the Fifty-foot and Bayard sands, although the Big Injun and Fifth sands often produce light flows. A show of oil is reported in the Dunkard sand in the John Bennett well No. 1 (8).

Waynesburg field.—The Waynesburg field includes about 75 wells in and around the town of Waynesburg, and extends from Ruff Creek, in Morgan Township, to the western part of Whiteley Township. Most of the wells are in the northern half of Franklin Township, and within 4 miles of town. Probably the first producing well drilled in this field is the Grimes well (19), which was put down in April, 1889. This well is located on the Grimes farm, on Grimes Run 1½ miles above its mouth and 2 miles northeast of Waynesburg. It is 2900 feet deep and is still yielding a small amount of gas. A well drilled on the Robert A. Sayers farm (section F on the columnar section sheet) in February, 1889, at the site of the Carnegie Gas Company's pump station 2 miles east of Waynesburg, reached a depth of 2675 feet without producing gas in paying quantity. The records of the Grimes and Sayers wells were published by the Second Geological Survey of Pennsylvania in Vol. I5, pp. 312–313.

A portion of this district is sometimes spoken of as the Bayard field, taking its name from the well (41) on the Thomas Bayard farm, where the Sixth or Bayard sand was discovered in February, 1895, at a depth of 2400 feet below the Pittsburg coal. This sand is the largest producer in the Waynesburg field. It is found 2461 feet below the Pittsburg coal in the Conger well (20), on Overflowing Run, showing an increased interval to the west. For the field the average interval between the Pittsburg coal and the Bayard sand is 2435 feet.

Active drilling in the immediate vicinity of Waynesburg followed the discovery of gas on the E. M. Sayer farm (35), just west of the Waynesburg and Washington Railroad station. This well was sunk in the flood plain of the creek and reached the Bayard sand at a depth of 2945 feet below the surface. It was completed in March, 1900.

Many of the wells in this field get small quantities of gas in the Big Injun, Gantz, Gordon, and Fifth sands. Producing wells are obtained in the area extending from the crest of the Bellevernon anticline almost to the bottom of the next syncline on the west. Exploitation of the field continues at the present writing.

The following is the record of a well owned by the Fort Pitt Gas Company, on the land of Mrs. H. P. Slauterback in Dodysburg, 1½ miles east of Waynesburg and near the center of the field. The well mouth is about 40 feet above the outcrop of the Waynesburg coal. Depths given are from the well mouth to the bottom of the sands.

Slauterback well (29), near Waynesburg, Greene County.

	Thickness in feet.	Depth in feet.
Pittsburg coal	..	395
Dunkard sand	16	840
Gas sand	30	1261
Salt sand	24	1380
Red rock	..	1525
Lime	..	1580
Big Injun	280	1895
Squaw sand	30	2015
Thirty-foot	120	2315
Gordon sand	25	2565
Fourth sand	31	2680
Fifth sand	20	2725
Stray sand	10	2750
Bayard sand	22	2845
Bottom		2854

Kneisley field.—Eight or ten wells in the immediate vicinity of Kneisley schoolhouse are within the Waynesburg quadrangle. This group is located in Wayne Township 8 miles southwest from Waynesburg, at the head of Pursley Creek, and 2½ miles due west of Gump. These wells have been drilled since the summer of 1902 by the Carnegie, Philadelphia, and Western Pennsylvania gas companies.

All of the wells in this field were completed in the Fifth sand with a good flow of gas except the Cornelison (53), which was dry in the Fifth sand, but struck a good flow of gas in the Bayard sand. The Guthrie No. 1 (52) showed a gas pressure of 810 pounds in ten minutes and a rock pressure of 865 pounds. The Arthur Hoy well (54) was completed at a depth of 3493 feet, with a big flow of gas from the Fifth sand. This field is on the western flank of the Bellevernon anticline and in it the Pittsburg coal is at an elevation of 400 feet above sea level.

Roberts Run field.—On Roberts Run, between Spraggs and Blacksville, eight or ten wells have been drilled. All seem to be near the anticlinal axis, but the fold is low, disappearing to the south. About half of the wells here produced strong flows of gas when they were completed, while others were so weak that they were abandoned. A number of companies have been engaged in the attempt to develop a field in this region, some looking for gas and others for oil, but without marked success. A small quanity of oil was found in a well on the H. M. Spragg farm (56) in the Big Injun sand.

Miscellaneous wells.—In the Waynesburg syncline, which forms the western base of the Bellevernon anticline, a number of wells have been drilled with some success. The Allison (16), Closser (C), and Tim Ross (4) wells, in Washington Township, yielded fair flows of gas. The Hoge (3), Stillwell (5), and Shape (6) wells, however, were practically dry. The Shape well at Castile struck salt water in the Big Injun, and the Wisecarver well (17) on Wisecarver Run was a failure for the same reason; salt water in the Bayard sand rose 1200 feet in the hole in three hours.

Wildcatting in the Whiteley syncline brought in good flows of gas on the Molesey (48), Bell (44), and W. S. Scott (42) farms, and wells sunk on the Eaton (46), Haver (47), and C. M. Scott (45) farms were not absolutely dry. The Elizabeth Stephens well (49) on Dyers Fork about 1 mile above Whiteley Creek had enough gas to fire one boiler, while the Josephus Bowers well (H) near the mouth of Lanz Run was dry.

Pipe lines.—The gas from the fields in this area is carried by pipe lines to Pittsburg, where it is used largely by manufactories for steaming and heating purposes and by the city in general for heating and lighting. Gas is used for heating, lighting, and cooking at Waynesburg and on many farms which are near producing wells.

The Carnegie Natural Gas Company has a pump station 2 miles east of Waynesburg which draws from wells in the Waynesburg field and from two 10-inch lines; one of these lines extends to Mount Morris and the other enters Greene County 3 miles west of Blacksville. The gas is sent toward Pittsburg from this station through a 12-inch and a 16-inch pipe line.

The Philadelphia Company has a 16-inch line extending across the county from northeast to southwest; a 10-inch line from Blacksville to Waynesburg; two or three lines to the Waynesburg field, and a second 16-inch line from Waynesburg northeast toward Pittsburg.

The Peoples Natural Gas Company has lately completed a 20-inch line which enters Greene County at Dent, 3½ miles west of Blacksville, passes 4 miles east of Waynesburg, and goes out of the county near Zollarsville.

The Manufacturers' Light and Heat Company takes gas from the field south of Waynesburg through a 16-inch line, and the Fort Pitt Gas Company has a 12-inch line which crosses the county from a point 4½ miles east of Blacksville to Zollarsville, and carries gas to Pittsburg.

OIL.

Early history in Greene County.—The earliest development of an oil field in Greene County probably was on Dunkard Creek, about 2½ or 3 miles above its mouth, at a place known as Bobtown, where oil was found in the Dunkard sand 450 feet below the Pittsburg coal. The operations in this field extended from 1860 to 1864.

In 1885–6, E. M. Hukill, of Pittsburg, drilled a series of holes along a line extending southward from Rices Landing through Greene County, and discovered oil at Willow Tree and Mount Morris. A small pool known as the Whiteley Creek field was developed at Willow Tree and is still producing about 80 barrels of oil a day. The well at Mount Morris was the first drilled in what is now the large and well-known Mannington–Mount Morris field.

The development of the first oil pool within the Waynesburg quadrangle—the extension of the Mount Morris field north of Dunkard Creek—took place in the nineties. The second and only other oil field in the quadrangle is the Fonner field, in Morris Township.

The relation of oil to geologic structure and the stratigraphy of the sands in which both oil and gas occur are discussed under the heading "Natural gas."

Mannington–Mount Morris field.—The oil field which terminates in Dunkard Township between Glade Run and Bowen Fork, three-quarters of a mile west of Davistown, is the northern extension of the great Mannington–Mount Morris pool. This pool is marked by a continuous line of producing wells from a point about 6 miles southwest of Mannington, W. Va., to Dunkard Creek, a distance of 35 miles. It lies on the western limb of the Fayette anticline.

The development of the Mount Morris field dates from October 21, 1886, when Mr. E. M. Hukill got a 20-barrel well in the Big Injun sand. This well was located on the D. L. Donley farm, on Morris Run, half a mile southeast of Mount Morris, in Perry Township, Greene County. In 1887 the tools were put in again and the well was drilled to the deep sands, without increasing the production, however. In November of that year the lower part of the hole was plugged and a torpedo exploded in the Big Injun with satisfactory results. By this time operations were extending rapidly to the northeast and southwest.

The Dunkard Oil and Gas Company was organized in 1892 and developed the pool in Perry and Dunkard townships. The pool is about 1000 feet wide and 2 miles long, and very rich. Wells drilled east of the oil belt and higher up on the flank of the Fayette anticline produce gas.

Oil in this pool is found in the Big Injun sand, which is a part of the Pocono formation. The records of 13 wells in Dunkard Township, most of them within this quadrangle, show that the first pay streak is 1367 to 1392 feet below the Pittsburg coal, or about 100 feet below the top of the Big Injun. The average distance between the coal and the oil horizon in the 13 wells is 1377 feet.

A system of pipe line controlled by the Standard Oil Company transports the product of the field to the seaboard. Pump stations are located at Mount Morris, Dolls Run, Jakes Run, Fairview, and Mannington. These stations pump the oil to a central station on Monongahela River 2 miles above Morgantown, W. Va. It is estimated that the present daily output of that portion of the field lying north of the State line is 1000 barrels.

Fonner field.—The Fonner oil field is in the eastern part of Morris Township, Greene County, and crosses the extreme northwest corner of the Waynesburg quadrangle. It extends north into the Amity quadrangle, and in Washington County is known as the Dunns Station field. A portion of the field is in the Rogersville quadrangle and comprises the wells on and near the Shoup farm. The wells in this field are located on the Amity anticline, which crosses the corner of the quadrangle with a northeast-southwest strike.

Oil was discovered in this field in March, 1897, in a well drilled on the farm of William Fonner (1). This first well produced 1800 barrels a day for a short time and then declined. A number of wells were drilled in 1898–99 to the Gantz sand, which yields the oil. The average depth of the oil-bearing sand below the Pittsburg coal, as shown by the records of 7 wells which produced oil, is 1943 feet. The Pittsburg coal (reported in Fonner No. 5 (2) to be 7 feet thick) is 400 to 450 feet above sea level in this field, and the elevations of the well mouths vary from 1180 to 1500 feet above tide. This gives a variation in the depth of the Gantz sand from 2680 to nearly 3000 feet, depending on the location of the well.

A number of dry holes were struck in territory immediately adjoining productive wells. There were 10 producing wells in the Fonner field in February, 1903, with a total daily production of about 50 barrels. The oil is pumped into small tanks and transported by the South West Pennsylvania Pipe Lines to storage tanks at Meadow Lands, Washington County, Pa.

Miscellaneous wells.—A number of wells in various parts of the quadrangle have encountered oil in small amounts. Among these are the Molesey well (48) 1½ miles east of Jefferson, which obtained some oil from the Dunkard sand. This well was sunk to the Elizabeth sand, which proved to be a good gas producer. The Ellen Ross well (D) on Ruff Creek, five-eights of a mile above Ruff Creek post-office, obtained about 1 barrel of oil daily from the Gantz sand. The flow of gas in this well was weak. A well on the land of E. M. Sayers (35) at Waynesburg got a showing of oil in the Fifth sand. Oil was found also in small quantity in the H. M. Spragg well (56), Roberts Run, Wayne Township. In this case it was in the Big Injun sand. None of these wells yielded enough to pay for pumping.

STONE.

Sandstone.—Building stone of fair quality is quarried at Waynesburg, in the bluff opposite the terminus of the Waynesburg and Washington Railroad, and in three or four places on Smith Creek. The position of the stone is above the Washington coal. It is massive, coarse grained, has good color, and dresses easily. This stone is used largely for foundations and other rough work.

The Waynesburg sandstone is abundant in parts of this territory, forming precipitous, low bluffs along the creeks above the Waynesburg coal. The stone is variable in quality, being durable in some localities, while in others its friability seems to increase on exposure. When massive and compact this sandstone is suitable for rough work. No quarrying is done except for local needs.

The Pittsburg sandstone outcrops on Tenmile Creek below Clarksville and is suited for rough work. It is not quarried for building purposes. The power house of the Dilworth Coal Company at Rices Landing was built with this stone taken from the shaft while sinking.

Limestone.—Various limestones in the Monongahela and Dunkard formations are quarried in this region and burned for use as a fertilizer. The Benwood limestone, which is the most important limestone in the Monongahela Valley, is available south of Davistown and on Tenmile Creek below Jefferson. Nearly all of its beds are good enough for this use, but only a few yield a lime suitable for building.

The following analyses in the reports of the Second Geological Survey of Pennsylvania (K, p. 388, and MM, p. 285) show the variable composition of the limestone:

Analyses of Benwood limestone from Washington County.

	I.	II.	III.	IV.
Insoluble residue	13.300	22.520	15.750	14.920
Calcium carbonate	68.837	48.823	47.080	47.750
Magnesium carbonate	14.649	20.621	28.528	30.943
Ferrous carbonate	3.306	3.625	7.511	5.608
Alumina		3.523		
Sulphur	.097	.203	.069	.126
Phosphorus	.049	.051	.127	.015

I. One mile north of Cannonsburg; upper layer; very hard and compact, like conglomerate; bluish gray.
II. One mile north of Cannonsburg; middle layer; compact, structure somewhat shaly; bluish gray.
III. One mile north of Cannonsburg; lower layer; hard, compact, unctuous; pearl gray.
IV. Property of Dr. Shaner, 8 miles from Washington, Somerset Township.

These analyses show that at that locality there is a greater proportion of magnesia in the lower portion of the limestone, but as no analyses from other localities are available it can not be stated, nor is it safe to assume, that this composition is generally characteristic of the limestone. The limestone has been used in the past for the manufacture of natural cement, but on account of the very high percentage of magnesia and of the somewhat too great proportion of insoluble residue, to alumina plus iron, it is not suitable for Portland cement.

The Waynesburg limestone, which is found from 20 to 40 feet below the Waynesburg coal, makes a strong, dark lime. It is exposed and readily accessible in a number of places in the quadrangle. Among these may be mentioned Braden Run a few hundred feet downstream from Kelly's coal bank; Browns Run near Fowler's coal bank; along South Fork of Tenmile Creek near the covered bridge 1 mile southwest of Jefferson; on the road from Clarksville to Castile Run, going over the hills; on Whiteley Creek three-quarters of a mile east of Whiteley; and in the hollow three-quarters of a mile east of the mouth of Glade Run.

The Jollytown limestone is usually considered to be worthless, but the Upper Washington limestone, which is 20 feet above it, has some value. The Upper Washington is widely distributed throughout the quadrangle and is readily recognized by its white, weathered surface. It varies in this part of Greene County from 4 to 15 feet in thickness, and has been burned in many places for enriching the soil. The dark or middle portion is said to give a fine, white lime which is clear enough for inside work. The position of the Upper Washington limestone, where present, is shown on the map by the thin black line which indicates the boundary between the Washington and Greene formations.

BRICK-MAKING MATERIAL.

Two classes of material suitable for making brick are abundant in this territory. These are clay and shale, both of which are of sedimentary origin, and are composed of fine-textured, more or less decomposed rock fragments.

Clay.—In this quadrangle there are residual surface clays and deposits on the stream terraces. These are low grade and fairly abundant. Terrace clays are stripped at Waynesburg and made into red building brick. There are good clays at Jefferson, but they have not been exploited. A very finely laminated clay was seen in a well dug near the gristmill at the south end of the village. The general development of the region has not yet demanded the utilization of these brick clays, and it is probable that these deposits will not be used to any extent for brick making until this region is traversed by a railroad.

A church was built in 1902 about a mile west of Khedive, on Muddy Creek, from clay dug and made into brick on the spot.

Shale.—Fine-textured and homogeneous deposits of shale are of widespread occurrence in the Dunkard group, and outcrop over a large part of the area under discussion. These shales are not utilized, but they seem to offer a field worthy of investigation. Homogeneous deposits of fine-textured, moderately fusible, and fairly plastic clay shales are valuable, not only for the manufacture of building brick, but for making paving brick and for many other uses to which clay is applied. In connection with limestone, suitable deposits of shale are a possible source of crude material for the manufacture of cement.

IRON ORE.

Iron concretions occur frequently in certain shale beds in the Waynesburg quadrangle. In no case are they in sufficient abundance to be of value. Professor Stevenson has the following to say on this subject in his report on Greene County, published in 1876:

> Nodular ore occurs in moderate quantity in the shales underlying the Waynesburg coal, in Greene County. At one time this was digged in several localities in Morgan Township, and taken to the old furnace at Clarksville. But the undertaking was not profitable, and it was abandoned many years ago. The ore is in small quantity, and is distributed throughout a considerable mass of argillaceous shale. It seems to be quite persistent.
>
> Ore occurs in small quantity in the black shale representing the Little Washington coal, in Greene County. Analysis is given in the general report of the laboratory work of Mr. M'Creath. On Smith's Creek, near Waynesburg, an ore is found in moderate quantity immediately above the Washington coal, of which a specimen yields as follows, on analysis:
>
> | | Per cent. |
> |---|---|
> | Metallic iron | 37.400 |
> | Sulphur | .278 |
> | Phosphorus | .285 |
> | Insoluble residue | 9.950 |

At a number of places in the quadrangle iron concretions were seen above the Jollytown coal, but they are never abundant enough to be mined.

WATER.

The Waynesburg quadrangle is well supplied with water. Creeks and runs are numerous and make flowing water readily accessible. None of them carry sufficient water in summer time, however, to furnish much water power, and at present there are no dams across any of the streams. Springs and shallow wells are the source of water for domestic use.

The springs, which are comparatively abundant in this region, come from various formations. The Upper Washington limestone is a frequent water producer, and springs from it are numerous in Franklin and Washington townships. It is believed that the Waynesburg sandstone, which overlies the Waynesburg coal and often has a thickness of 40 feet, is usually a water-bearing rock. The wells sunk into it produce water of excellent quality.

Waynesburg, which has a population of 3500 or more people, derives its water supply from South Fork of Tenmile Creek at the western end of the village. The water is taken from the stream above the tin mill, which is a source of considerable pollution. It is pumped to a reservoir on a hill north of the village at an elevation of 250 feet above the main street. As the creek carries a large amount of silt after every heavy rain, the supply is often muddy, although it passes through a sand filter before reaching the reservoir. For days at a time the water drawn from faucets is so heavily charged with sediment as to be almost useless. There seems, however, to be no other adequate supply within the immediate vicinity of the village. The proposition to drill deep wells has been considered, but never tried by the village authorities. Most of the people in Waynesburg drink water from shallow wells. In some instances a well sunk from 17 to 30 feet will reach bed rock and furnish a constant supply of fairly pure, hard water.

The Waynesburg Cold Storage Company drilled an 8-inch well 134 feet deep at its plant in the village in March, 1901. This well struck water in the Waynesburg sandstone and yields a supply which has never been exhausted. Although the pump raises 75 barrels an hour, there is always about 90 feet of water in the hole. The water is soft and is used for the manufacture of ice.

Water for the village supply can probably be obtained in moderate quantities by drilling wells in the immediate vicinity of the village to the Waynesburg sandstone. Practically all of the wells drilled for gas near Waynesburg have yielded potable water at this horizon in what seemed to be inexhaustible quantities. This sandstone is approximately 35 feet thick, is overlain and underlain by relatively impervious shale, and forms a reservoir capable of holding a large amount of water. This bed receives water at its outcrop along Tenmile Creek and its tributaries east of the village, and dips west, so that near the mills it is about 200 feet below the creek. There are promising localities for artesian water in the synclinal areas where sandstone outcrops on adjacent anticlines.

The second largest village in the quadrangle is Jefferson, which has a population of 310. It is located on a terrace deposit of clays and gravels, and obtains its water supply from wells sunk from 20 to 60 feet through this material to bed rock. The supply is sufficient, and but few of the wells have been known to go dry except during a protracted drought. The water is hard.

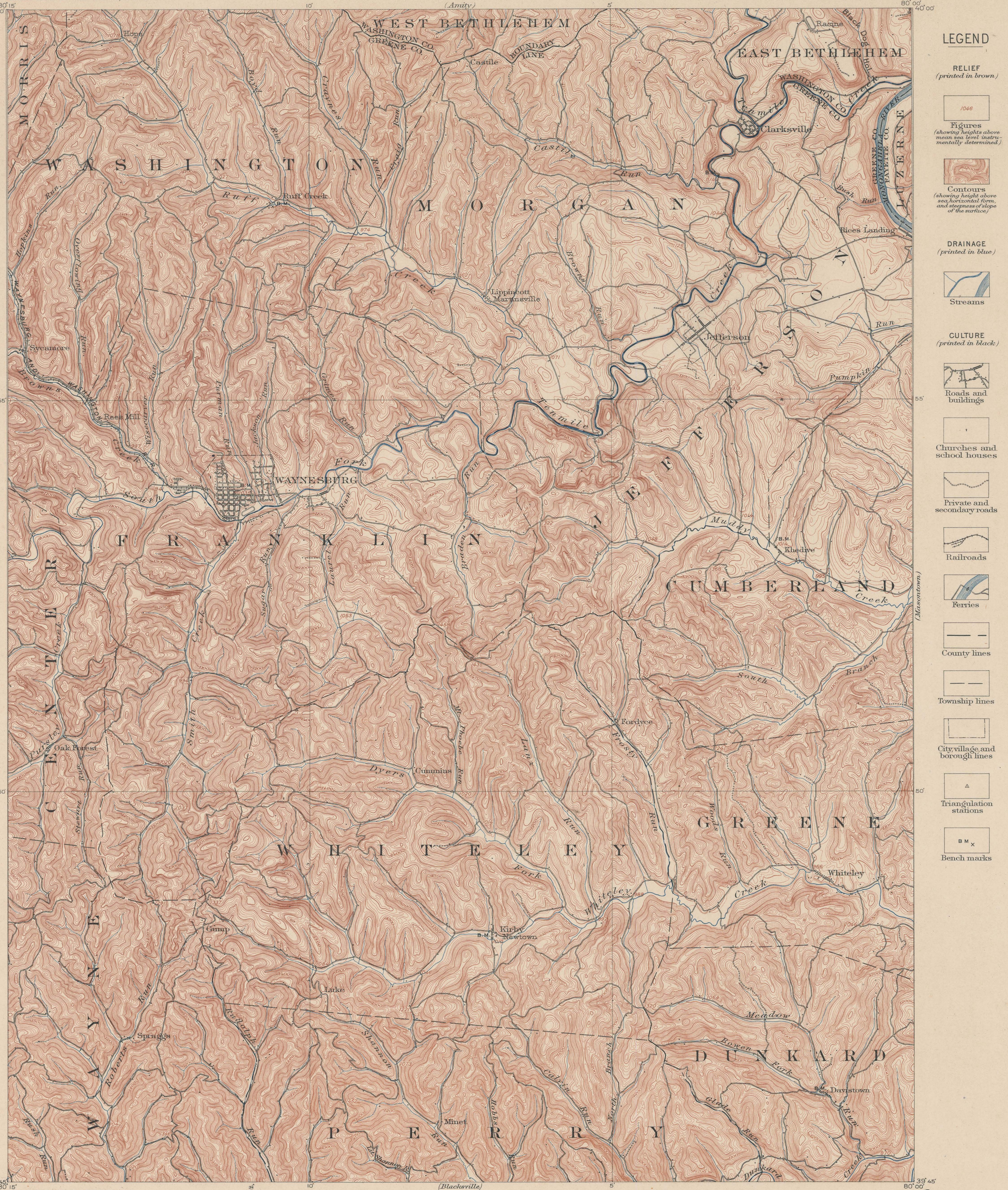
In all of the other villages, which have populations varying from 250 down to 25, the water supply is obtained from private wells which are from 15 to 50 feet deep.

May, 1904.

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

TOPOGRAPHY

PENNSYLVANIA
WAYNESBURG QUADRANGLE



H. M. Wilson, Geographer in charge.
Triangulation by Sledge Tatum.
Topography by Frank Sutton, T. G. Basinger, and J. D. Forster.
Surveyed in 1901.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

APPROXIMATE MEAN DECLINATION 1901.

Scale $\frac{1}{62500}$

Contour interval 20 feet.

Datum is mean sea level.

Edition of Feb. 1904 reprinted Feb. 1905.

U. S. GEOLOGICAL SURVEY
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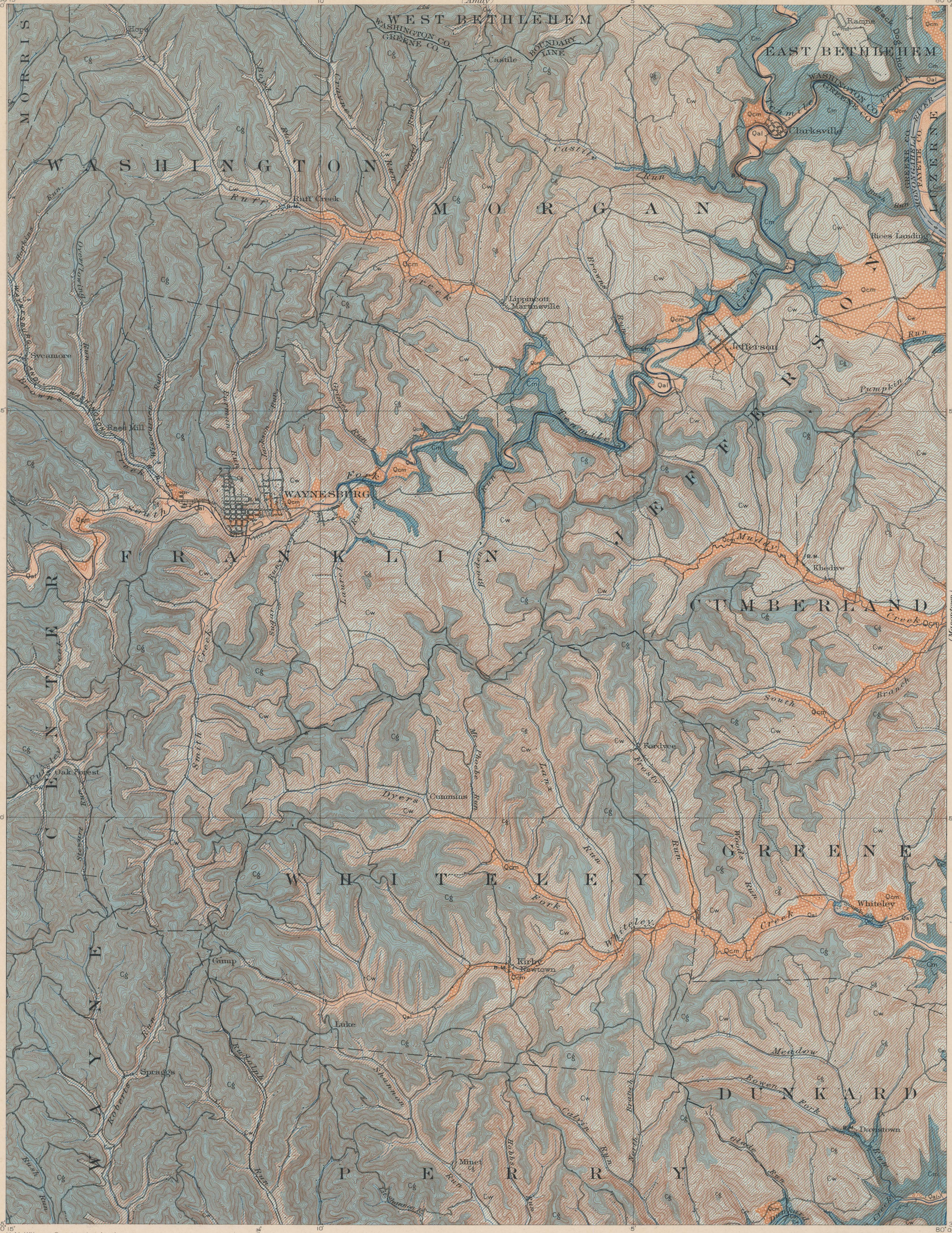
AREAL GEOLOGY

PENNSYLVANIA
WAYNESBURG QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

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

Qcm — Carmichaels formation *(clay, sand, and bowlders on terraces and old valley floors)*

CARBONIFEROUS

Permian? — Dunkard group

Cg — Greene formation *(shale and sandstone, with thin limestones and beds of coal)*

Cw — Washington formation *(sandy shale and coarse sandstone, with thin limestone and beds of coal)*

Pennsylvanian

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)*

H. M. Wilson, Geographer in charge.
Triangulation by Sledge Tatum.
Topography by Frank Sutton, T. G. Basinger, and J. D. Forster.
Surveyed in 1901.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1901.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.
Edition of Feb. 1905

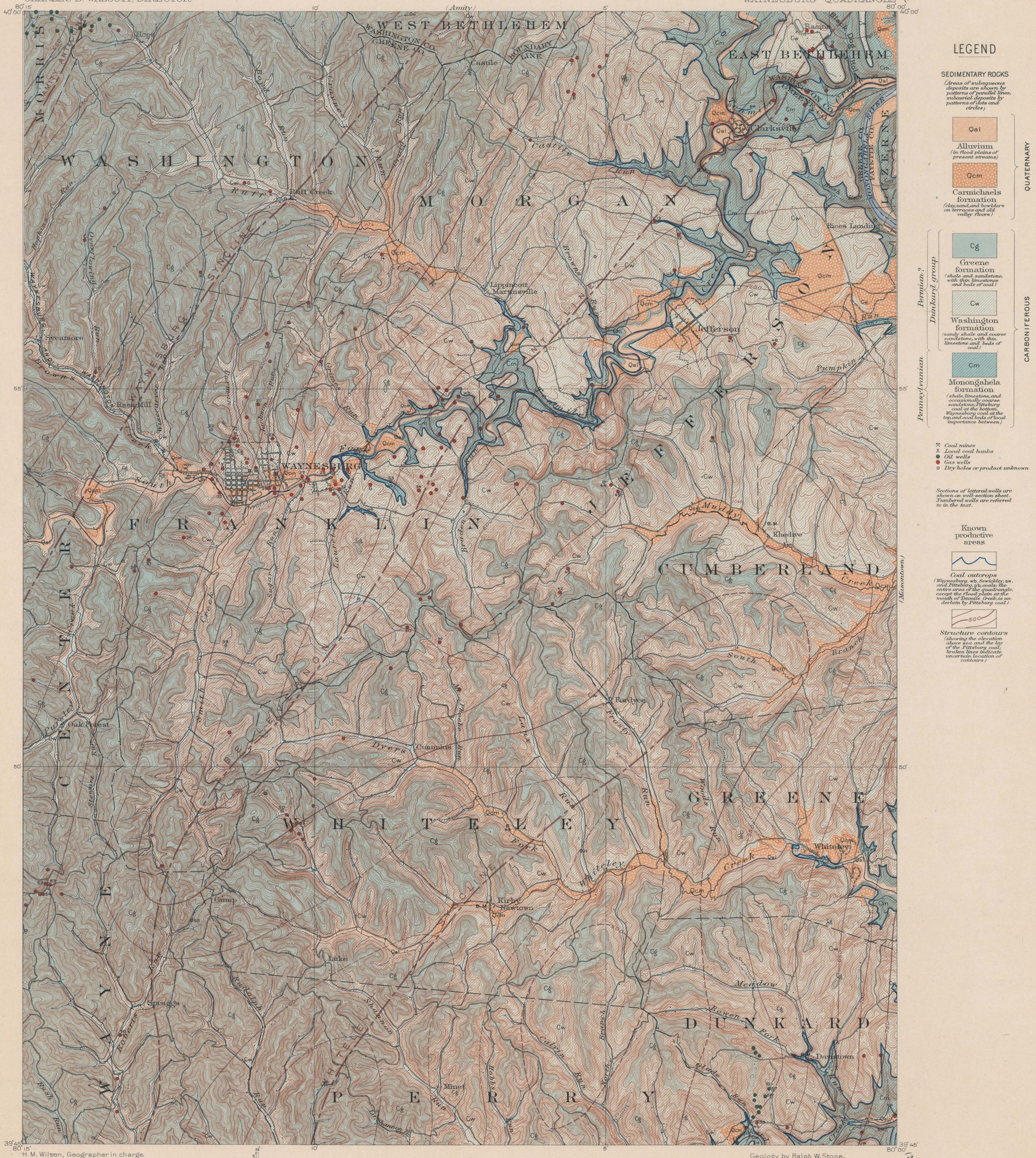
Geology by Ralph W. Stone,
assisted by M. I. Goldman,
under the direction of Marius R. Campbell.
Surveyed in 1902.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

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

STRUCTURE AND ECONOMIC GEOLOGY

PENNSYLVANIA
WAYNESBURG QUADRANGLE



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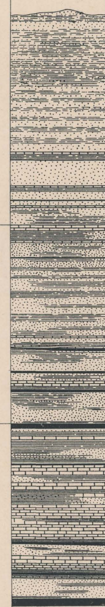
SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA

COLUMNAR SECTION

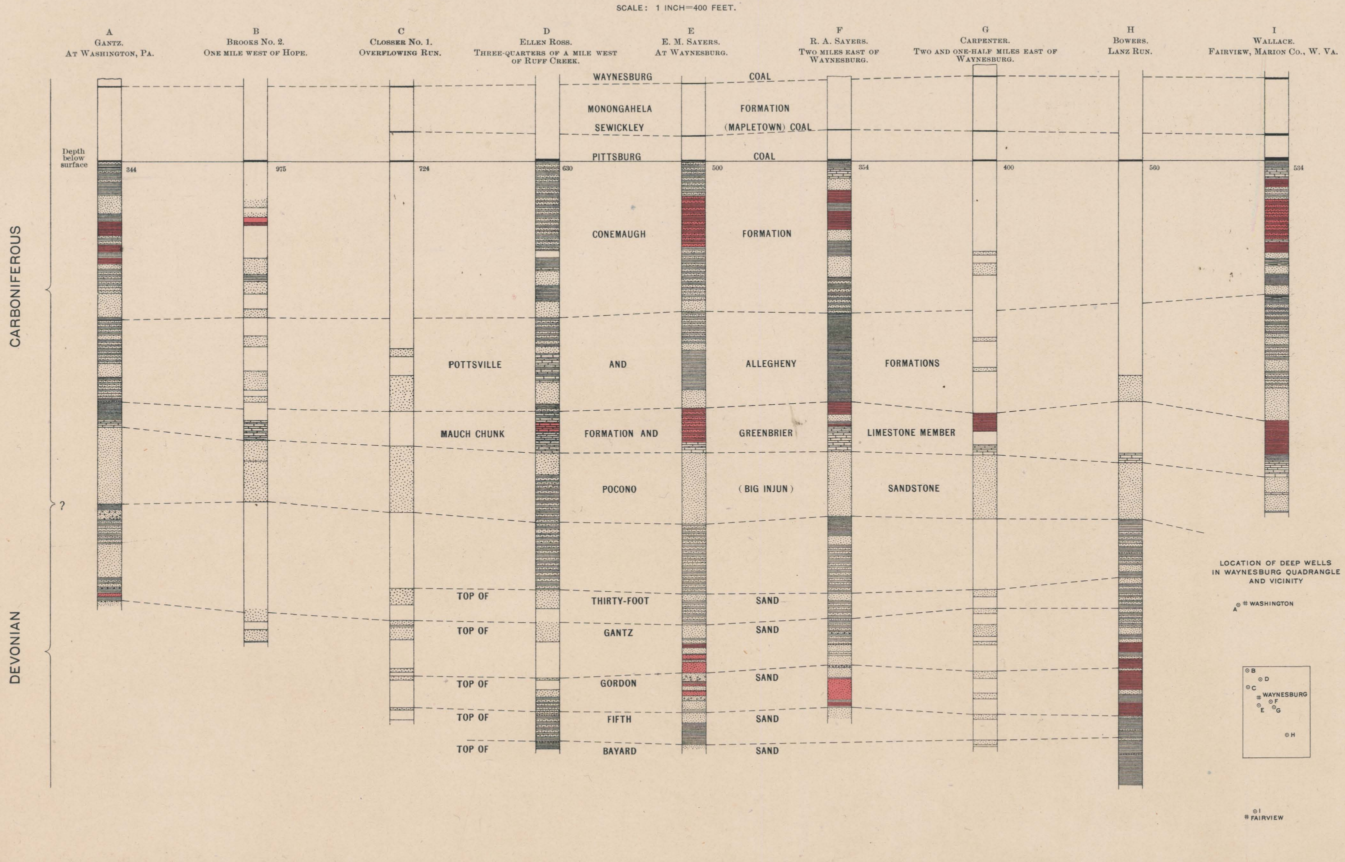
GENERALIZED SECTION FOR THE WAYNESBURG QUADRANGLE

SCALE: 1 INCH=200 FEET.

System.	Series.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Names of Members.	Character and Distribution of Members.	General Character of Formations.
CARBONIFEROUS	PERMIAN ?	Greene formation.	Cg		450±		Shales and shaly sandstone without distinctive traceable features.	These formations, with the exception of the Waynesburg sandstone at the base and a heavy sandstone above the Upper Washington limestone, are soft and shaly. Contain a number of coal beds, which are generally thin and unimportant.
		Washington formation.	Cw		400±	Upper Washington limestone. Jollytown limestone. Jollytown coal. Washington coal. Waynesburg "B" coal. Waynesburg "A" coal. Waynesburg sandstone.	Blue to black limestone, weathering white. Well developed in northern half of quadrangle. Of good quality. Burned for making fertilizer. Iron-stained limestone; persistent, but of no value. Thin and unimportant. Persistent bed, too badly broken by partings to be of value. Persistent, but too thin to be of value. Thin bed, generally of good quality. Coarse sandstone. Usually separated from Waynesburg coal by a few feet of shale.	
	PENNSYLVANIAN	Monongahela formation.	Cm		370±	Waynesburg coal. Uniontown coal. Benwood limestone. Sewickley (Mapletown) coal. Redstone coal. Pittsburg sandstone. Pittsburg coal.	Persistent bed. Four to 6 feet of coal. Mined for local use. Thin and unimportant. Blue limestone and calcareous shale beds. Persistent bed. Best developed on Dunkard Creek, where it is 5 feet thick. Thin bed of no value. Persistent, but variable in thickness. Shaly in places. Six to 9 feet of available coal of great value.	The most important coal-bearing formation of southwestern Pennsylvania. The rocks are decidedly calcareous, but beds of sandstone develop locally and become prominent members of the formation.

SECTIONS OF DEEP WELLS IN THE WAYNESBURG QUADRANGLE AND VICINITY.

SCALE: 1 INCH=400 FEET.



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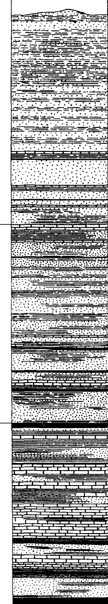
Geologist.

COLUMNAR SECTION

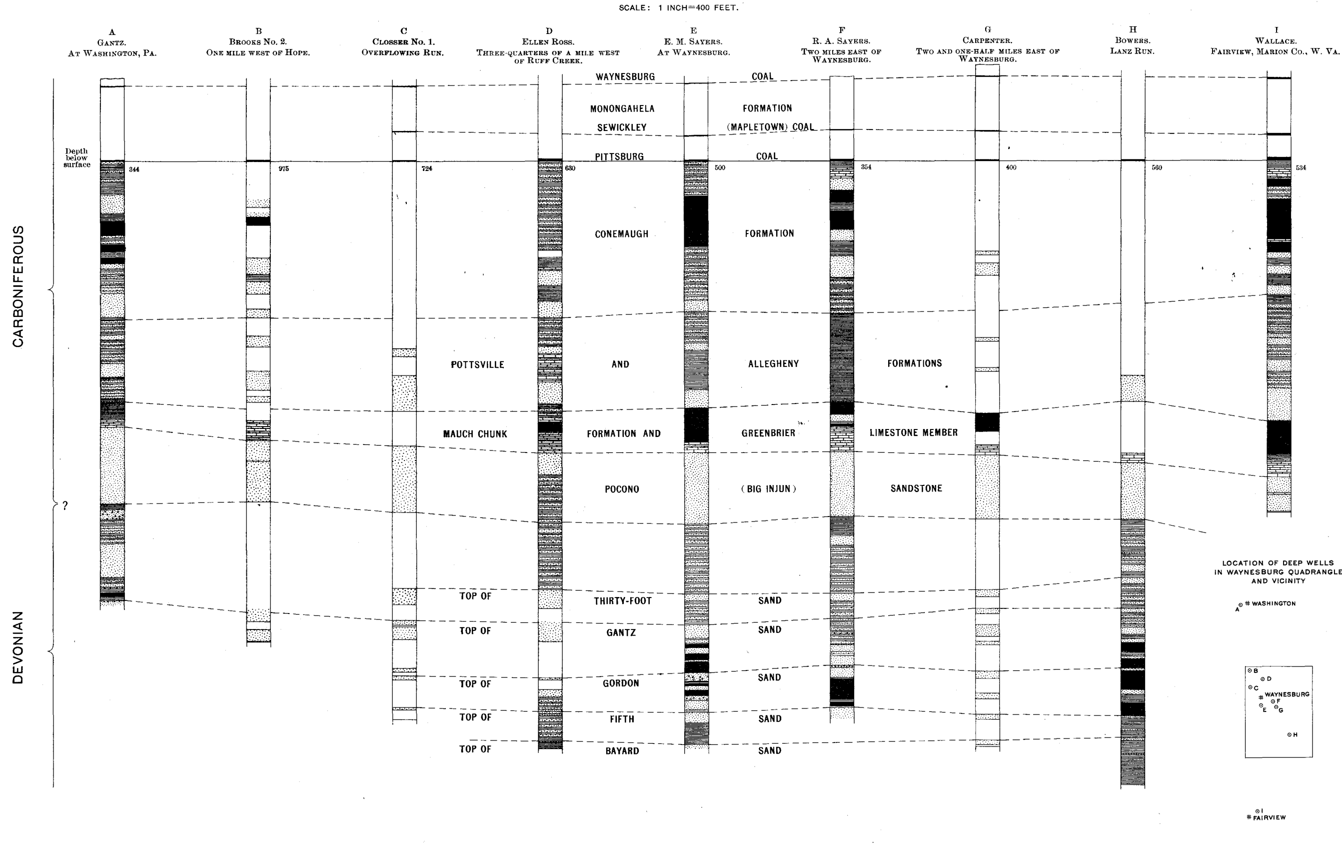
GENERALIZED SECTION FOR THE WAYNESBURG QUADRANGLE

SCALE: 1 INCH=200 FEET.

System.	Series.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Names of Members.	Character and Distribution of Members.	General Character of Formations.
CARBONIFEROUS	PERMIAN ?	Greene formation.	Cg		450±		Shales and shaly sandstone without distinctive traceable features.	These formations, with the exception of the Waynesburg sandstone at the base and a heavy sandstone above the Upper Washington limestone, are soft and shaly. Contain a number of coal beds, which are generally thin and unimportant.
		Washington formation.	Cw		400±	Upper Washington limestone.	Blue to black limestone, weathering white. Well developed in northern half of quadrangle. Of good quality. Burned for making fertilizer.	
						Jollytown limestone.	Iron-stained limestone; persistent, but of no value.	
						Jollytown coal.	Thin and unimportant.	
						Washington coal.	Persistent bed, too badly broken by partings to be of value.	
						Waynesburg "B" coal.	Persistent, but too thin to be of value.	
						Waynesburg "A" coal.	Thin bed, generally of good quality.	
						Waynesburg sandstone.	Coarse sandstone. Usually separated from Waynesburg coal by a few feet of shale.	
	PENNSYLVANIAN	Monongahela formation.	Cm		370±	Waynesburg coal.	Persistent bed. Four to 6 feet of coal. Mined for local use.	The most important coal-bearing formation of southwestern Pennsylvania. The rocks are decidedly calcareous, but beds of sandstone develop locally and become prominent members of the formation.
						Uniontown coal.	Thin and unimportant.	
						Benwood limestone.	Blue limestone and calcareous shale beds.	
						Sewickley (Mapletown) coal.	Persistent bed. Best developed on Dunkard Creek, where it is 5 feet thick.	
						Redstone coal.	Thin bed of no value.	
						Pittsburg sandstone.	Persistent, but variable in thickness. Shaly in places.	
						Pittsburg coal.	Six to 9 feet of available coal of great value.	

SECTIONS OF DEEP WELLS IN THE WAYNESBURG QUADRANGLE AND VICINITY.

SCALE: 1 INCH=400 FEET.



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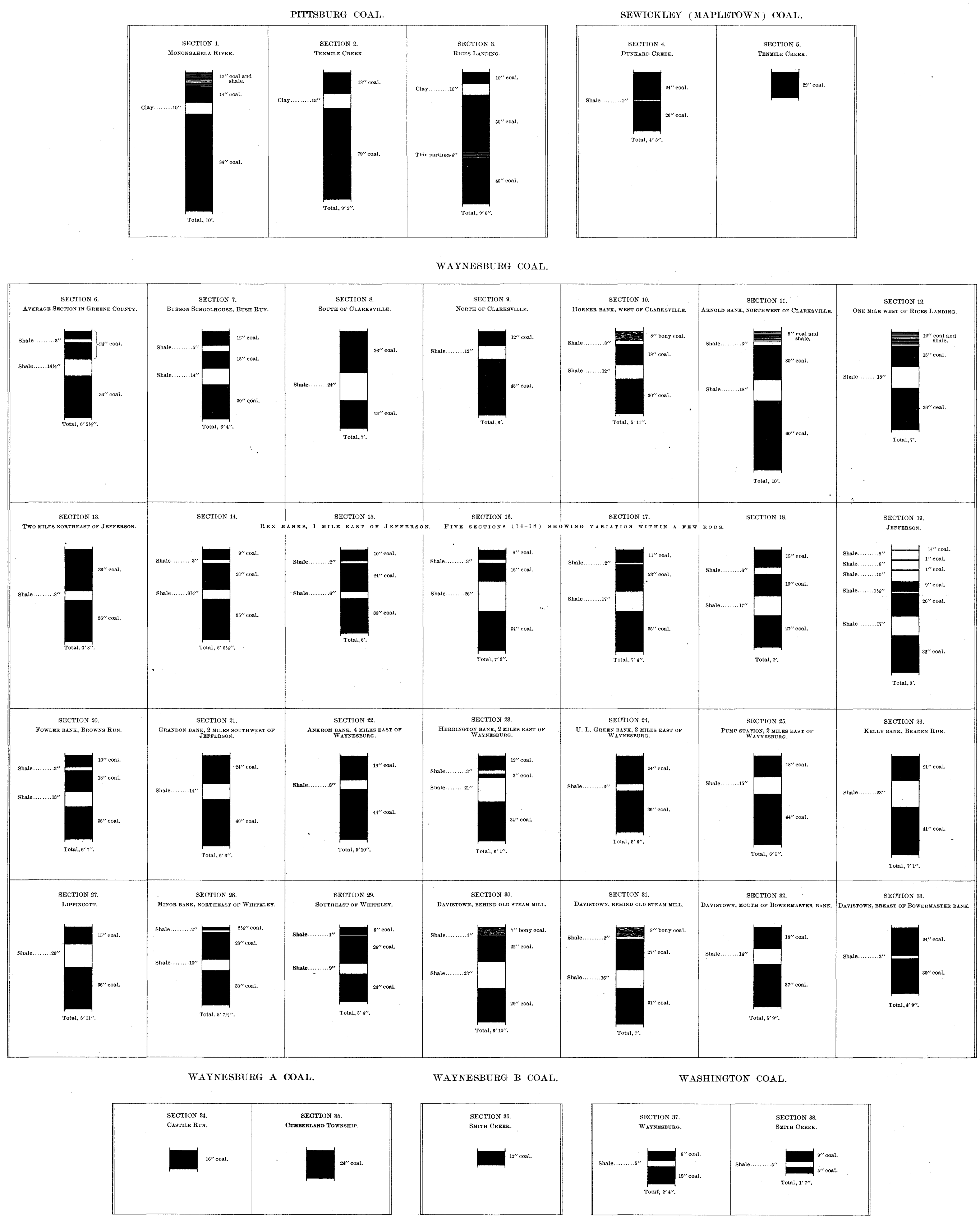
Geologist.

COAL SECTIONS

SECTIONS OF COAL SEAMS IN WAYNESBURG QUADRANGLE.

SCALE: 1 INCH=5 FEET.



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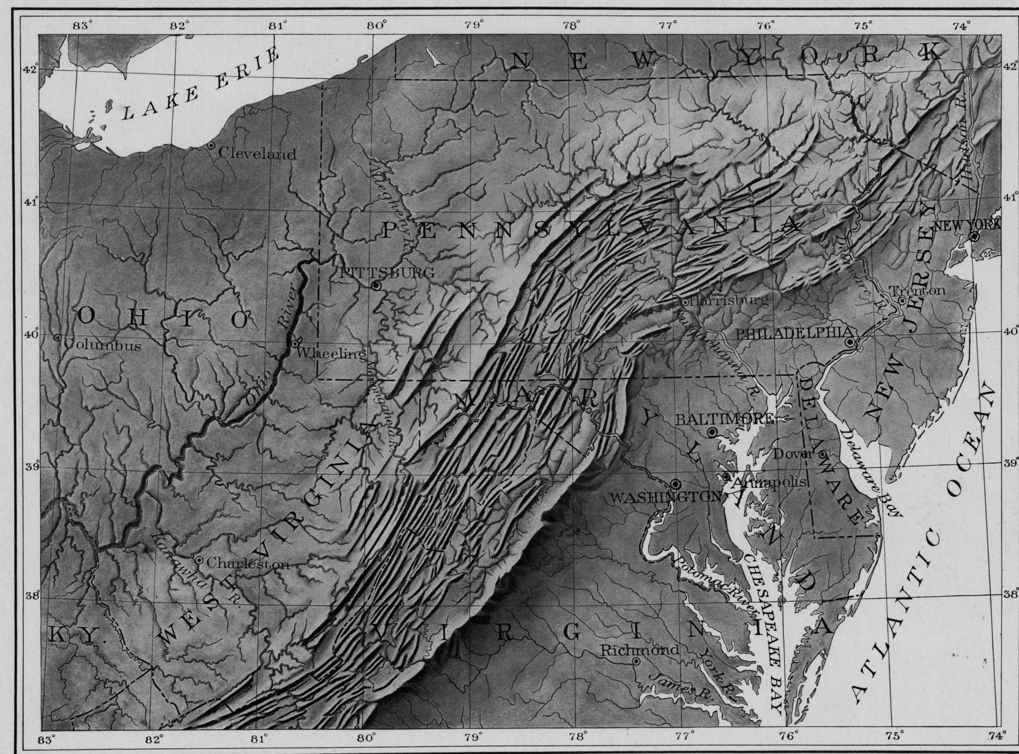

FIG. 6.—RELIEF MAP OF THE NORTHERN APPALACHIAN MOUNTAINS.

The Waynesburg quadrangle is situated on the plateau west of the belt of valley ridges, in the southwest corner of Pennsylvania.

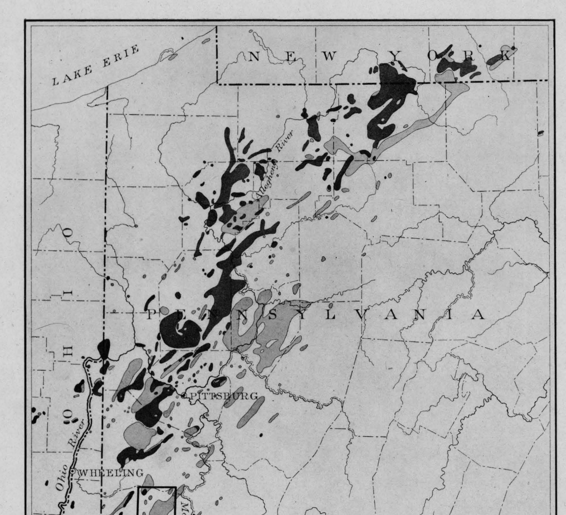

FIG. 7.—MAP SHOWING THE DISTRIBUTION OF THE GAS AND OIL POOLS IN WESTERN PENNSYLVANIA.

Compiled from map by the Second Geological Survey of Pennsylvania, and from maps by the United States Geological Survey. Dark areas, oil; lighter areas, gas. The location of the Waynesburg quadrangle is shown by the rectangle.

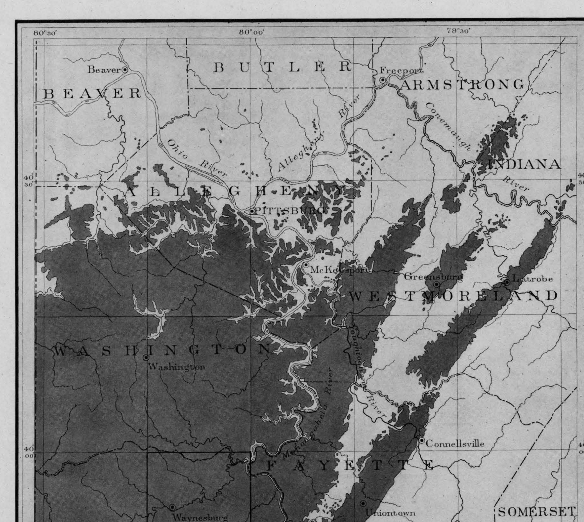

FIG. 8.—MAP SHOWING THE AREA OF THE PITTSBURG COAL IN PENNSYLVANIA.

The Waynesburg quadrangle is situated wholly within the field, as indicated by the rectangle.

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38	Butte Special	Montana	50
39	Truckee	California	25
40	Wartburg	Tennessee	25
41	Sonora	California	25
42	Nueces	Texas	25
43	Bidwell Bar	California	25
44	Tazewell	Virginia-West Virginia	25
45	Boise	Idaho	25
46	Richmond	Kentucky	25
47	London	Kentucky	25
48	Tenmile District Special	Colorado	25
49	Roseburg	Oregon	25
50	Holyoke	Massachusetts-Connecticut	50
51	Big Trees	California	25
52	Absaroka	Wyoming	25
53	Standingstone	Tennessee	25
54	Tacoma	Washington	25
55	Fort Benton	Montana	25
56	Little Belt Mountains	Montana	25
57	Telluride	Colorado	25
58	Elmoro	Colorado	25
59	Bristol	Virginia-Tennessee	25
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61	Monterey	Virginia-West Virginia	25

No.*	Name of folio.	State.	Price.†
			Cents.
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69	Huntington	West Virginia-Ohio	25
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73	Coos Bay	Oregon	25
74	Coalgate	Indian Territory	25
75	Maynardville	Tennessee	25
76	Austin	Texas	25
77	Raleigh	West Virginia	25
78	Rome	Georgia-Alabama	25
79	Atoka	Indian Territory	25
80	Norfolk	Virginia-North Carolina	25
81	Chicago	Illinois-Indiana	50
82	Masontown-Uniontown	Pennsylvania	25
83	New York City	New York-New Jersey	50
84	Ditney	Indiana	25
85	Oelrichs	South Dakota-Nebraska	25
86	Ellensburg	Washington	25
87	Camp Clark	Nebraska	25
88	Scotts Bluff	Nebraska	25
89	Port Orford	Oregon	25
90	Cranberry	North Carolina-Tennessee	25
91	Hartville	Wyoming	25
92	Gaines	Pennsylvania-New York	25
93	Elkland-Tioga	Pennsylvania	25
94	Brownsville-Connellsville	Pennsylvania	25
95	Columbia	Tennessee	25
96	Olivet	South Dakota	25
97	Parker	South Dakota	25
98	Tishomingo	Indian Territory	25
99	Mitchell	South Dakota	25
100	Alexandria	South Dakota	25
101	San Luis	California	25
102	Indiana	Pennsylvania	25
103	Nampa	Idaho-Oregon	25
104	Silver City	Idaho	25
105	Patoka	Indiana-Illinois	25
106	Mount Stuart	Washington	25
107	Newcastle	Wyoming-South-Dakota	25
108	Edgemont	South Dakota-Nebraska	25
109	Cottonwood Falls	Kansas	25
110	Latrobe	Pennsylvania	25
111	Globe	Arizona	25
112	Bisbee	Arizona	25
113	Huron	South Dakota	25
114	De Smet	South Dakota	25
115	Kittanning	Pennsylvania	25
116	Asheville	North Carolina-Tennessee	25
117	Casselton-Fargo	North Dakota-Minnesota	25
118	Greeneville	Tennessee-North Carolina	25
119	Fayetteville	Arkansas-Missouri	25
120	Silverton	Colorado	25
121	Waynesburg	Pennsylvania	25

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