DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

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IN COOPERATION WITH

STATE OF PENNSYLVANIA

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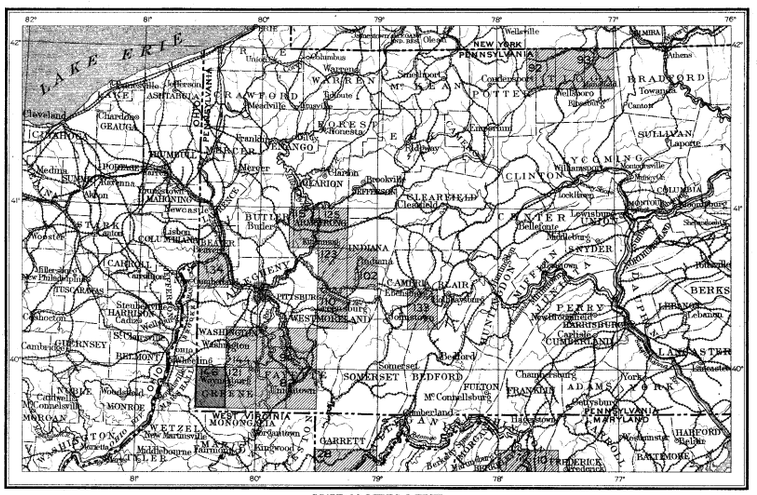
GEOLOGIC ATLAS

OF THE

UNITED STATES

ROGERSVILLE FOLIO

INDEX MAP



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WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

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

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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).

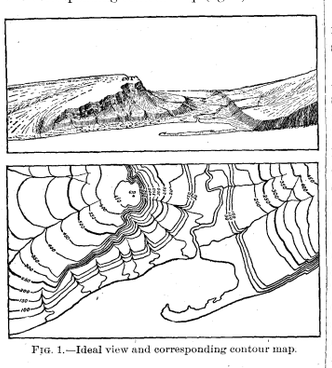

FIG. 1.—Ideal view and corresponding contour map.

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		Tr	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		AR	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:

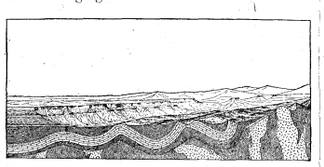

Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

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:

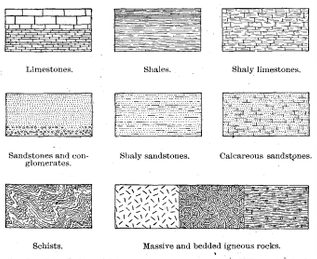

Fig. 3.—Symbols used in sections to represent different kinds of rocks.

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

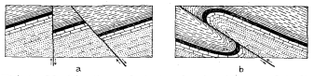

Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

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 ROGERSVILLE QUADRANGLE.

By Frederick G. Clapp.

INTRODUCTION.

GEOGRAPHIC RELATIONS OF THE QUADRANGLE.

The Rogersville quadrangle lies in the extreme southwest corner of Pennsylvania, principally in Greene County, but it includes portions of East Finley and West Finley townships of Washington County. It extends from latitude 39° 45′ on the south to 40° on the north, and from longitude 80° 15′ on the east to 80° 30′ on the west. It covers one-sixteenth of a square degree of the earth's surface, comprising 229.22 square miles.

The quadrangle is bounded on the north by the Claysville, on the east by the Waynesburg, on the south by the Mannington, and on the west by the Cameron quadrangle. It contains no large towns, but scattered through it are a few villages.

The quadrangle is important because it contains rich oil and gas fields and because it is underlain throughout almost its entire extent by the Pittsburg coal, a great bed that lies at most places rather deep below the surface and has therefore not yet been mined in this region. Until a few years ago the oil fields were unknown, and consequently there has been little inducement to build railroads into the region.

PHYSIOGRAPHIC AND GEOLOGIC RELATIONS.

Outline of Geography and Geology of Northern Part of Appalachian Province.

PHYSIOGRAPHIC DIVISIONS.

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

A line drawn along the Allegheny Front across Pennsylvania, Maryland, and West Virginia, and continued along the eastern escarpment of the Cumberland Plateau across Virginia, Tennessee, Georgia, and Alabama, would divide the Appalachian province into two nearly equal parts. The escarpments named are not well marked topographically for the entire distance, but the Allegheny Front is especially prominent in southern Pennsylvania. The physiographic divisions of the northern part of the province are illustrated in fig. 1. The

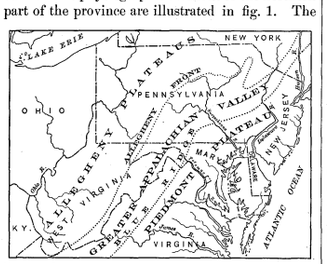

FIG. 1.—Diagram of northern portion of the Appalachian province, showing physiographic divisions.
The Rogersville quadrangle is in the southwestern part of Pennsylvania and lies wholly within the Appalachian Plateau.

rocks southeast of the line mentioned are greatly disturbed by faulting and folding. They are very old, and at many places are so metamorphosed that their original character can be determined only with difficulty. The rocks northwest of the line are thrown into gentle folds, which are so broad that they are scarcely noticeable to one passing across the region.

Southeast of the Allegheny Front lies a series of alternating ridges and valleys; and still farther southeast a dissected upland, known to geologists as the Piedmont Plateau. Northwest of the Allegheny Front lies a rather elevated plateau region, broken by a few ridges where minor folds have affected the rocks and greatly dissected by streams. To distinguish it from the lowlands of the Mississippi Valley, still farther west, and the rugged alternating ridges and valleys of the Appalachian Valley, this part of the province has previously been called the Allegheny Plateaus. By a decision of the United States Geographic Board of February 6, 1907, the name Appalachian Plateau will hereafter be used. The Rogersville quadrangle lies entirely within this region.

The Appalachian Plateau is characterized by distinct types of geologic structure, surface features, and arrangements of drainage. 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 this portion of the Appalachian Plateau is given below.

APPALACHIAN PLATEAU.

GEOGRAPHY.

Drainage.—The water of the Appalachian Plateau flows almost entirely into Mississippi River, but the northeastern end of the region is drained partly into the Great Lakes and partly through Susquehanna, Delaware, and Hudson rivers into the Atlantic Ocean.

In northern Pennsylvania the arrangement of the drainage lines is due largely to conditions that existed during the glacial epoch. It is supposed that before that time all of the streams north of central Kentucky flowed toward the northwest and discharged their waters through the St. Lawrence river system. The advance of the great ice sheet closed this northern outlet and new drainage lines were established in a southerly direction along the present courses of the streams.

Relief.—As the name 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 believed to be a remnant of a very old land surface which by long-continued erosion had been reduced nearly to a plain, and was therefore properly a peneplain. This surface is believed to be the continuation of that which is well developed in the region of Schooley Mountain, in northwestern New Jersey, and it has therefore been named the Schooley peneplain. The peneplain has been deformed by differential uplift of the land, and in most regions has been so completely dissected by erosion that its original character has disappeared. In southern Pennsylvania it has an altitude of about 2600 feet, but it descends to 2300 or 2400 feet in the central part of the State. The surface of the Schooley peneplain is well developed in northern Pennsylvania at altitudes of 2000 to 2400 feet. Areas of considerable extent are still preserved where they have been protected from erosion by the massive sandstones of the Pottsville formation. In northern West Virginia there are a few remnants of high, rather flat land that appear to be parts of this peneplain, but it is generally so dissected that its surface is preserved only in the hilltops. Throughout most of the province there are knobs and ridges that rise to a greater height than the general surface of the plateau, marking areas that were not reduced to the old peneplain level.

Along the border of the Schooley peneplain on the northwest, over large portions of Ohio, Pennsylvania, and New York, there are remnants of a second peneplain, younger than the Schooley. This has been called the Harrisburg peneplain, on account of its excellent development near Harrisburg, Pa., where its elevation is about 500 feet above the sea. North of Ohio River this peneplain was developed on harder rocks than in Tennessee and Kentucky, 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 1600 to 2100 feet throughout northern Pennsylvania and southern New York. The Schooley and Harrisburg peneplains are generally separated by a northwestward-facing escarpment. In southern Pennsylvania this is rather pronounced where the hard rocks of Chestnut Ridge rise abruptly above the plain formed on the softer rocks of the Monongahela Valley. Toward the central part of the State the two plateaus seem to approach each other, and the escarpment is merged into a mass of irregular hills which represent all that now remains of the higher plateau.

GEOLOGIC STRUCTURE.

General features.—The geologic structure of the Appalachian Plateau is simple. The strata lie nearly flat, and their regularity is broken only by small faults and low, broad folds. They are bounded on the west by a low, broad arch known as the Cincinnati anticline. As the Rogersville quadrangle is situated entirely within that portion of the Appalachian Plateau which comprises the Appalachian coal field, a somewhat detailed description of this field is necessary to present a clear idea of the geologic features of this quadrangle.

Structure of the Appalachian coal field.—The geologic structure of the Appalachian coal field is very simple, being, in a general way, that 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 southwestward from Pittsburg across West Virginia to Huntington, on Ohio River. From both the northwest and southeast the rocks dip toward the center of this trough. About the canoe-shaped northern end, in southwestern Pennsylvania, they outcrop in a roughly semicircular belt and dip in general toward the deepest part of the trough.

Although the structure is for the most part simple the eastern limb of the trough is crumpled into a number of parallel wrinkles or folds. These are similar to the great folds southeast of the Allegheny Front, but they are on a much smaller scale and as a rule are not broken by faults, as are 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 details of structure somewhat complicated and break up the regularity of the westward dip, so that at first sight the more general structure is not apparent. In the southern part of Pennsylvania there are six pronounced anticlines, two of which disappear near the West Virginia boundary.

ROCKS OF THE APPALACHIAN PROVINCE.

PRE-CARBONIFEROUS ROCKS.

The oldest rocks of the Appalachian province are crystalline rocks, such as granite and gneiss, which outcrop along its southeastern and northern margins and presumably underlie all the younger rocks of the province. Above the crystalline rocks lie thousands of feet of sandstone, limestone, and shale, comprising several systems. These rocks are exposed in the greatly folded and disturbed region east of the Allegheny Front and around the northern and western margins of the province, within the crystalline belt, but in the interior, as well as in the deep synclines of the anthracite and Broadtop regions of the Appalachian Valley, they are concealed beneath younger rocks.

CARBONIFEROUS SYSTEM.

The rocks exposed at the surface in the Appalachian Plateau belong almost entirely to the Carboniferous system. They include the Pocono, Mauch Chunk, Pottsville, Allegheny, Conemaugh, and Monongahela formations and the Dunkard group. Brief descriptions of these are here given in the order of their age, beginning with the lowest.

Pocono formation.—At the base of the Carboniferous system lies the Pocono formation, which derives its name from Pocono Mountain, in the eastern part of Pennsylvania. Over a large area in Pennsylvania the top is well marked by a calcareous and sandy stratum known as the Loyalhanna ("Siliceous") limestone, but in Greene County this limestone is not known.

On the Allegheny Front the Pocono is about 1030 feet thick. In consists of sandstone with occasional beds of gray sandy shale, and in places thin beds of red shale. In southwestern Pennsylvania the formation is generally under cover. In this part of the State it probably includes all the rocks between the top of the Big Injun sand and the bottom of the Fifty-foot sand.

Mauch Chunk formation.—This formation outcrops on the Allegheny Front on top of the Loyalhanna ("Siliceous") limestone of the Pocono formation; also 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 and is composed largely of red shale. On the Allegheny Front and along Conemaugh River it is about 180 feet thick and is composed of about 80 feet of heavy grayish to greenish sandstone overlain by 100 feet of soft red shale. On Chestnut Ridge, however, the sandstone beds disappear, and the formation is composed of red shale, in the lower part of which occurs a bed of fossiliferous limestone. This is the feather-edge of the Greenbrier limestone of Virginia, and represents the upper part of the great Mississippian (Lower Carboniferous) limestone of the Mississippi Valley. In eastern Washington and Greene counties the formation is known in oil and gas wells and includes the Big lime and the accompanying red shale.

Pottsville formation.—This group of rocks derives its name from Pottsville, in the southern anthracite coal field. It is 1200 feet thick at the type locality, and it is composed mainly of coarse conglomerate. In the eastern part of the bituminous coal field in Pennsylvania the formation consists of at least two sandstone members separated by a bed of shale. The upper bed is known as the Homewood sandstone and the lower as the Connoquenessing. Locally the intervening shale contains a coal bed of workable thickness, and at some places a valuable fire clay and one or more thin limestones.

The shale and various associated beds are known collectively as the Mercer member. In most parts of the bituminous coal field in Pennsylvania the thickness of the Pottsville runs from 125 to 200 feet. In the extreme western part of Pennsylvania and also at some localities in the west-central part of the State the Pottsville lies unconformably on the Pocono formation.

Allegheny formation.—This formation takes its name from Allegheny Valley, along which it is typically developed and well exposed. In character it is rather more variable than the lower formations in the Carboniferous system. It consists essentially of shale and sandstone, but comprises many beds of coal, clay, and limestone, which make it of great economic importance. It is especially distinguished by the fact that in the northern part of the bituminous coal field it contains a greater number of workable coal seams than any of the lower formations, and on that account was originally called the "Lower Productive measures." Nearly all the coal mined in Pennsylvania north of Pittsburg and east of Connellsville and Blairsville is taken from this formation. In addition to its coals, it contains valuable beds of fire clay which form the basis of important industries at several localities, and it also contains thin beds of limestone of some local importance.

Conemaugh formation.—The rocks overlying the Allegheny formation rarely contain workable coal beds, and for that reason they were formerly known as the "Lower Barren measures." These rocks are now known as the Conemaugh formation, from Conemaugh River, where they outcrop extensively. In some parts of Pennsylvania, however, workable coals of limited extent occur in this

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formation, and at some places they are accompanied by thin limestones. The great mass of the formation is composed of alternating shale and sandstone. The shale is in many places conspicuous on account of its red color. The thickness of the Conemaugh formation varies from 600 to 700 feet.

Monongahela formation.—This formation was named from Monongahela River, along which it is typically exposed. It has also been called the "Upper Productive measures." It overlies the Conemaugh in southwestern Pennsylvania, and extends from the bottom of the Pittsburg coal below to the top of the Waynesburg coal above. Its thickness varies from 270 to 400 feet. It contains several workable coal beds, of which the Pittsburg is by far the most valuable and the best known. It is much more calcareous than any of the other calcareous formations, fully one-third of the formation being made up of limestone and calcareous shale. 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, which comprises the Washington and Greene formations, was formerly known as the "Upper Barren measures," but is now called the Dunkard group, after Dunkard Creek, in Greene County, along which these rocks form the surface for many miles. The group lies above the Monongahela formation and includes the highest rocks of the Carboniferous system found in this region. It has a maximum thickness in the southwest corner of Pennsylvania of over 1100 feet, and consists mainly of shale and sandstone, though it also contains beds of coal and limestone. Some of the coals are locally workable, but generally they are worthless. In this area the group is subdivided into the Washington and Greene formations. The Washington formation includes the rocks lying between the Waynesburg coal and the top of the Upper Washington limestone; the Greene formation comprises all higher rocks in the group. It is doubtful whether the line of separation can be carried far outside of Washington and Greene counties, so that in Ohio and West Virginia these rocks will probably be known simply as the Dunkard formation. In southwestern Pennsylvania and along Ohio River in West Virginia and Ohio they occupy an area similar in form to that occupied by the Monongahela formation, but of less extent.

TOPOGRAPHY OF THE QUADRANGLE.

DRAINAGE.

General features.—The Rogersville quadrangle contains no large streams. It lies about midway between Monongahela and Ohio rivers and is crossed by the watershed that separates these streams, which divides it into two nearly equal areas. The eastern area contains the upper course of South Fork of Tenmile Creek and parts of tributary basins, draining eastward, and several small streams flowing southward into Dunkard Creek. The western area contains the greater part of Enslow and Dunkard forks of Wheeling Creek, flowing westward, and the head of Pennsylvania Fork of Fish Creek, flowing southward. All the streams of the Rogersville quadrangle flow in deep, narrow valleys that are bordered by narrow flood plains. At some places a few of them, as Fish Creek, are bordered by high sandstone cliffs. There are no falls, the grades of the streams being gentle, rarely sufficient to furnish water power. In spring and directly after heavy rains they may be swelled to considerable size, but during the droughts of summer all but the largest of them become entirely dry. There are no natural lakes or ponds, but small ponds could doubtless be formed on some of the larger streams by damming.

Asymmetrical valleys.—A peculiar feature of the drainage of this region—a feature that is better developed in adjacent quadrangles—is the asymmetrical position of the eastward- or westward-flowing streams with respect to their drainage basins. The streams are not in the centers of the basins, but are generally nearer the southern sides. By reference to the topographic map it will be seen that practically all the streams except those flowing north or south have such asymmetrical drainage basins. In every basin showing this asymmetry the grade is steeper on the southern than on the northern side. The basins of Blockhouse Run, Toms Run, Bates Fork, McCourtney Run, Wagonroad Run, Laurel Run, Herod Run, and Crabapple Creek are good examples.

This lack of symmetry is more marked in neighboring quadrangles covering portions of southwestern Pennsylvania and eastern Ohio, and is present in less degree in northern West Virginia. The cause of this feature is not yet well understood. It can not be due to the influence of geologic structure, because the creeks flow across anticlines and synclines alike. Neither can it be due to the character of the rocks, as the distribution of hard and soft beds shows no relation to the direction of the asymmetrical lines. It may have been caused by some form of warping or gentle folding of the surface on a large scale, such as an uplift during Cretaceous or Tertiary time along a southwest-northeast axis located somewhere in Ohio and perhaps crossing into northern Pennsylvania.

SURFACE RELIEF.

The Rogersville quadrangle is located on the crest of the divide between Monongahela and Ohio rivers and is a good example of a thoroughly dissected region. The larger creeks have eroded their valleys to a fairly uniform grade, and the smaller branches have cut back into the uplands, producing hundreds of narrow ridges and rounded knobs in the interstream areas, so that the surface is very hilly.

The relief of the hills amounts to about 800 feet, extending from the 860-foot contour, in the valleys of Enslow and Dunkard forks of Wheeling Creek, to 1660 feet on the summits northeast of New Freeport. In general, the larger valleys descend to 1000 or 900 feet and the hilltops rise to 1500 or 1600 feet. Most of the lower slopes of the hills are steep, and in some hills the rock is exposed in cliffs along the lower slopes, while the upper slopes are more gentle. The crests of the knobs and ridges are as a rule smoothly rounded, and at a few places are broad enough to furnish sites for small villages. Throughout the area, except in the valley bottoms, the rock lies at the surface or is covered only by a thin coating of residual soil. Ledges are not abundant, but occur along some of the creeks, and heavy sandstone beds project at a few places as small terraces near the hilltops.

Most of the crests of the principal hilltops and ridges in the northern half of the area are between 1400 and 1500 feet above sea level, a few summits standing above 1500 feet. Along the main divide between the drainage of Monongahela and Ohio rivers, which crosses western Morris and eastern Richhill townships, running the entire length of the quadrangle from north to south, elevations as high as 1500 and even 1600 feet are of common occurrence. The highest hilltops in the vicinity of this divide are surprisingly uniform in altitude: 1580 feet northeast of Time, 1660 feet between Time and Graysville, 1600 feet between Graysville and Bristoria, 1580 feet between Bristoria and White Cottage, 1600 feet near Nettle Hill, 1600 feet near Ashtree, and 1620 feet near the southern border of the quadrangle. Moreover, this uniformity of upper level is rather marked throughout the southern and especially the southwestern part of the quadrangle. In Jackson, Aleppo, Springhill, and western Gilmore townships probably 60 hilltops reach altitudes above 1550 feet. None of them rises above 1660 feet, and only about a dozen above 1600 feet. Not only do the main divides in these townships rise to nearly the same height, but even the narrow ridges separating Wagonroad, Laurel, Herod, and other runs stand at about the same level.

Such an agreement in the altitudes of hilltops, when not in accord with the structure of the underlying rocks, may be interpreted in one of two ways. It may represent either the surface of a peneplain that has been dissected until all that is left of it is the extreme summits of the hills, or it may be the product of a more advanced stage of dissection, in which all of the old surface is gone and the hilltops have been worn somewhat below its level, but approximately parallel with it. This old surface may be the continuation of the Schooley peneplain, which is supposed to have an elevation of 2600 feet in the central part of the Appalachian province in southern Pennsylvania. Along the center of the Appalachian province in this region there is a broad arch, formed, it is supposed, as a result of post-Paleozoic movements, and it is believed that the old peneplain surface slopes westward from the crest of this arch. On this supposition it is possible that the highest hilltops of the Rogersville quadrangle constitute a few scattering remnants of this peneplain, which slopes from an altitude of about 2600 feet in the region farther east to about 1500 feet in this region.

Features of less prominence than the peneplain surfaces are the terraces or benches along some of the larger creeks of the quadrangle. On Tenmile Creek at Rogersville, and again within half a mile east of that village, there are several rather flat-topped terraces at elevations of 980 to 1030 feet above sea level. Similar benches appear near Durbin, on Dunkard Fork, where their rock foundation is the Waynesburg sandstone. In both these valleys the surface deposit on the benches consists of gravel and silt, known as the Carmichaels formation. These terraces are types of rock benches that are distributed through the Monongahela and other valleys. They are remnants of ancient valley floors, which were broader than the present ones and were formed during the last stages of the Tertiary period.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY AND AREAL GEOLOGY.

GENERAL STATEMENT.

The discussion of the rocks of this quadrangle divides itself naturally into two parts, the first treating of the rocks that are exposed at the surface, the second of those that are entirely hidden by overlying rocks and are known only from fragments brought up by the drill. Except a few comparatively recent sediments in the valleys, the rocks exposed at the surface are all sedimentary and of Carboniferous age. They belong chiefly to the Dunkard group, comprising the Washington and Greene formations, but the upper Monongahela strata reach the surface in two small patches, one on each fork of Wheeling Creek. The underground formations include, from the top downward, the Monongahela, Conemaugh, Allegheny, Pottsville, Mauch Chunk, and Pocono formations of the Carboniferous system and part of the Chemung formation of the Devonian system. Below the Chemung lie thousands of feet of buried strata which have never been reached by the drill. The relative positions and characters of the formations are shown on the columnar section sheet.

Although the general relations of the strata remain fairly constant, there are considerable variations in detail in different parts of the quadrangle. Sections a number of miles apart are likely to differ somewhat in the character and thickness of equivalent beds. Over widely extended regions, however, uniform conditions prevailed during sedimentation and produced strata that show only slight variation at the same horizon. Such beds serve very useful purposes in geologic correlation, and make many convenient division lines in mapping. The Waynesburg sandstone, Pittsburg coal, Big lime, and Big Injun sand are examples of strata that are persistent over wide areas.

From the oldest to the youngest exposed strata the thickness is about 1100 feet. The youngest beds are on the hills in western Springhill and Aleppo townships, near Morford, where some knobs reach about 1400 feet above the Pittsburg coal. The rocks are chiefly sandstone, shale, and thin beds of limestone, but in the lower part of the section there are several beds of coal of minor importance. The formations will be described in order of age—from oldest to youngest.

Rocks That Form the Surface.

CARBONIFEROUS SYSTEM.

PENNSYLVANIAN SERIES.

MONONGAHELA FORMATION.

General features.—The Monongahela formation extends downward from the top of the Waynesburg coal to the bottom of the Pittsburg coal, its total thickness varying from 270 to 400 feet. In this quadrangle the formation reaches the surface at only two localities, on Enslow and Dunkard forks of Wheeling Creek, and only a few feet at the top of the formation are exposed. The outcropping beds consist of the Waynesburg coal, its underlying shales and clay, and the top of the Waynesburg limestone.

Waynesburg coal.—This is a bed of considerable importance and has a wide distribution in southwestern Pennsylvania and northern West Virginia. It ranges between 3 and 7 feet in thickness and is of some economic value. It outcrops for about 8 miles on Enslow and Dunkard forks of Wheeling Creek. Its outcrop is shown on the map by the line of contact between the Monongahela and Washington formations.

PERMIAN SERIES.

DUNKARD GROUP.

GENERAL CHARACTER, RELATIONS, AND THICKNESS.

The Dunkard group includes all rocks from the top of the Waynesburg coal to the latest Carboniferous beds of the Appalachian basin. All the surface rocks in the Rogersville quadrangle belong to this group, except those described above as Monongahela, which outcrop in two small areas. The greatest thickness of Dunkard rocks in the quadrangle is about 1100 feet, in western Aleppo and Springhill townships. This is probably not far from the deepest portion of the Appalachian coal basin, although deeper points may yet be found in the extension of the central syncline in northern West Virginia. How many feet of strata have been removed by erosion is not known. The only evidence at hand on which to base an estimate is the character of the rocks still remaining, which, with the exception of a few limestones, are mostly soft shales and shaly sandstones that are eroded with comparative ease. Taking this fact as a basis, and remembering that in other parts of the United States the Permian rocks are the latest beds in the Carboniferous system, it seems probable that these upper rocks, including the Dunkard beds, were here originally at least several hundred feet thicker than they are at present.

The character of the rocks of the Dunkard group differs greatly in different regions. In general, they consist of shale and shaly sandstone, but they comprise also a few more or less persistent beds of rather massive sandstone and a number of thin limestones. The lower part of the group contains several coals, but they are of little economic value. In Greene County the Dunkard carries many beds of red shale. These increase in importance toward the southwest and are most prominent in West Virginia, but toward Washington County they disappear, giving way to the ordinary drab or yellowish shales.

SUBDIVISIONS.

The Dunkard group has in most places been considered a distinct formation, like the Conemaugh and Monongahela. In some regions it is necessary to map it as such, on account of the absence of any recognizable bed along which the group may be separated into lesser divisions. In Washington and Greene counties, however, the lower part of the group is more calcareous than the upper part and contains several minor coal beds. In the eastern part of these counties the Dunkard comprises a very persistent limestone, the Upper Washington, which can be easily recognized and forms an excellent horizon at which to subdivide the group into formations. In western Greene County the Upper Washington limestone is poorly developed, less characteristic, and at some places absent, as shown on the map by the omission of the boundary line. It has been possible, however, to carry it over nearly the entire area where the horizon outcrops. The portion of the Dunkard group below the Upper Washington limestone is known as the Washington formation, and that above as the Greene formation, from the respective counties in which they are typically developed.

FOSSILS AND AGE.

The fossils of the Dunkard consist of the remains of large numbers of plants and ostracods, with some pelecypods and fish fragments. The flora is characterized by the abundant occurrence of such genera as *Neuropteris*, *Pecopteris*, *Sphenopteris*, and *Sphenophyllum*, with which are mingled representatives of *Callipteris* and *Equisetites*, together with late types of the common "Coal Measures" genera.

The precise age of the Dunkard group as a whole is still questioned by certain geologists. By some it is considered simply as an upper formation in the Pennsylvanian series. The deposits are now generally believed to be Permian in age, however,

and they are so treated in this folio. The basis for this conclusion lies largely in the occurrence of many species of fossils which have been identified by paleontologists as characteristic of the Permian. The list of species is as follows:

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

The Permian age of the Dunkard group is also confirmed by the existence of a flora regarded as identical with the Permian flora in the Wichita beds of Texas. The fossil insects of the Cassville shale also confirm the evidence.

WASHINGTON FORMATION.

Stratigraphic limits and thickness.—This formation, as stated above, includes all strata between the top of the Waynesburg coal and the top of the Upper Washington limestone, being bounded below by the Monongahela and above by the Greene formation. Its thickness varies, but in this quadrangle is generally 300 to 400 feet.

Distribution.—The largest areas of the Washington formation in this quadrangle lie in its northwest quarter, mostly in Richhill and West Finley townships. On Enslow Fork the formation outcrops to and beyond Simpson Store, on Robinson and Templeton runs to the edge of the quadrangle, on Owens Run for 2½ miles, on Crabapple Creek over 4 miles, on North Fork to within a mile of Bristoria, and on South Fork as far as McCracken. A small outcrop lies between Graysville and the crest of the Washington anticline. Along this anticline south of Crabapple Creek the formation outcrops high up on the hills, and at Jacksonville reaches nearly to their crests. Farther west and southwest, over a considerable area, the Upper Washington limestone is poorly developed and in some places could not be found.

In the eastern part of the quadrangle this formation is exposed only in long, narrow areas along the principal creeks. On Bates Fork it reaches nearly to Deerlick, on Browns Creek to within 2½ miles of Nineveh, on McCourtney Run nearly to Woodruff, on Hargus Creek it outcrops for 2½ miles, and on Pursley Creek for 1½ miles. Throughout the central and southern parts of the quadrangle the formation is not exposed.

General character.—The Washington formation consists mainly of shale, sandstone, thin beds of limestone, and one workable coal bed, but it comprises several minor coals of small extent. No detailed section of the formation has been measured in this quadrangle; but Report K of the Second Geological Survey of Pennsylvania gives a generalized section of the rocks in Greene County, and, as this is fairly representative of the formation, it is given below. Several minor changes have been made in this section to adapt it to the Rogersville quadrangle.

Generalized section of the Washington formation.

	Feet.
Upper Washington limestone	5
Shaly sandstone	20
Jollytown limestone	3
Shale and sandstone	40
Jollytown coal	1
Shale and sandstone	180
Middle Washington limestone	3
Sandstone	18
Black shale	3
Lower Washington limestone	3
Shale	6
Washington coal	3
Shale and sandstone	18
Little Washington coal	1
Sandstone and shale	40
Waynesburg "A" coal	1
Shale	10
Waynesburg sandstone	60

In using this generalized section it should be borne in mind that the various members and the intervals between them vary from point to point, and some of the beds disappear in places.

Waynesburg sandstone.—The next persistent bed above the Waynesburg coal is the Waynesburg sandstone. This is a coarse, flaggy to massive, light-gray to yellowish-gray sandstone, its general features being unlike those of most other sandstone beds in the region. Its name is derived from the town of Waynesburg, near which it is finely exposed, but the outcrops along Dunkard Fork of Wheeling Creek near Durbin are just as typical. It is one of the most conspicuous and persistent sandstones in the upper part of the Carboniferous system, and furnishes a good guide to the position of the underlying coal. Here and there a few feet of shale intervenes between the Waynesburg coal and the Waynesburg sandstone.

In the Rogersville quadrangle the Waynesburg sandstone is most prominent on Dunkard Fork and Crabapple Creek near Durbin, where it crops out in 50-foot cliffs directly above the coal. The rock is here very massive. Where the coal appears on Enslow Fork, however, the sandstone is absent and is represented by shale.

Waynesburg "A" and Little Washington coals.—Two coal blossoms are seen at many places in the interval of 50 feet or more of shale and sandstone above the Waynesburg sandstone and below the Washington coal. These beds are known as the Waynesburg "A" and the Little Washington coals. Probably neither is entirely persistent, nor at any place more than a foot or two thick.

Washington coal.—The Washington is the most persistent coal bed in the Dunkard group. It lies 110 to 170 feet above the Waynesburg coal and a few feet below the Lower Washington limestone. In other areas this coal reaches at some places a thickness of 7 feet, but here it rarely exceeds 4 feet. It is exposed for several miles in the valley of Crabapple Creek and on Dunkard Fork.

Lower Washington limestone.—This is the lowest of the three limestones outcropping near Washington, and is named after that town. It is generally separated from the Washington coal by a few feet of shale, but in places it forms the roof of the coal. Its thickness at some localities reaches 5 feet, but at others diminishes to a mere trace. Its color is variable, but it generally varies from light slate-gray to blue-gray, mottled, or brecciated. Following is a sample section:

Section of Lower Washington limestone 1 mile west-northwest of Ryerson Station.

	Ft.	In.
Limestone	1	8
Shale	1	1
Limestone	1	6
	4	3

Local limestones.—Several other thin limestone beds are found scattered through the Washington formation, but none of them seem to be persistent. One bed between the Lower and Upper Washington limestones, characterized by a yellowish weathered surface, is supposed to be the Middle Washington limestone. The Jollytown limestone, occurring 20 to 40 feet below the Upper Washington, is also found over considerable areas.

Upper Washington limestone.—This is the topmost bed of the Washington formation, and, with the exception of the Waynesburg sandstone, is the most persistent member of the Dunkard group. For this reason it was chosen as the best horizon at which to subdivide the group into formations. It is found from 620 to 750 feet above the Pittsburg coal and from 250 to 400 feet above the Waynesburg coal. These intervals vary irregularly and in no particular direction, but in general the interval between the Upper Washington limestone and the Pittsburg coal is lowest in the northeast corner of the quadrangle and on North Fork of Dunkard Fork, where the limestone dips beneath the surface west of Bristoria. There is some doubt, however, regarding the correct identification of the bed in that area. The position of the top of the Upper Washington limestone is represented on the map by the fine line separating the Washington and Greene formations. Where the limestone is absent or so thin that it could not be found the boundary is omitted.

Where the Upper Washington limestone is well developed it has distinct characteristics. In its most typical exposures, in eastern Washington County, it is dark bluish to nearly black in color on fresh fracture and nearly white on a weathered surface. Along Bates Fork, Browns Creek, Tenmile Creek, McCourtney Run, Hargus Creek, and Pursley Creek, in the eastern part of the Rogersville quadrangle, it presents its characteristic features. The limestone generally is from 5 to 10 feet thick and in some places forms two benches. A measured section is as follows:

Section of Upper Washington limestone in Morris Township.

	Ft.	In.
Limestone, weathering white	2+	0
Shale	0	3
Limestone, weathering yellow	0	3
Shaly limestone	0	3
Limestone, weathering white	2	0
Fire clay shale	1	0
Limestone, weathering white	2+	0
	7	8+

Toward the west the Upper Washington limestone becomes thinner and less typical, and merges more and more into shale. At some places on Enslow Fork it forms two benches, but at the extreme western edge of the quadrangle it has not been found. Over considerable areas it is absent or is doubtfully identified, as is shown on the map by the lack of a definite boundary between the Washington and Greene formations. A limestone with many shaly layers occurs near McCracken about at the horizon of the Upper Washington limestone, but it has none of the distinguishing features of that bed. Directly above the Upper Washington limestone occurs a black fossiliferous shale which contains many impressions of leaves and shells.

GREENE FORMATION.

Stratigraphic limits and thickness.—The Greene formation comprises all solid rocks above the Upper Washington limestone, having in this quadrangle a maximum thickness of 700 to 800 feet. This formation contains the youngest beds in the Dunkard rocks of Pennsylvania. In Aleppo Township, one-half mile northwest of Morford, they form the summit of a knob that rises to an elevation of 1560 feet, 100 feet above the Windy Gap limestone and over 1400 feet above the Pittsburg coal.

Distribution.—By far the greater part of the surface of the Rogersville quadrangle is covered by the Greene formation. It occupies the entire southern and central parts of the area and all of the eastern border except bands in the main valleys, formed of the Washington formation. In Richhill and West Finley townships its base is brought up on the Washington anticline, and it forms only the upper 100 or 200 feet of the hilltops.

General character.—The Greene formation is so variable in character that no general section can be given for the whole quadrangle. In most places it consists of shales and shaly sandstones. A few of the sandstones are massive, and the shales contain thin beds of a reddish color. The formation comprises several thin limestones, which are not persistent over the whole area it occupies, and from two to four thin coals. The important strata are described below.

Tenmile coal.—From 50 to 100 feet above the Upper Washington limestone a small coal bed has been found at several points in the northern part of the quadrangle. Its stratigraphic position is the same as that of the Tenmile coal, found near North Branch of Tenmile Creek in the Amity quadrangle, where at some places it reaches a thickness of 3 feet. In the Rogersville quadrangle it diminishes from that thickness to zero. This coal has been called the "Jollytown coal," but that name is incorrectly used for this bed, for the reason that the term "Jollytown" was first applied to a bed that in other parts of the county lies *below* the Upper Washington limestone.

Dunkard coal.—This bed lies 100 to 160 feet above the Upper Washington limestone and outcrops at many points in the Rogersville quadrangle. It generally occurs in two benches, but is not persistent and is only a foot or two in thickness.

Fish Creek sandstone.—The most prominent sandstone bed above the Waynesburg has been named the Fish Creek sandstone, from Fish Creek, in this county, where it is finely exposed. In stratigraphic position it is 800 to 900 feet above the Pittsburg coal and a few feet above the Dunkard coal. Its maximum thickness seems to be about 60 feet. It consists generally of a coarse-grained rock, varying in character from massive to flaggy, and having a light grayish to brownish color on fresh fracture. On Pennsylvania Fork of Fish Creek, between New Freeport and Deep Valley, it crops out in vertical cliffs 50 feet in height. It is also present in the southern part of Richhill Township and there serves as a guide to the position of the Upper Washington limestone, which is about 200 feet below it. In the eastern part of the quadrangle this sandstone is prominent in several of the ravines tributary to Tenmile Creek west of Rogersville, and between that area and Nineveh. At several points it forms conspicuous cliffs on the hillsides.

So-called "Nineveh" limestone.—About 105 feet above the Fish Creek sandstone lies a limestone bed of local occurrence, which has been called the "Nineveh" limestone. Whether or not it is identical with the limestone that outcrops at Nineveh is not certain. It outcrops on North Fork of Dunkard Fork, where it is 5 to 10 feet thick. It weathers in a peculiar manner, somewhat like shale, and contains much interstratified shale.

Nineveh coal.—This is a thin coal bed which lies 130 to 150 feet above the Fish Creek sandstone. It is not persistent, but it appears at many widely separated points in western Greene County. It is at few places over a foot in thickness and is of no economic importance.

So-called "Nineveh" sandstone.—In the southwestern part of the quadrangle there is a massive sandstone lying about 50 feet above the Nineveh coal. This has been called "Nineveh" sandstone, but some doubt exists as to whether the bed is continuous to Nineveh from the places where it is exposed.

Gilmore sandstone.—At an average distance of 200 to 250 feet above the Nineveh coal there is a prominent sandstone bed named the Gilmore sandstone, from Gilmore Township, where it is well developed. It is generally found on the higher hills in Gilmore, Springhill, Aleppo, and Jackson townships, but is not known farther north. In the southern part of Aleppo Township it is especially well developed. The sandstone is coarse and massive, and it has a maximum thickness of about 30 feet. It forms a prominent bench on the hillsides and frequently crops out in great bowlders or in cavernous cliffs.

Windy Gap coal.—In southern Aleppo and northern Springhill townships a faint coal blossom is sometimes observed a little above the Gilmore sandstone and just below a limestone bed. This is worth mentioning as the highest coal bed in the Dunkard group, although it is very impure and generally consists only of coaly shale.

Windy Gap limestone.—This bed lies a few feet above the horizon of the Windy Gap coal, and 40 to 60 feet above the Gilmore sandstone. It is thin but prominent in the limited area in which it remains uneroded. At Windy Gap this limestone lies about 1340 feet above the Pittsburg coal. This bed was named from its occurrence at Windy Gap, 1.3 miles east of Morford, in Aleppo Township. It outcrops near the top of many of the hills along this part of the Nineveh syncline and occurs over an area of several square miles. It is dark bluish to bluish black in color, and weathers light gray. Minute fossils have been found in it, but the species have never been studied for identification. The bed includes several layers, having an aggregate thickness of 8 to 10 feet. The Windy Gap limestone comes within 110 feet of the highest horizon remaining in the Dunkard.

Red beds.—Throughout the Dunkard group, and especially in the Greene formation, red shale is of common occurrence. The beds are seldom conspicuous in Washington County, but appear in Morris Township of Greene County and become more and more common toward the West Virginia boundary. They occur at no particular horizon, but are generally more abundant in the Greene formation.

Other beds in the Greene formation.—Distributed through the Greene formation are a great number of thin beds of limestone and sandstone. Some of these can be traced for short distances and a few are somewhat persistent. It would be possible to give names to these beds and describe them more fully, but as the upper Dunkard strata will probably never be of much importance in this region, and as few of the beds are traceable for long distances, extended descriptions would be useless. Detailed information regarding these beds can be obtained from Report K, Second Geological Survey of Pennsylvania, 1876.

QUATERNARY SYSTEM.

PLEISTOCENE DEPOSITS.

CARMICHAELS FORMATION.

The scattered deposits of clay, sand, and gravel in the valleys of the creeks above their present level are known, by their composition and by occasional contained crystalline pebbles, to have been formed in Pleistocene time. The formation takes its name from the village of Carmichaels, in eastern Greene County, near Monongahela River. This village is situated in a broad, high-level valley that was at one time followed by Monongahela River, which deposited clay, sand, and silt to depths in places as great as 70 feet.

The deposits at Carmichaels are typical of an extensive system of sediments which occur throughout the main valley of Monongahela River, and on Youghiogheny, Conemaugh, Allegheny, and Beaver rivers and many branches of Ohio River. On Dunkard Fork, in the western part of this quadrangle, a few thin deposits of gravel have been found up to a maximum elevation of about 980 feet. This elevation agrees well with the upper level of the Carmichaels formation throughout the various valleys in which it is found. Small deposits are found on the rock terrace just west of Durbin, and along the sides of the valley for a mile south of Durbin. In general the gravels lie on rock benches and a thin layer of silt overlies the coarser part of the deposit.

The exact manner in which the Carmichaels deposits originated is debatable. They were without doubt laid down at a time when the water was at a higher level than at present and were left on the rock benches by a subsequent lowering of the water. At least three theories have been proposed to account for the method of ponding. They are described in the Masontown-Uniontown, Brownsville-Connellsville, Latrobe, and Amity folios. As the deposits are local in this quadrangle, it is unnecessary to discuss them fully here.

RECENT DEPOSITS.

ALLUVIUM.

The valleys of most of the streams in the quadrangle are very narrow and with a few exceptions the flood plains are not over a few hundred feet wide and too small to map. Only the larger areas of alluvium are indicated on the map. The flood plains are best developed along South Fork of Tenmile Creek, on Browns Creek, and on the branches of Dunkard Fork of Wheeling Creek.

Rocks That do not Reach the Surface.

Importance.—In a region like the Rogersville quadrangle, where the economic products of greatest importance consist of oil, gas, and coal which are found in rocks deeply buried beneath the surface, it is economically important to know the character and sequence of the various formations, even though they do not reach the surface at any point within the quadrangle. A knowledge of these beds is also important to show their horizontal extent and the variations in their character from that shown by them in regions where they outcrop.

Sources of knowledge.—Information concerning these rocks is derived entirely from the records of deep wells bored for gas and oil and is therefore somewhat imperfect. Many of these records have been carelessly kept, and beds that are important from a geologic standpoint, such as coals, bands of red rock, and limestones, have been overlooked or not recorded. In some records only the oil and gas sands have been noted, so that great gaps appear in them. The methods of measurement and the difficulty of identifying rocks by the relative ease with which the drill penetrates them and by the drillings brought up in the sand pump are likely to be sources of considerable error. To errors of this sort may be due in part the lithologic variations recorded in wells not far apart. A heavy sandstone in one well may represent a highly arenaceous shale or shaly sandstone in a neighboring well, and thus be regarded as "slate" or shale. Important beds which are not recorded may not really be absent, but may have been overlooked.

Thickness of the well sections.—The greatest thickness of rocks penetrated by the drill in the Rogersville quadrangle is in a well on the Benson Heirs farm in Aleppo Township, 2½ miles west-northwest of Aleppo. This well is 5322 feet deep, being, so far as known, the second deepest well in the United States. It starts 800 feet above the Pittsburg coal, and reaches a depth of 4722 feet below it. A complete record was not kept, only the coals and principal sandstones being recorded. The rocks of the lower 2032 feet were reported simply as "shells and slate," a phrase that affords no clue to their character. Several wells in the quadrangle reach depths of 2400 to 2500 feet below the Pittsburg coal, and a few give fairly complete records of portions of the strata. Unless otherwise stated, all intervals given in the folio are reckoned from top to top of the respective beds. The beds are described in the order in which they are encountered by the drill, from youngest to oldest.

CARBONIFEROUS SYSTEM.

PENNSYLVANIAN SERIES.

MONONGAHELA FORMATION.

The Monongahela formation includes all rocks comprised between the top of the Waynesburg coal and the bottom of the Pittsburg coal, an interval averaging 330 feet. As explained in the descriptions of surface rocks, only a few feet of the Monongahela formation reaches the surface, and except through its exposures on Dunkard and Enslow forks, the formation is known here only from records of wells.

General character and thickness.—The thickness of the Monongahela formation is well known from records of about 70 wells in the quadrangle, in which both the Waynesburg and Pittsburg coals are recorded. The following table, calculated from the well records, illustrates its variations throughout the area:

Thickness of Monongahela formation in western Greene County.

Township.	Thickness, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	299	353	322	8
Center	310	385	329	9
Richhill	273	374	310	36
Wayne	323	350	335	11
Gilmore	313	340	326	2
Jackson			367	1
Aleppo	279	362	313	8
Springhill	302	405	351	17
General average			332	

As a rule records of wells penetrating the Monongahela formation give little information regarding its character, except as to some of the more prominent coals. In one or two records the rocks comprised within the entire interval of 270 to 400 feet are reported as limestone and shale, which is of course erroneous. The most complete record of the strata is that given by the Cook No. 1 well, in Center Township. The log of the Monongahela formation in this well is as follows:

Monongahela formation in Cook No. 1 well, Center Township.

	Feet.
Coal, "Fairview" (Waynesburg)	3
Sand, gray	20
Slate and shells	40
Limestone (Benwood)	30
Slate	25
Sand	30
Shells	50
Slate, black	22
Coal, Mapletown (Sewickley)	3
Slate	30
Shells	25
Lime, very hard	15
Slate, black	22
Coal, Pittsburg	5
	320

The term "shells," which occurs frequently in well records of this region, does not signify fossil shells of organisms, the commonly understood meaning of the word, but is used in a sense given to it by the well drillers, meaning thin alternations ("shelly" layers) of sandstone, shale, and sandy shale.

The names given in parentheses are the true geologic names of the beds, and have been added to the log by the geologist. In this record, as originally copied, the name Waynesburg was applied to a coal bed 243 feet above the "Fairview," but this is evidently a mistake. Below are descriptions of the individual beds of the Monongahela formation, so far as they are known, except the Waynesburg coal, which was described in connection with the surface rocks.

Uniontown coal.—In the records of several wells, all of which except one or two are situated in Richhill Township, a thin coal is reported at a distance varying from 53 to 105 feet below the top of the Waynesburg coal and 229 to 263 feet above the Pittsburg coal, the averages being 77 and 238 feet, respectively. This coal corresponds in position with the Uniontown seam, a well-known bed east of Monongahela River. Where this seam has been opened in eastern Greene County it is of little value.

Benwood limestone.—The bed of limestone reported in the Cook well 63 feet below the Waynesburg coal occupies the upper part of an interval which is marked by a thick deposit of limestone in the Monongahela and Ohio valleys. This limestone has recently been called the Benwood, from the town of that name near Wheeling, W. Va., where it is typically exposed. Where it is best developed at the surface this limestone is over 150 feet thick, and consists of an upper and lower bed separated by shale.

Sewickley (Mapletown) coal.—With the exception of the Pittsburg seam, the coal bed most frequently reported in this formation is the Mapletown coal. This is equivalent to the Sewickley bed of the First Geological Survey of Pennsylvania and to the Meigs Creek coal of Morgan County, Ohio. The name Mapletown was also applied to the coal, from the village of that name in eastern Greene County, Pa. This coal is reported to range in thickness from 3 to 10 feet.

The interval between this coal and the Waynesburg varies from 185 to 303 feet, and its distance from the Pittsburg varies from 79 to 120 feet. In Springhill Township the variation is from 95 to 119 feet, and 45 of the 74 records in that township make it exactly 100 feet. The intervals between the Sewickley coal and the Waynesburg and Pittsburg are shown in the following tables:

Interval between Sewickley and Pittsburg coals.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	94	120	104	5
Center	79	117	99	4
Richhill	80	120	104	28
Wayne	83	107	92	13
Gilmore	90	113	102	3
Jackson	86	120	99	15
Aleppo	90	110	101	41
Springhill	95	119	102	73
General average			100	182

Interval between Sewickley and Waynesburg coals.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Center	232	290	261	2
Richhill	185	225	206	19
Wayne	225	250	238	7
Gilmore			202	1
Jackson	220	270	245	2
Aleppo	195	303	225	7
Springhill	187	297	247	13
General average			232	51

Pittsburg coal.—The coal lying at the base of the Monongahela formation is the thickest and least variable seam in western Pennsylvania and the most valuable in the bituminous coal field. It is the only stratum that is reported in practically every well record in the quadrangle. In thickness this seam varies from 6 to 13 feet, and, so far as known, it can be mined throughout this area.

CONEMAUGH FORMATION.

Thickness.—The rocks known as the Conemaugh formation comprise all those between the Pittsburg coal above and the Upper Freeport ("Connellsville" of the drillers) coal below, both coals being excluded from the formation. (The use of "Connellsville" by the drillers for the Upper Freeport must not be confused with the use of "Connellsville" for the Pittsburg coal which is so extensively coked in that district.) The thickness of this formation in Pennsylvania varies from 500 to over 700 feet. In this quadrangle it is known only from well records, and, as in the majority of cases no coal has been recorded below the Pittsburg bed, little evidence is at hand by which to judge its thickness. The following records contain mention of a coal bed which lies 550 feet or more below the Pittsburg coal and which is supposed to be the Upper Freeport:

Interval between bottom of Pittsburg coal and top of "Connellsville" coal.

Name of well.	Township.	Interval, in feet.
Wm. Millikin No. 2	Center	570
Ezra Sayers No. 1	Richhill	658
Grant Burns No. 1	Richhill	670
Crow No. 1	Richhill	655
Fletcher No. 1	Richhill	685
Thomas Blair No. 1	Richhill	647
Harvey No. 1	Richhill	664
Gray and Gribbon No. 1	Richhill	631
J. B. Fordyce No. 1	Gilmore	681
Benson Heirs No. 1	Aleppo	630
Average thickness		649

It will be seen that the intervals range from 570 to 681 feet. Assuming the "Connellsville" coal to be the Upper Freeport in every case, the average thickness of the Conemaugh formation in this quadrangle is 649 feet.

General character.—This formation consists principally of alternating shales and sandstones, although thin limestones and some thin coal beds occur in it. In this part of Pennsylvania it always contains a considerable number of red shale beds. These are not found at any one horizon, but are generally distributed through the upper 500 feet of the formation.

Few well records in the Rogersville quadrangle give the Conemaugh beds in detail, but the general character of these beds can be seen from the columnar section sheet. The best record is probably that of the William Milliken No. 2 well, 2 miles southeast of Graysville, which is given below:

Conemaugh formation in William Milliken No. 2 well, Center Township.

	Feet.
Pittsburg coal.	
Slate	60
Red rock	10
Slate and "shells"	52
Red "cave"	30
Lime	10
Slate	26
Sand, Murphy	20
Slate	60
Red "cave"	45
Slate	65
Sand, Little Dunkard	19
Slate	120
Sand, Hurry-up or Big Dunkard	31
Slate	22
Upper Freeport coal below.	
	570

Lest it be supposed that the various beds in the above section are definite and persistent, another section is given for comparison. This occurs in the Michael Funk No. 3 well, in Morris Township, 1½ miles west of Nineveh. As no Freeport coal is mentioned in this record, the determination of the base of the formation can not be made with certainty.

Conemaugh formation in Michael Funk No. 3 well, Morris Township.

	Feet.
Pittsburg coal.	
Limestone	30
Sand, white	100
Red rock	35
Limestone (Murphy sand)	40
Slate, white	35
Red rock	45
Slate, black	35
Sand, white (Little Dunkard)	40
Slate, black	60
Sand (Big Dunkard)	50
Slate, black	60
Base of formation indefinite.	

Where this formation outcrops it contains only thin limestones, and it therefore seems probable that most of the "limestone" mentioned in records of Conemaugh rocks is in reality sandstone.

Sandstones.—Several more or less persistent sandstone beds are recorded in the Conemaugh formation, and three of them have been named by the drillers. Their appearance in records does not necessarily mean that sandstones are absent elsewhere in the formation, but that the names have been applied to certain beds which are fairly persistent and which the drillers believe they can generally recognize. The sandstones in the Conemaugh formation and coal-bearing rocks generally are not persistent beds underlying the whole surface, but occur in the form of lenses in the various formations.

Below the Pittsburg coal the most conspicuous sandstone is that known to drillers as the "Murphy

sand." It lies at most places from 170 to 200 feet below the coal, but in Springhill Township the interval is at many places as much as 240 feet. The thickness of this sandstone ranges from 5 to 30 feet, and is exceptionally as much as 70 feet. In stratigraphic position it corresponds approximately with a prominent bed at the surface in southwestern Pennsylania and northern West Virginia known as the Morgantown sandstone, named from Morgantown, W. Va.

Between the Murphy sand and the Upper Freeport coal lie two rather important sandstone beds, known to well drillers as the Little Dunkard sand and Big Dunkard sand. The former lies 300 to 420 feet below the Pittsburg coal, and varies in thickness from 30 to 100 feet. This sandstone corresponds in position in the geologic column with a lenticular bed that outcrops extensively farther east in the State and is known over considerable areas as the Saltsburg sandstone, from its typical outcrop near Saltsburg, Pa.

The Big Dunkard sand lies below the Little Dunkard and generally from 420 to 600 feet below the Pittsburg coal. Its thickness is variously recorded, ranging from 20 to 150 feet. At some places this sandstone rests directly upon the Upper Freeport coal, but generally it is separated from the coal by a bed of shale. The representative of the Big Dunkard sand on the surface in western Pennsylvania is known as the Mahoning sandstone, and, like the Saltsburg, it is conspicuous over wide areas.

At some places the Little Dunkard and Big Dunkard are distinct beds; at others the two sandstone beds are practically in contact. The interval between them may be as much as 150 feet, but more often it is under 100 feet. Another name for the Big Dunkard sand, often used by the drillers in this quadrangle, is the Hurry-up sand. In one or two records the name Cow Run is applied to the Little Dunkard, for the reason that it lies at about the horizon of the First Cow Run sand of Ohio.

Red shale beds.—The most conspicuous strata in the Conemaugh formation are beds of red shale, which are reported in many records. These may be found anywhere in the interval extending from a horizon 30 feet below the Pittsburg coal down to the top of the Big Dunkard sand, but they are most abundant in the upper part of this interval, most of them lying above the Little Dunkard sand. If the records are trustworthy the red beds in some wells have a total thickness of 200 feet or more.

ALLEGHENY FORMATION.

Beneath the Conemaugh lies the Allegheny formation. This is defined as extending downward from the top of the Upper Freeport ("Connellsville") coal to the top of the Pottsville sandstone (Salt sand).

Thickness.—Where it is exposed in western Pennsylvania, this formation ranges in thickness from 270 to 370 feet, probably averaging about 300 feet. In the southwest corner of the State, where it is under deep cover, it is not easy to make definite determinations, as few complete records have been kept in this region. In general, however, these limits are believed to be about the same throughout this quadrangle. In the southwest corner of the quadrangle the thickness is possibly as low as 230 feet.

General character.—The Allegheny formation consists of sandstones, shales, and some thin limestones. Wherever it is exposed in western Pennsylvania it also contains several valuable coal beds. In the Rogersville quadrangle the most detailed section is furnished by the William Milliken No. 2 well, as given below. The driller has noted both the Upper Freeport coal and the Salt sand, and therefore the record furnishes a fairly good measure of the formation. Names in parentheses have been added by the geologist.

Allegheny formation in William Milliken No. 2 well.

	Feet.
Coal (Upper Freeport)	4
Slate and shells	25
Lime cave	35
Slate	86
Coal (Upper Kittanning?)	5
Slate	45
Sand (Gas sand)	115
Slate	52
Salt sand below.	
	367

Rogersville.

Nine records, most of them in Richhill Township, which give both the "Connellsville" coal and the Salt sand, make the greatest interval between them 367 feet, the least interval 241 feet, and the average 282 feet. Of course there is no certainty that the coal is correctly identified, and in some cases another bed than the Upper Freeport may have been noted.

Sandstones.—Sandstones occur at several horizons in the Allegheny formation. On the surface these beds are known as the Upper Freeport, Lower Freeport, Kittanning, and Clarion sandstones, each bed being identified by its position in the formation. Only one of these sandstones is recognized by the drillers in this region, and that is the Gas sand, which occurs from 650 to 850 feet below the Pittsburg coal. This bed reaches at some places a thickness of 150 feet; at others it is much thinner or entirely absent. It is not probable that this forms a definite or persistent bed; the name seems to have been applied to any sandstone found between the Big Dunkard sand and the Salt sand. In general, the Gas sand occurs at about the horizon of the Kittanning or Clarion sandstone in the lower half of the formation.

Coals.—The principal coal bed of the Allegheny formation seems to be the Upper Freeport ("Connellsville") coal, at the top of the formation. This is reported in about a dozen wells in the quadrangle. Little is known of the other coals of this formation. In the Allegheny Valley at least five workable seams are found, but how many of these extend beneath this corner of the State is not known. Several wells, of which the William Milliken No. 2 is an example, record a bed 150 feet below the Upper Freeport, and this probably represents one of the Kittanning beds. In the J. B. Fordyce well, in Gilmore Township, the name "Connellsville" is applied to a 5-foot bed of coal 725 feet below the Pittsburg. Forty-four feet above this, and directly underneath the Big Dunkard sand, there is a bed of coal 3 feet thick. It seems probable that the former is the Upper Freeport ("Connellsville") bed, in which case the lower of the two seams may be the Lower Freeport or Upper Kittanning coal. This coal bed lies only 197 feet above the Salt sand. The "Connellsville" coal reported in other wells may be the Lower Freeport instead of the Upper Freeport seam, in which case the Allegheny formation is in places thicker than its maximum estimate given above.

POTTSVILLE FORMATION.

This formation is the lowest in the Pennsylvanian series. It lies directly beneath the Allegheny formation, and at most places rests unconformably on the Mauch Chunk formation. It is the Salt sand of the well drillers.

Character and thickness.—In portions of Pennsylvania where it is exposed the Pottsville consists of two massive members, the Homewood and Connoquenessing sandstones, separated by a thin bed of shale, which generally carries fire clay and coal beds. This shale is known as the Mercer member. As recorded in wells in the Rogersville quadrangle the formation consists of a single sandstone, variously reported as from 70 to 200 feet thick, but it is possible that the shale may have been overlooked. Only one well, on the Orndorf farm in Richhill Township, reports coal in the Salt sand. This formation contains more salt water than any other formation, as its name would indicate.

MISSISSIPPIAN SERIES.

MAUCH CHUNK FORMATION.

Limits.—The Mauch Chunk formation may be defined as including the rocks below the Pottsville sandstones (Salt sand) and above the Burgoon (Big Injun or Pocono) sandstone.

Character and thickness.—The interval between the base of the Salt sand and the top of the Big Injun varies in this quadrangle from 100 to 270 feet, being generally less toward the north. The lower portion of the Mauch Chunk formation consists of a limestone bed that is known to drillers as the Big lime. This is the thin edge of the Greenbrier limestone of Virginia, which outcrops farther east in Pennsylvania on Chestnut Ridge and Laurel Hill, and has also been called the "Mountain limestone." This limestone varies in thickness from 30 to 100 feet. Directly above it are a few feet of a soft shale which breaks up in a very peculiar manner into small splinters. This is rapidly cut by the drill, as it emerges from the harder rock above, and tends to "cave in." On account of this tendency and of the pencil-like fragments into which the rock breaks this shale bed is known as the "pencil cave."

Above the "pencil cave" lie from 20 to 70 feet of a rock which in the northern part of the area is generally called the Little lime. In some records, however, it is classed as a part of the Big lime, which lies below the "pencil cave." In Aleppo and Springhill townships the upper bed is most frequently reported as sandstone, the term Salvation sand being generally applied to it. In West Virginia this is called the Maxton sand.

The character of the Mauch Chunk formation above the limestone is variable, but at many places in this region it comprises a mass of red shales 100 feet or less in thickness. In other portions of the State red shales constitute the greater part of the Mauch Chunk, and for that reason the formation is often known as the Mauch Chunk red shale. In the Rogersville quadrangle the shale is reported red only in Wayne and Center townships.

Complete sections of the Mauch Chunk formation are scarce in this quadrangle, and as there is no certainty that the base of the Salt sand coincides at all places with the bottom of the Pottsville formation, we have no means of accurately measuring the thickness of either formation. Since many records report only 50 to 100 feet of Salt sand, it seems probable that the lower part of the Pottsville formation is at some places composed of shale. The majority of the records report black shales between the Salt sand and the Little lime, and it is not known whether these shales are of Mauch Chunk or Pottsville age.

Unconformity at top of the Mauch Chunk.—The irregularity in thickness of this formation throughout western Pennsylvania is caused by an unconformity between the Pottsville and the Mauch Chunk formation, due to erosion after the deposition of the Mauch Chunk and before that of the Pottsville. This unconformity is not shown by differences of dip, but is determined from evidence afforded by fossil plants. It has been traced along the Carboniferous basin from Pennsylvania to Alabama and eastward in Pennsylvania at least as far as the Allegheny Front. In the northern part of the State the Mauch Chunk is absent, presumably having been removed by erosion, and the massive sandstones of the Pottsville rest in places upon almost equally heavy sandstones of the Pocono formation. In Washington and Greene counties the thickness of the Mauch Chunk formation decreases toward the northwest, indicating that erosion was greatest in that direction.

The thinning is illustrated by records of wells drilled in the Amity quadrangle, which lies northeast of this area. Sections of wells drilled in the northwestern portion of that quadrangle show that the Mauch Chunk formation in that area is not over 100 feet thick, and at some places much thinner, while at some localities in the southeastern part of that quadrangle it is as much as 200 feet thick. The red shales are prominent in the eastern part of Washington and Greene counties, but die out toward the northwest. In northwestern Washington County the Salt sand in some places rests directly upon the Big Injun, the Mauch Chunk having been wholly removed by erosion.

The incompleteness of the records in the Rogersville quadrangle prevents any very detailed statements about this unconformity. The best information at hand is that gathered from a compilation of the intervals between the Pittsburg coal and the Big Injun sand. These are represented by isochore lines in fig. 3, in which the interval is the same at all points along any one line. These lines show a decrease in the thickness of the formation toward the north. At many points these lines may be somewhat in error, owing to the fact that few steel-line measurements have been made to the Big Injun sand. Just where the Mauch Chunk disappears and whether the black shale between the Salt sand and Big Injun sand is Mauch Chunk or Pottsville, are questions that can not now be definitely answered.

POCONO FORMATION.

Stratigraphic limits, character, and thickness.—The Pocono is the lowest formation in the Mississippian series and in the Carboniferous system. Its upper limit is the top of the Big Injun sand of the drillers, which corresponds with the Burgoon sandstone of the Allegheny Front. The formation extends downward 300 to 860 feet, according to different views. Considerable doubt exists as to the true position of its base, as there is a strong resemblance between its rocks and those of the Chemung formation, at the top of the Devonian. Even where these outcrop it is difficult to make a definite separation between them. The evidence regarding this question is given on page 6. As the "Nineveh" sand, at the top of the red shale, is also red in some places, its top marks a distinct horizon, which will be provisionally regarded as the top of the Devonian. In this folio the Pocono is considered as including certain strata of doubtful age that directly overlie the Catskill red shales of the Devonian system. As thus defined the Pocono formation in this quadrangle has an average thickness of about 850 feet.

One of the best sections of Pocono rocks in this quadrangle is furnished by the Cook No. 1 well, in Center Township.

Pocono formation in Cook No. 1 well, Center Township.

	Feet.
Sand, Big Injun	261
Slate	35
Shells	30
Sand and shells	30
Slate	50
Sand, hard, gray	30
Slate	35
Shells, very hard	20
Sand, close, gray	20
Slate	40
Sand, gray, very hard	15
Shells	10
Slate	30
Sand	45
Slate	10
Sand	61
Slate	25
Shells (Gantz)	22
Slate	10
Sand, hard (Fifty-foot)	48
Slate	36
	853

The record of the D. A. McCracken well, in Richhill Township, is not quite so complete as this, but it is published here for the reason that it notes the red shale (Bedford) between the Thirty-foot and Gantz sands.

Pocono formation in D. A. McCracken No. 1 well, Richhill Township.

	Feet.
Sand (Big Injun; break in sand 75 feet from its top)	250
(Not recorded)	80
Sand, Squaw	75
Slate	155
Sand (Thirty-foot)	100
Slate	25
Sand, red	12
Sand, white (Gantz) and slate	63
Sand, Fifty-foot	52
Slate	30
	842

Sandstones.—This formation contains four principal sandstone horizons—the Big Injun, Thirty-foot, Gantz, and Fifty-foot sands. The most important of these geologically is the Big Injun, or "Mountain" sand. In portions of Pennsylvania where it outcrops it now goes by the name of Burgoon sandstone, from Burgoon Run, near Kittanning Point, on the Allegheny Front. In Greene County this bed of sandstone ranges in thickness from 200 to 300 feet, and is persistent. A "break" of shale 50 feet or less in thickness is found in some wells about or somewhat above the middle of the bed. This "break" is reported in the S. S. Iams No. 1 well, in Center Township, and in the J. C. Cole No. 1 well, in Wayne Township.

In this quadrangle—except, possibly, in its northwest corner—the top of the Big Injun sand lies immediately beneath the Greenbrier limestone, and this line of contact forms a definite datum for measuring intervals. The interval from the Pittsburg coal to this sandstone varies from 1073 feet in the David Stickle well, near Simpson Store, to 1297 feet in the Kuhn Heirs well, near Hoovers Run. A comparison of the figures given in the various fields shows a very noticeable increase in this interval toward the south. The variation is known to be due largely to the unconformity at the top of the Mauch Chunk formation, although slight differences may be caused by variations in thickness due to unequal deposition. The following table gives the measurements of this interval in various parts of the quadrangle.

Interval from top of Pittsburg coal to top of Big Injun sand.

Location.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Fonner field	1175	1185	1185	2
Northwest of Deerlick.	1194	1194	1194	2
Between Rogersville and Deerlick.	1120	1225	1177	4
Nineveh field	1168	1213	1194	9
East of Graysville	1147	1215	1174	5
Richhill field	1073	1215	1149	18
East of Rogersville			1245	1
Hoovers Run field	1225	1297	1259	20
Gilmore Township	1275	1288	1280	3
Between Holbrook and White Cottage.	1203	1268	1236	7
Bristoria field	1180	1280	1221	124
New Freeport field in Aleppo Township.	1171	1255	1223	49
New Freeport field in Springhill Township.	1177	1265	1239	91
Board Tree field	1240	1269	1250	5
Aleppo field	1215	1248	1227	13
Northwestern Aleppo Township.	1119	1195	1175	4
Southwestern Richhill Township.	1120	1210	1149	4
Wright Run field	1200	1234	1215	3
General average			1211	

Most of the well records show that an interval of 250 to 300 feet below the Big Injun is occupied by "slate," or "slate and shells," but in a few wells the Squaw sand occurs 50 to 100 feet below the base of the Big Injun. In places this sand is 100 feet thick, though it generally runs about 50 feet. In the Amity quadrangle it is a rather persistent bed.

Below the Squaw and 550 to 620 feet below the top of the Big Injun lies the Thirty-foot sand. The name Thirty-foot does not represent its general thickness, however, for it reaches at some places a thickness of 100 feet or more. The interval from the top of this sandstone to the Pittsburg coal ranges from 1729 to 1882 feet. The stratigraphic position of this sandstone is not definite, but it corresponds approximately with the Berea sand of Beaver and northern Washington counties, with the Butler gas sand of northern Pennsylvania, and with the Berea grit of Ohio. It is difficult to decide whether a sandstone that lies at about this position in some wells of this quadrangle is the Thirty-foot or Gantz sand, but this question can generally be settled by noting the positions of all red beds cut by the drill, as the red rock provisionally correlated with the Bedford shale of Ohio lies between the Thirty-foot sand and the Gantz sand, and the next lower red bed occurs at the horizon of the Nineveh sand, 100 to 200 feet deeper.

In Washington County the Gantz sand, the next sandstone below the Thirty-foot, is a very persistent bed and a prominent oil horizon, and the same is true in the Fonner field, in the northeast corner of Morris Township, Greene County. Throughout the northern part of the Rogersville quadrangle this sandstone can generally be distinguished in the borings, though it sometimes thickens and unites with the Fifty-foot sand, next below. The Gantz is recorded throughout Richhill Township and in some borings in northwestern Aleppo Township, but seems to disappear in the Bristoria and New Freeport oil fields and generally throughout the southern half of the quadrangle. Where this sandstone is distinct from the Fifty-foot sand it generally ranges in thickness from a trace to 20 feet, although in Morris Township it is in some borings over 40 feet thick. As explained on this page, the Gantz sand represents the upper portion of the Hundred-foot sand of Beaver, Butler, and Allegheny counties, and this is supposed to be equivalent to the First sand of Oil Creek, Pennsylvania. Where present, the Gantz ranges from 100 to 200 feet below the top of the Thirty-foot, and 1850 to 1950 feet below the Pittsburg coal. The figures are given in the next table.

Where the Gantz sand and Fifty-foot sand are developed separately they are in some places as much as 40 feet apart, but usually the interval between them is much less. The Fifty-foot sand comprises the lower portion of the Hundred-foot sand. The interval between the Pittsburg coal and the Fifty-foot sand ranges from 1900 feet in a well on the John Ackley farm, 1 mile northeast of Video, in Richhill Township, to 2034 feet in Springhill Township. The variation in this interval is not regular, but it shows no such great extremes as that between the Pittsburg and the Big Injun. In a general way the measurements in the southern part of the quadrangle average 30 to 40 feet greater than those in the northern half.

Owing to the relations of the Gantz sand to the Fifty-foot, it is not always possible to determine whether the top of a sandstone occurring at about this horizon is the one or the other.

Interval between top of Pittsburg coal and top of Gantz sand in the northern two-thirds of the Rogersville quadrangle.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	1870	1931	1916	10
Center	1864	1946	1894	3
Richhill	1850	1907	1876	12
Northern Aleppo	1913	1945	1925	7
General average			1903	

Interval between top of Pittsburg coal and top of Fifty-foot sand.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	1905	1966	1948	13
Richhill	1900	1992	1954	35
Center	1907	1995	1951	13
Jackson	1930	1995	1968	77
Aleppo	1913	2021	1978	96
Wayne	1933	1980	1955	15
Springhill	1952	2034	1982	95
General average			1962	

The interval between the Big Injun and Fifty-foot sands varies from 674 to 845 feet, the extremes occurring in the J. B. Coen well, 2¾ miles south of Hoovers Run, and in the Barney Wiley well, 2½ miles west-southwest of Ryerson Station, both wells being a little outside the borders of the quadrangle. The variation is shown by the table given below:

Interval between top of Big Injun and top of Fifty-foot sand.

Township.	Interval, in feet			Number of records considered.
	Least.	Greatest.	Average.	
Morris	710	815	754	11
Richhill	690	845	762	31
Center	715	772	755	13
Jackson	686	765	745	75
Aleppo	690	835	756	96
Wayne	674	725	702	14
Gilmore			706	1
Springhill	675	805	742	93
General average			753	

On comparing this group of measurements with those of the interval between this sandstone and the Pittsburg coal it is seen that, while the first group shows an evident thinning toward the north, the second group gives a much better agreement of the averages, and the thinning is in the opposite direction—from north to south. The lowest averages are in the southeastern townships. The cause of this divergence is evidently a lessening of the interval between the Big Injun sand and the Pittsburg coal, which is supposed to be due largely to the unconformity at the top of the Mauch Chunk formation, though it is in part due to a slight diminution in the thickness of the Pocono formation toward the southeast.

The Fifty-foot sand is at most places directly underlain by a bed of shale, 10 to 40 feet thick, which is regarded as the lowest bed in the Carboniferous system.

Red shale (Bedford?).—The red shale mentioned above as occurring between the Thirty-foot sand and the Gantz sand, and probably belonging in the Bedford group, is noted in the records of many wells in the Rogersville quadrangle, and serves as a key rock in the correlation of the overlying and underlying sandstone beds.

This red shale deserves more attention than it has hitherto received. As has been said, it is generally present beneath the Amity and Burgettstown quadrangles, and has been noted in Beaver County. Toward the southeast, however, it is not known. Several years ago this bed was traced by means of well records and shown to extend beneath the surface in Forest, southern Venango, and western Butler counties in Pennsylvania, and in eastern Ohio as far west as its outcrop along the Cincinnati anticline. (Second Geol. Survey Pennsylvania, Rept. I^5, 1890.) Since then considerable drilling has been done in Washington and Greene counties, and the red shale is there found to be present some distance farther southeast. Where it is best developed in western Pennsylvania it is 100 feet thick.

In the Rogersville quadrangle this bed is reported in Morris, Richhill, Aleppo, Springhill, Gilmore, and northwestern Center townships, but is not known in Wayne, Jackson, or eastern and southern Center, nor farther east in Greene County. Its thickness is not generally over 10 or 20 feet.

Base of the Pocono.—As already stated, the position of the base of the Pocono formation has been differently determined by different authorities. The accurate placing of the lower limit of this formation is rather important in a geologic discussion, and for this reason the latest evidence on the subject will be given.

In the Uniontown quadrangle, surveyed several years ago, characteristic Chemung fossils were found only 2 feet below the bottom of the Burgoon (Big Injun) sandstone. The Pocono was accordingly considered to be limited to the Burgoon sandstone, which is but 300 feet thick, and which was divided from the Chemung at the base of this sandstone. This limitation was fixed in the Masontown-Uniontown, Brownsville-Connellsville, and Waynesburg folios.

In the Latrobe and adjacent quadrangles a bed of red shale has been recognized from 350 to 500 feet below the top of the Big Injun sand, and has been correlated with the red Patton shale, which outcrops at Patton on Redbank Creek in Jefferson County. The Patton shale carries fossil plants which have been identified as of Pocono age. The Pocono formation in that region is therefore considered to be at least 400 to 500 feet thick.

The measured Pocono outcrop nearest to this quadrangle is on the Allegheny Front along the Pennsylvania Railroad east of Bennington, in Blair County. The rocks there contain Pocono fossils, and although the base was not definitely determined the formation appears to be about 1000 feet thick. This section is described in considerable detail in the Kittanning folio. A group of red shales 1000 feet below the top of the Burgoon sandstone is probably the Catskill beds at the top of the Devonian. These shales and the beds between them and the top of the Burgoon have been correlated with beds in similar positions in the Bennington section. According to that correlation, the post-Catskill beds in the Kittanning quadrangle are likewise of Pocono age, and they have been so considered. As these red beds lie not far below the Hundred-foot (Gantz and Fifty-foot) sand of that region, it follows that the Hundred-foot, Big Injun, and intervening sands are all to be included in the Pocono, and that the division between the Carboniferous and Devonian systems should be made at the top of the first red bed below the Hundred-foot sand.

The horizon of the Hundred-foot sand and the underlying red shale (Catskill) has been traced through Butler County and the Beaver quadrangle by comparison of a large number of well sections. In the Beaver folio the upper limit of the Devonian is placed at the top of the first red shale below the Hundred-foot sand. On this basis the Pocono in the Beaver quadrangle is 800 to 900 feet thick.

Between the Beaver and Rogersville quadrangles the strata seem to become more variable by reason of the thickening of the Mauch Chunk formation, but the top of the Big Injun sand is nearly everywhere definite and can be used as a datum surface for the comparison of intervals. Many well records in the Burgettstown quadrangle indicate that the Hundred-foot sand of the northern counties is equivalent to the Gantz and Fifty-foot sands of Washington County, and the tracing from Washington into Greene County is equally certain. In the same way the Berea sand of Ohio and of the "Panhandle" of West Virginia has been traced across Washington County and found to occur at the same horizon as the Thirty-foot.

Another argument in favor of including these lower beds in the Pocono is furnished by the bed of red shale which in the Beaver, Burgettstown, and Amity quadrangles is reported in many well records a short distance below the Thirty-foot sand and above the Gantz sand. By means of well borings this bed has been traced into the Beaver quadrangle, and thence into Ohio, and shown to be probably equivalent to the Bedford shale, of lower Pocono age, though the correlation is not certain.

A group of red shale beds similar to those called Catskill or sub-Blairsville in the Latrobe and Kittanning folios is reported in the Amity quadrangle in all the detailed well sections that have penetrated that horizon. In the Rogersville quadrangle the beds are present, though thinner, but die out toward the west. They are shown graphically in the well sections on the columnar section sheet.

Thus by tracing the beds through well records from the east and from the north, two dissimilar conclusions are reached. When traced from the east there seems to be little question that the Pocono formation as a whole is equivalent to the Big Injun sand. When traced from the north the formation seems to be about three times as thick, including also the Thirty-foot, Gantz, and Fifty-foot sands.

From the above considerations it seems more probably correct to include the Gantz and Fifty-foot sands in the Pocono, and the base of the Carboniferous is accordingly drawn at the top of the uppermost red bed (the Nineveh sand, which is sometimes red) between the Fifty-foot and Bayard sands. It is probable that the disagreements of various writers in estimating the thickness of the formation are due to a merging of the Devonian and Carboniferous rocks and consequent indefiniteness of the division plane rather than to incorrectness of observation or actual variations in the thickness of the Pocono formation. If the two formations merge, we should expect to find some Chemung species living on in Pocono time, and their occurrence as noted in the Uniontown quadrangle would not be out of harmony with other observations.

DEVONIAN SYSTEM.

CHEMUNG FORMATION.

General character.—Throughout the Rogersville quadrangle the Devonian rocks lie far below the surface, never approaching nearer than many hundreds of feet from it. As has been said, the top of this system is very indefinite, but is provisionally fixed at the top of the first red beds below the Fifty-foot sand. Since the Nineveh sand is frequently reported as red sand, the boundary is drawn on the top of this bed.

The Benson Heirs well, in Aleppo Township, was drilled into Devonian rocks for about 2500 feet, but most of the wells in the quadrangle reach only 100 to 500 feet into the Chemung. The strata below the Pocono pierced by wells in this quadrangle are believed to belong entirely to this formation, as in areas where the Chemung rocks outcrop they are generally several thousand feet in thickness. The character of the Chemung rocks varies from very sandy to very shaly, most of the sandstone beds occurring as lentils. Near the top of the formation a number of beds of red shale or sandstone are found.

One of the most complete sections in the quadrangle is that of the Thomas Grove No. 1 well, in Center Township.

Upper part of the Chemung formation in Thomas Grove No. 1 well.

	Feet.
Sand, gray (Nineveh)	11
Red rock, slate, and shells	30
"Cave"	5
Sand (Gordon)	37
Slate and shells	18
Red rock	57 (?)
Sand (Fourth)	23
Sand, hard, shells and slate	45
Sand (Fifth)	35
Slate	105

This section is not deep enough to reach the Bayard sand and Elizabeth sand, which average 130 and 200 feet, respectively, below the top of the Fifth sand.

Catskill (sub-Blairsville) beds.—All the complete records in this quadrangle report one or two beds of red shale or sandstone near the top of the Chemung formation. These occur at the same horizon as the red beds which lie 900 to 1000 feet below the top of the Big Injun beneath a wide area in

western Pennsylvania and which were named in the Latrobe folio the sub-Blairsville beds, for the reason that they were found in wells near the town of Blairsville, in Indiana County, Pa. They are believed to be the westward feathering out of the Catskill formation, which is several hundred feet thick in eastern Pennsylvania and the Catskill Mountain region. The peculiar conditions under which the Catskill beds were formed are described under the heading "Historical geology."

The detailed character of this group, which includes the red beds, can be seen from the well sections at the end of this folio. The individual red beds range from 10 to 50 feet in thickness, and are generally two in number, although there are four or five a short distance east of the quadrangle. In the Latrobe quadrangle their thickness reaches 300 to 400 feet and there the Catskill beds become more of a stratigraphic unit than here. In the Rogersville quadrangle either the uppermost red beds are commonly found directly under the Nineveh sand, or that bed itself is red. This band of red shale rock is a good marker for the Nineveh sand. The second principal bed is less persistent. It lies 75 to 100 feet below the first, and between the Gordon sand and Fourth sand. In wells where these beds are present, therefore, the Nineveh and Gordon can almost certainly be identified. In several records in Richhill Township and elsewhere a "pencil cave" is reported between the Nineveh and Gordon beds. This must not be confused with the "pencil cave" more commonly recorded, which occurs in the Mauch Chunk formation.

The Catskill red beds should be carefully distinguished from the Bedford red shale, which occurs between the Thirty-foot and Fifty-foot sands. The red Catskill increases in thickness toward the east, while the Bedford disappears in that direction and becomes more prominent toward the northwest. The former has been proved to be Devonian; the latter, where it outcrops in Ohio, is of Mississippian age.

Sandstones in the Chemung.—The principal sandstone horizons of the Chemung formation are known to well drillers from the top downward as the Nineveh, Gordon Stray, Gordon, Fourth, Fifth, Bayard, and Elizabeth sands.

The Nineveh sand ranges in thickness from 10 to 40 feet, averaging about 20 feet, and its distance from the top of the Fifty-foot sand in the Pocono varies from 60 to 130 feet. It is at some places gray and at others red in color, and in complete well records it may generally be recognized by the presence of red rock directly below it. The interval between the Pittsburg coal and the Nineveh varies from 1997 to 2121 feet, as shown in the table given below. Most of the original records show mistaken identification of "sands," and it has been necessary to interpret them in calculating the average intervals.

Interval between top of Pittsburg coal and top of Nineveh sand.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	2028	2110	2055	6
Richhill	1997	2054	2036	32
Center	2005	2120	2039	8
Jackson	2024	2065	2044	66
Aleppo	2018	2098	2056	101
Wayne	2033	2045	2039	2
Gilmore	2065	2113	2089	2
Springhill	2033	2121	2052	94
General average			2051	

The Jacob Rice No. 3 well, in Springhill Township, reports the following detailed section of the Nineveh sand:

Nineveh sand in Jacob Rice No. 3 well.

	Feet.
Sand, hard, dark	1
Sand, hard, white	7
Sand, gray, soft	1
Sand, white, hard	4
Sand, gray, soft	1
Sand, dark, hard	6
	20

At varying intervals below the red rock associated with the Nineveh sand and above the true Gordon sand, there is at many places an irregular bed of sandstone which in Richhill Township is called Gordon Stray, or simply Stray. This name has been often applied to the Nineveh, but such usage is obviously incorrect, as the Nineveh and Gordon are separated by red rock. The Gordon Stray seems to be the least definite of all the commonly recognized sandstone beds, and is probably a split from the Gordon. In many borings the two beds are not distinguishable.

The true Gordon sand, which by many drillers has been designated the Fourth sand, lies 100 to 180 feet below the top of the Nineveh. This sand reaches in some places a thickness of more than 100 feet, and its interval from the Pittsburg coal ranges from 2070 to 2287 feet. The upper limit of this sand is extremely variable.

Interval between top of Pittsburg coal and top of Gordon sand.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	2100	2141	2133	6
Richhill	2094	2155	2136	17
Center	2083	2170	2127	8
Jackson	2070	2175	2111	16
Aleppo	2110	2183	2157	30
Wayne	2133	2287	2213	13
Gilmore	2177	2189	2181	3
Springhill	2130	2205	2166	8
General average			2153	

The Fourth sand is another rather variable bed lying 20 to 120 feet below the top of the Gordon and 2154 to 2316 feet below the Pittsburg coal. This sandstone, like the Gordon Stray, is very irregular and at many places is coterminous with the Gordon.

The horizon of the Fifth sand lies 80 to 180 feet below the top of the Gordon, and its thickness ranges from 10 to 40 feet. In the Felix Bell No. 1 well, in Wayne Township, just off the quadrangle, the detailed section of the Fifth sand is as follows:

Section of Fifth sand in Felix Bell No. 1 well.

	Feet.
Sand, gray	16
Slate	2
Sand, dark	12
Slate	10
Sand, dark	3
Slate	3
Sand (small pebbles; gas, 8 feet in this bed)	15
	61

Its depth below the Pittsburg coal varies from 2204 to 2352 feet. This is more persistent in occurrence than the Fourth sand and more constant in its intervals.

Interval between top of Pittsburg coal and top of Fifth sand.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	2270	2283	2276	4
Richhill	2204	2270	2237	7
Center	2225	2335	2260	8
Jackson	2232	2325	2271	4
Aleppo			2275	1
Wayne	2301	2339	2325	11
Gilmore	2335	2352	2344	2
Springhill			2294	1
General average			2285	

A few borings in the Rogersville quadrangle are deep enough to reach the Bayard and Elizabeth sands. The upper of these—the Bayard—lies about 130 feet below the top of the Fifth, and reaches in places a thickness of 12 feet. In neighboring regions it is an important bed, but in the Rogersville quadrangle it is at many places absent. Its depth below the Pittsburg coal varies from 2400 to 2448 feet, and it lies from 1168 to 1194 feet below the Big Injun in the half dozen records from which the figures can be obtained.

The deepest persistent sand is the Elizabeth, which lies 200 to 230 feet below the Fifth and about 2400 to 2500 feet below the Pittsburg coal. Its thickness rarely exceeds 10 feet, but in one well it is 12 feet thick. In the Warren Mankey well near Nineveh, and in several wells near by, the Elizabeth is reported as a red sandstone.

Beds below the Elizabeth sand.—Only a few wells have been sunk below the Elizabeth sand, and these record only shale or "slate and shells" for a depth of 1000 to 2000 feet. A well on the Lewis Kuhn farm, 1 mile southeast of Hoovers Run—the second deepest well in Greene County—reports 15 feet of "sand" at a depth of 2915 feet below the Pittsburg coal.

Correlation of sands.—The sands of the Nineveh and Gordon group were first penetrated in northwestern Pennsylvania in 1885, in the large oil field at Washington. In the Gordon well of that field the Gordon sand lies 244 feet below the top of the Gantz. As the progress of drilling has extended over southwestern Pennsylvania, the use of the names Gantz, Gordon, and others that have originated from time to time has been extended through the greater part of Washington and Greene counties. Thus, when operations were first begun in the Nineveh field in the Rogersville quadrangle, the names Gordon and Fourth were applied to sandstones which were supposed to be equivalent to the beds bearing those names at Washington. The names have been correctly applied by certain drillers to some of the beds in wells in the Rogersville quadrangle. This is true of most of the wells in Wayne Township, of a few in Center, Morris, and Springhill townships, and of nearly all the wells drilled by the Natural Gas Company of West Virginia in Richhill Township. A few records of wells of other companies in Richhill Township are correctly correlated. Throughout the oil field lying between Nineveh and the West Virginia line south of Deep Valley, however, the name Gordon has been generally applied to a sandstone occurring between the true Gordon and the Fifty-foot, and lying at the top of the Catskill beds; and the term Fourth has generally been applied to the true Gordon sand. The name Gordon Stray has been used to designate any bed a short distance above what the drillers have regarded as the Gordon. As can be seen from the columnar section sheet, the Gordon sand maintains its interval of 150 to 200 feet below the top of the Fifty-foot sand and lies below the bed hitherto called Gordon in the Nineveh, Bristoria, and New Freeport oil fields.

In Richhill Township the names Nineveh Thirty-foot, Nineveh, and sometimes Thirty-foot have been applied to the sandstone at the top of the Catskill beds. The name was derived from the village of Nineveh, near which the sandstone has produced oil. In this folio, for the sake of simplicity, only the term Nineveh is used for this bed.

By referring to the columnar section sheet, the tracing of the sands from Washington into Greene County can be seen. The Nineveh sand is not recorded in the Gantz well, but in the Baker well, near Lone Pine, it occurs 102 feet below the top of the Fifty-foot. In that region and at many places in eastern Washington County the name Gordon Stray has been applied to this sandstone. In the Baker well this bed attains the unusual thickness of 63 feet. The next section in line is that of the Fonner No. 2 well, in the extreme northeast corner of the quadrangle. In this well the Nineveh sand consists of 13 feet of red sandstone lying 48 feet below the top of the Fifty-foot, and a second red rock occurs 68 feet below it, a few feet above the Gordon sand. In the John Lewis well the Nineveh sand was called Gordon, and can be traced under this name, or that of Gordon Stray, from that well through the entire length of the oil district.

STRUCTURAL GEOLOGY.

GENERAL FEATURES OF THE STRUCTURE.

The Rogersville quadrangle is situated near the center of the great Appalachian synclinal basin, and the geologic structure of the area is characterized by a series of gentle folds which traverse the basin in a northeast-southwest direction and warp the strata into broad anticlinal arches and synclinal troughs, some of them continuous for many miles. It is these folds that bring various coal beds above the stream levels in some places and below the surface in other places having the same elevation.

The relations of the structure in this quadrangle to that in adjacent regions farther east are indicated by fig. 2, which shows by contour lines the lay of the Pittsburg coal in the Amity, Rogersville, and Waynesburg quadrangles. The general features of the region consist of broad anticlines and synclines. These are most pronounced along the eastern border of the Appalachian basin, but become gentler in dip and less continuous toward the west.

The detailed structure of the Rogersville quadrangle in its relations to the geology and geography is exhibited by the structure and economic geology map.

REPRESENTATION OF STRUCTURE.

Method employed.—Geologic structure can be graphically represented in two ways. The older method—the one in general use—is to represent it by cross sections, which show the strata as if cut through along a given vertical plane. In this method a difficulty arises from the fact that only a limited number of sections can be given on the map, and between them lie considerable areas in which there are no sections to furnish a clue to the the structure. Another objection to the use of the cross-section method in this district is that the dips are so gentle as to make a section of little assistance in illustrating the structure. The structure is therefore represented by contour lines, as follows:

The top or bottom of some persistent and easily recognizable stratum is selected as a datum surface, and its elevation above sea level is determined at as many points as possible. In the Rogersville quadrangle the horizon selected is the bottom of the Pittsburg coal bed, this being the best known and most persistent bed in the region. The structure is shown on the structure and economic geology map by means of heavy, purplish contour lines. These lines are drawn at uniform intervals above sea level, and all points on any one line have the same elevation. In other words, a given structure contour is the line of intersection of the datum surface with a horizontal plane that stands at a stated height or elevation above sea level. For instance, the Pittsburg coal at all points along the 350-foot contour has an elevation of 350 feet above sea level. It descends in the direction of the 300-foot contour and rises toward the 400-foot contour.

An intersection of a surface contour with a structure contour of the same elevation marks an outcrop of the Pittsburg coal. The approximate depth of the coal below the surface at any given point can readily be found by subtracting the elevation of the structure contour from that of the intersecting surface contour. To find the depths of other beds than the Pittsburg coal, their intervals above or below it must be subtracted or added to the depth of the Pittsburg.

To illustrate the use of structure contours, we will suppose that the depth of the Pittsburg coal is desired at Higbee. As can be seen from the map, the elevation of the bottom of the valley here is about 1150 feet and the point is three-fifths of the way between the 150- and 200-foot structure contours. Hence the Pittsburg coal is calculated to be 970 feet (1150 minus 180) below the surface at Higbee.

Degree of accuracy.—It should be borne in mind that it is impossible to make structure contours everywhere strictly accurate, and allowance for possible errors should therefore be made in using them. Over large areas there are no wells or borings by which the exact depth of the coal below the surface can be determined. To fix its depth in such areas it is necessary to depend upon estimated intervals between the coal and the beds that outcrop at the surface, and, as these intervals are never perfectly constant over any considerable area, an error may thus be introduced in the structure contours. In this quadrangle, however, the inaccuracy is probably nowhere very great.

By reference to the map it will be noticed that in certain localities the contours have many waves and turns, while in other parts of the quadrangle they run for miles in long, regular curves. This difference is largely due to the fact that within the oil and gas fields levels have been run to the mouths of many of the wells, and the elevations of the coal have been determined at a great many points. In regions like Gilmore and southern Jackson townships, on the other hand, data are scant, and the contours are of necessity greatly generalized.

In making the studies for this folio, all the roads in the quadrangle have been traversed and the position of every outcrop along them has been noted. These data have been supplemented by the records of as many deep wells in the quadrangle as could be obtained through the courtesy of oil and gas operators and other persons.

In general, the structure-contour interval in a given area is decided by two factors: (1) the steepness of the dip, and (2) the accuracy with which the available data enable the contours to be drawn.

In a region like this, where the dips are all fairly gentle, only the second factor has to be considered. For example, if over a given area the elevation of the datum bed was determined only within 50 feet, it would be misleading to draw contours with a 25-foot interval. The limit of error, then, for the area as a whole can be taken as not greater than the contour interval. In the oil and gas fields it would be possible to draw contours considerably closer, but over the greater part of the area there are only scattered wells and the rock exposures do not permit accurate tracing or correlation of the beds. It must be remembered also that the intervals between the surface rocks and the coal vary from place to place, as explained on this page. Consequently, in only a small part of the quadrangle would the information on the Pittsburg coal justify a 25-foot contour interval.

DETAILS OF STRUCTURE.

FOLDING SHOWN BY THE PITTSBURG COAL.

The principal structural features of the quadrangle, as shown on the structure and economic geology map, are two anticlines and two synclines, all having a general northeast-southwest trend. These will be described in order from east to west.

Waynesburg syncline.—This name has long been applied to a synclinal axis which passes west of the town of Waynesburg and enters the Rogersville quadrangle 1 mile south of South Fork of Tenmile Creek. Within the quadrangle this syncline is very unsymmetrical. Along the center of the basin the Pittsburg coal ranges from 275 to 350 feet above tide, and the depth of the basin ranges from 50 to 150 feet below the bordering anticlinal crests. Where the axis enters the quadrangle from the east the depression is very shallow, the Pittsburg coal lying between 300 and 350 feet above sea level, and the basin almost connects with the Nineveh syncline on the west. These do not quite unite, however, and the axis turns directly southward into Wayne Township. Several wells about 2½ miles east of Bluff show the Pittsburg coal about 350 feet above tide, and here the direction of the axis changes to S. 30° W., passing just west of the village of Hoovers Run and reaching the southern border of the quadrangle 1 mile southeast of Pinebank. In Wayne Township the axis plunges toward the south, and well records just south of the quadrangle show the coal about 275 feet above sea level. There is some doubt whether the basin near Hoovers Run should properly be connected with the Waynesburg syncline, and on this point previous usage is followed. East of the Waynesburg syncline the strata rise gently toward the Bellevernon anticline.

Amity anticline.—This anticline is named from the village of Amity, in southern Washington County, and has previously been called the "Pinhook" anticline. Its axis enters the Rogersville quadrangle 2 miles south of the northeast corner and takes a southerly course, running close to the eastern border of the quadrangle. At Browns Creek it turns slightly to the southwest and passes almost directly through the town of Rogersville, near which it seems to die out. Where this axis enters the quadrangle the elevation of the Pittsburg coal on its crest is about 450 feet and the Upper Washington limestone outcrops at about 1050 feet. The axis pitches slightly at Browns Creek, but the coal is above the 400-foot level beyond the head of Bush Run. At Rogersville the coal is probably below the 350-foot level. The rise and fall of the Upper Washington limestone along this anticline do not agree with the structure contours for the coal, as the two beds are not parallel. Northwest of the Amity anticline the rocks dip with moderate grade to the bottom of the Nineveh syncline.

On the structure and economic geology map a domelike arrangement of the contours is seen nearly in line with the Amity anticline in the vicinity of Buzz, Bluff, and White Cottage, suggesting a faint continuation of the anticline. The structure is not definitely known here, on account of a lack of well records, but from the evidence gathered in tracing local limestones and associated beds on the surface, it seems to be about as represented on the map. The Pittsburg coal is 400 feet above sea level just east of White Cottage and is at the same elevation 1 to 2 miles southeast of Bluff. Over a considerable area east of this the strata are rather flat. South of this area there is a faint continuation of the anticline to the border of the quadrangle. The rocks are lower, however, and the coal is 342 feet above sea in a well on Blockhouse Run and 331 feet on Garrison Fork of Dunkard Creek, 1 mile south of the quadrangle. The arch is here barely 50 feet above the bottom of the syncline on the east.

Nineveh syncline.—This trough enters the quadrangle 2¼ miles west of its northeast corner and takes a southwesterly course, with a range in direction of about 45°. It passes just west of Nineveh, 1 mile west of Rutan, 1 mile southeast of Bristoria, 1 mile northwest of Higbee, nearly through Aleppo and Morford, and leaves the quadrangle 2 miles north of the southwest corner.

The Nineveh syncline is the deepest trough in Greene County and one of the deepest in the Appalachian coal basin, near the center of which it lies. It ranges from 200 to 400 feet below the crest of the Amity anticline, and 300 to 700 feet below the Washington anticline. At its lowest point, near Rutan, the Pittsburg coal at the center of the basin is less than 100 feet above sea level, and in the vicinity of Morford it is nearly as low. The depression near Morford is very small and rather hypothetical, but the Rutan basin contains one well in which the coal is reported as low as 95 feet. The axis of the Nineveh syncline is better defined than any other axis in this quadrangle, being proved for a great part of its length by numerous wells drilled on both sides of it. Between Aleppo and Lick Run especially it is clearly defined, for the reason that the oil district crosses this region and the wells are here numerous and close together. The determinations at Nineveh are likewise believed to be close. Elsewhere, as along the northern border of the quadrangle, between Rutan and Nineveh, and southwest of Aleppo, however, it has been necessary to draw the contours entirely on the evidence of surface rocks.

Except in the two deep basins mentioned above, the Pittsburg coal generally lies between the 100- and 200-foot levels, along the bottom of the Nineveh syncline. North of Nineveh, however, on the border of the quadrangle, it rises to an elevation of about 300 feet. Thus the greater pitch of the syncline is 200 feet. On the southeastern slope of the Nineveh syncline the structure is rather variable. East of Nineveh the rise is fairly uniform to the crest of the Amity anticline, but farther south this anticline disappears and the dips are more gentle. Northwest of the Nineveh syncline, throughout its entire length, the rocks rise abruptly to the crest of the Washington anticline. The greatest rise occurs between Jacksonville and Rutan and amounts to 600 feet.

In western Gilmore and southwestern Jackson townships lies an area of 15 to 20 square miles in which little is known of the structure, as rock exposures are poor and no wells have been drilled. From indications gathered on the eastern border of the New Freeport gas field and from several wells south of the quadrangle there seems to be a slight depression on the border of the quadrangle, like the northern end of a disappearing syncline. Around it the Pittsburg coal is supposed to be between 250 and 300 feet in elevation, but just east of New Freeport it is less than 240 feet. The subanticline separating this basin from the Nineveh syncline is well marked, passing directly through New Freeport and continuing thence southwestward. On the eastern slope of the Nineveh syncline, from Bristoria southward to the border of the quadrangle, the positions of the 200- and 250-foot contours are in places well determined. North of Deep Valley and northwest of Morford the dips of the surface rocks indicate the existence of two small domes. At the southwest corner of the quadrangle the positions of the contours are fairly well determined, owing to the development of a small oil field just off the border.

Washington anticline.—This fold is one of the prominent structural features, and receives its name from the town of Washington, near which it passes. It enters the Rogersville quadrangle north of Simpson Store and trends southwestward. At first its course is about S. 30° W., bringing it past Simpson Store, but in Richhill Township it sweeps to the west in a fairly regular curve, passing under Jacksonville and just southeast of Ryerson Station. Where it leaves the quadrangle its course is about S. 60°–70° W. The Pittsburg coal on the crest of this arch lies between 480 and 705 feet above tide.

One of the noticeable features of the Washington anticline in this quadrangle is a roughly triangular dome having its center at Jacksonville. North of this dome the pitch of the axis carries the coal from 705 feet down to 480 feet at Simpson Store. Farther north the axis rises again. The steep dip along the southeastern flank of the Washington anticline is the most prominent structural feature shown on the map. The average dip is about 100 feet per mile, but between Graysville and Bristoria it locally reaches 250 feet per mile. In this area and as far north as Enslow Fork of Wheeling Creek the contours have been rather accurately determined by records of wells in the Richhill gas field.

The dips on the western flank of the Washington anticline are gentle. The information about this part of the area is incomplete, but considerable data have been derived from outcrops on Crabapple Creek and Enslow Fork and from a few scattered wells. The dip here rarely exceeds 100 feet per mile and is sometimes less than 50 feet. West of Jacksonville a spur of the anticline shoots off toward the northwest and reaches as far as the border of the quadrangle near Enslow Fork. In West Finley Township the data are scant, but observations on the limestone and sandstone beds indicate the southern end of a depression here, in which the coal is slightly less than 400 feet above sea level. This may be a local basin, or it may be an offshoot from the syncline that lies west of the Washington anticline.

RELATION OF FOLDING OF PITTSBURG COAL TO FOLDING OF OTHER BEDS.

Lack of parallelism between beds.—In using the contours represented on the structure and economic geology map it must be remembered that strata are seldom exactly parallel to one another. Allowance must accordingly be made for the increase and decrease of intervals in various directions, due to causes explained below. For instance, the interval between the Upper Washington limestone, one of the most persistent outcropping beds, and the Pittsburg coal varies in this quadrangle from 620 feet to nearly 750 feet, and the Waynesburg coal ranges from 270 to 400 feet above the Pittsburg. Some of the formations below the surface vary even more than this, as shown in the tables of oil and gas wells. The causes of the variations are twofold: (1) The gradual increase or decrease in thickness of beds is generally due to differences in sedimentation, and (2) the marked decrease of the intervals between the formations in the Pennsylvanian series and those in the Mississippian series is due to the erosional unconformity at the top of the Mauch Chunk formation. The differences of the first class vary in direction for different formations, but in general the deeply buried formations are slightly thicker toward the north. The decrease due to erosion is from southeast to northwest.

Folding of Big Injun sand.—It has been said that the Mauch Chunk formation is over 200 feet thick in Gilmore Township and disappears entirely north of Enslow Fork. It is even probable that in portions of West Finley Township the top of the Big Injun is somewhat eroded. The accompanying sketch, fig. 3, shows by isochore lines (lines of equal interval) the changes in the interval between the Pittsburg coal and the Big Injun sand, ranging from 1075 to 1280 feet, and fig. 4 shows a section from south to north along meridian 80° 25′, giving the position of the coal, the top and bottom of the Mauch Chunk formation, and the top of the Nineveh sand. The lines for the Big Injun and Nineveh sands are interpolated from well records which give their position. The line for the top of the Mauch Chunk is more hypothetical, as the top of this formation is seldom perfectly definite in well

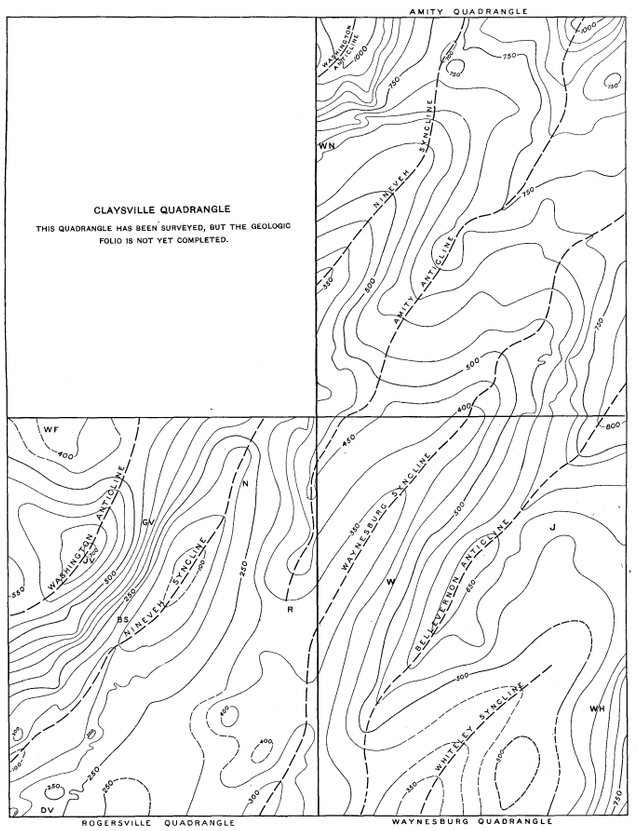

FIG. 2.—Sketch map of the Amity, Rogersville, and Waynesburg quadrangles, showing geologic structure by means of contour lines drawn on the floor of the Pittsburg coal. Contour interval, 50 feet.

BS, Bristoria; DV, Deep Valley; GV, Graysville; J, Jefferson; JV, Jacksonville; N, Nineveh; R, Rogersville; W, Waynesburg; WF, West Finley; WH, Whiteley; WN, Washington.

records. Errors in the position of the Big Injun may occur owing to errors in the cable measurements of the drillers.

In order to determine the elevation of the Big Injun sand at any point in the quadrangle it is only necessary to find the approximate interval given in fig. 3 for that point and subtract it from the elevation given for the Pittsburg coal on the structure and economic geology map. It should be borne in mind that fig. 3 is merely a sketch map and is liable to local errors.

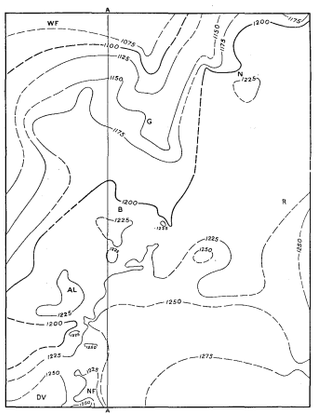

FIG. 3.—Sketch map of the Rogersville quadrangle, showing by isochore lines the variation of the interval between the Pittsburg coal and Burgoon sandstone (Big Injun sand) caused by the dying out of the Mauch Chunk formation due to unconformity.

AL, Aleppo; B, Bristoria; DV, Deep Valley; G, Graysville; N, Nineveh; NF, New Freeport; R, Rogersville; WF, West Finley.

Folding of Nineveh sand.—In the discussion of stratigraphy (p. 6), it was stated that the Pocono and Chemung rocks in general increase in thickness from south to north, in the same direction as the thinning due to erosion. The amount of this northward thickening is sufficient in the large beds to make up in part for the decrease due to erosion. The Nineveh sand lies from 800 to 970 feet below the top of the Big Injun, and this varying interval so compensates for the thinning due to erosion of the Mauch Chunk that along the line A–A the Nineveh sand is nearly parallel with the Pittsburg coal. As shown by fig. 4, the average interval between the two beds at a point 2 miles from the northern end of the section is only about 30 feet less than at its southern end, and the two lines vary from parallelism only slightly. It must not be supposed that this approximate parallelism holds to the same degree in all parts of the quadrangle, or that the Mauch Chunk unconformity is regular enough to compensate everywhere to the same extent.

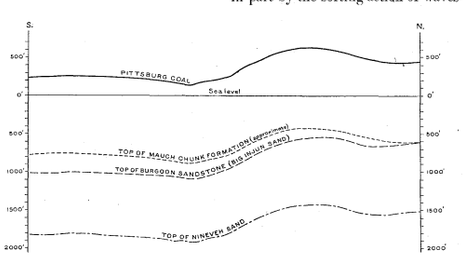

FIG. 4.—Section along the line A–A of fig. 3, showing the folding and relation of Pittsburg coal, Mauch Chunk formation, Burgoon sandstone, and Nineveh sand.

Intervals between the Nineveh and the coal are generally between 2000 and 2120 feet, and the averages in the various townships vary from 2036 to 2089 feet. Hence the approximate relation of this sand at any point in the quadrangle can be found by subtracting the average for the township from the elevation of the Pittsburg coal given on the structure and economic geology map. Suppose, for instance, that the elevation of the Nineveh sand is desired at Holbrook, Center Township. The structure contours show that the elevation of the coal there is about 290 feet. On looking at the table on page 7, it may be seen that the calculated average interval between the coal and the Nineveh sand in Center Township is 2039 feet. The Nineveh sand is therefore about 1750 feet (290–2039) below sea level.

HISTORICAL GEOLOGY.

PALEOZOIC ERA.

The Rogersville quadrangle is situated near the center of the great Appalachian synclinal basin, in which the pre-Devonian rocks are buried far beneath the surface. The oldest rocks exposed at the surface belong high up in the Pennsylvanian series of the Carboniferous system, but the extensive exploitation of oil and gas in this part of the State has made it possible to study the underlying Mississippian and Devonian rocks, and the sequence of strata has been determined with considerable accuracy.

DEVONIAN PERIOD.

CHEMUNG EPOCH.

As stated in the discussion of stratigraphy, the oldest rocks in this quadrangle that have been recorded by well drillers lie well down in the Chemung formation. In regions where rocks of this formation come to the surface they are composed largely of alternating beds of shale, sandstone, and thin impure limestone, the shale predominating. The character and abundance of the fossils indicate that the conditions were marine and that at times the sea swarmed with life.

When these rocks were formed a large part of what is now the continent of North America was covered by water, which formed a great inland sea that 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 probably crossing New England near its western border. This land extended far toward the south, and probably reached eastward considerably beyond the present Atlantic shore line. This great expanse of salt water, lying in the center of the present United States, had access to the open sea, but had no fixed shore line or constant relation to the land for any great period of geologic time.

At the beginning of the time considered by this history the streams were bringing into this open sea, which probably existed throughout most of the Devonian period, extensive deposits of muddy sediments from a land somewhere to the east. These muds were interbedded with layers of sand, owing perhaps to a slight elevation of the land, which increased active erosion, or perhaps to the reworking and assorting of sandy material already deposited. Thus the frequent changes noted in well records from "shale" to "sand" or to "shells" were probably caused in part by different rates of elevation or oscillating changes in climate, which affected the volume of the inflowing streams, and in part by the sorting action of waves and currents, which arranged the coarser deposits into beds by themselves in the form of beaches and bars.

CATSKILL SUBEPOCH.

At times during this long-continued deposition of alternating muds and sands, forming strata which the deep wells show to be many hundreds of feet thick, the streams brought to the sea great quantities of red material, presumably derived from a deeply oxidized land area. These deposits formed the Catskill beds.

In the Rogersville quadrangle the identification of the Catskill beds rests entirely upon their red color, as reported by well drillers. The red beds have a maximum thickness of only about 20 feet in the deep wells of this quadrangle, and represent the western margin of the Catskill. Most of the rock is rather fine grained, having been formed of sediment that was borne by the water along the eastern shores of the Appalachian Gulf, into which it was discharged by the rivers of the bordering lands. The Catskill strata in this region lie in detached beds or lentils of variable extent and thickness, alternating with gray shale and sandstone which may have had a different origin. It seems probable that the material that formed the extreme western deposits of red rocks was transported intermittently during floods, at intervals between the periods of deposition of the great beds of coarse gray sandstone that form the reservoirs for oil and gas in this part of Pennsylvania. After the deposition of this red material the preceding conditions were repeated, and sandy and muddy sediments were again laid down in alternation on the sea floor.

CARBONIFEROUS PERIOD.

POCONO EPOCH.

Since it is not possible to obtain fossils from beds that are deeply buried below the surface of the Rogersville quadrangle and are known only from the records of deep wells, the Devonian and Carboniferous sediments can not be definitely separated. It is believed, however, that the true Pocono deposits began at about the time the Fifty-foot sand was deposited, soon after the close of the time in which the red Catskill deposits were laid down in this region. As has been said, it seems probable that the difference of opinion regarding the base of the Pocono is due largely to a grading of one formation into the other. In general, the strata deposited during the Pocono epoch are rather more sandy than those formed during the preceding epoch. Several thick sandstone beds occur in them, the lowest or earliest being the Fifty-foot and Gantz sands. After these sandstones were deposited, gray mud followed with occasional red beds and several sandy lentils of rather indefinite extent.

During the latter part of Pocono time vast quantities of coarse sand were brought into the Appalachian Gulf and spread widely over its bottom, forming the coarse Burgoon, Big Injun, or Mountain sandstone, which in the Rogersville quadrangle averages 300 feet in thickness. A tilting and lowering 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 variations in thickness of the formation in different parts of the province are perhaps due to differences in distance from the shore.

MAUCH CHUNK EPOCH.

After the close of Pocono time there was an epoch during which little or no arenaceous sediment was deposited, this fact indicating that the sea had become deeper and clearer. Probably the coarser sediments brought down by the rivers were deposited in estuaries near their mouths. The open southern Appalachian sea abounded in marine animals, and by their agency, aided perhaps by chemical precipitation, beds of highly fossiliferous limestone were laid down to a thickness of 40 to 80 feet. This, the Greenbrier limestone, known to well drillers as the Big lime, forms the lower part of the Mauch Chunk formation. The period during which the limestone accumulated was of considerable duration and was free from movements of the earth's crust.

The deposition of the Greenbrier limestone was finally ended by an elevation of the land. This was sufficient to quicken erosion and to bring the coast line nearer the region under discussion, so that quantities of mud and some sand were brought into sea waters that had previously been clear. The shales thus formed are at some places in this region 100 feet thick, and are prevailingly red in color, suggesting a repetition of Catskill conditions. It is supposed that these red sediments were derived from a deeply disintegrated land surface in which the materials had by long oxidation become red in color and were much like those found in the southern United States. The greater thickness of these rocks toward the north and east indicates that the land lay in that direction. During the period in which the red shales were deposited the conditions are supposed to have been unfavorable to life, as few fossils are found.

EROSION FOLLOWING MAUCH CHUNK EPOCH.

In northeastern Pennsylvania the Mauch Chunk formation is over 2000 feet thick, but it diminishes in thickness toward the west. In wells in the eastern part of the Amity quadrangle its thickness is only about 200 feet and in the vicinity of Washington it is less than 100 feet. Farther west it is absent. The decrease in thickness is not uniform, as only about 50 feet of the formation occurs in wells in the vicinity of Blairsville, Indiana County.

Many facts of this nature indicate an uplift that raised above sea level a large land area extending from southern New York at least as far south as Alabama and as far east as the Allegheny Front. From this land area the upper part of the Mauch Chunk was eroded before the overlying Pottsville rocks were deposited. As illustrated by the well sections on the columnar section sheet, the erosion was greatest in the northwestern part of this area, decreasing toward the east. Just when this uplift occurred can not be determined definitely, but it probably took place at the close of Mauch Chunk time.

POTTSVILLE EPOCH.

At the beginning of Pottsville time there was a change in the character of the deposits. The deposition of fine reddish sands and clays was then succeeded by that of white and much coarser sands and gravels. The unconformity at the top of the Mauch Chunk formation indicates that at the beginning of the Pottsville epoch the greater part of western Pennsylvania was above sea level, and that erosion was in progress on the land surface.

From the evidence of fossil plants it is now known that in the southern anthracite basin sedimentation was continuous from the close of the Mauch Chunk epoch to the beginning of Allegheny time, whereas in western Pennsylvania the close of the Mauch Chunk was marked by an uplift that raised the main part of the bituminous field above sea level. Hence there was an interval during which no rocks of Pottsville age were deposited in the Rogersville quadrangle.

After about two-thirds of the Pottsville formation had been laid down in the southern anthracite basin, the land in southwestern Pennsylvania subsided and deposition was resumed there.

The Connoquenessing sandstone was deposited at this time. Next ensued a period during which the basin was covered with vegetation, and at this time the Mercer coals, accompanied by a varying amount of muds and thin limestones, were deposited. These beds are exposed where the formation outcrops in other regions, but on account of indefiniteness in well records it is not known whether or not they occur in this quadrangle. Next the Homewood sandstone was deposited over most of the region, closing the Pottsville epoch. The Pottsville sandstones compose the Salt sand of the well drillers.

ALLEGHENY EPOCH.

After the sands that formed the coarse sandstones of the Pottsville epoch had been laid down, materials of variable character were deposited in beds that now compose the shales, sandstones, limestones, and coal beds of the Allegheny formation. The great variations in material indicate that periods in which large amounts of coarse sediments were swept into the basin alternated with periods in which little or no material was supplied except the abundant plant growth from which the coal beds were formed. This is the earliest formation that contains important coal beds.

That coal is of vegetal origin is acknowledged almost universally, but there is great difference of opinion as to the method by which it accumulated in beds covering great areas. It seems safe to say that in the main the coal seams of the Appalachian province were formed in marshes that stood nearly at sea level and extended over thousands of square miles.

The nature of the well records in Greene and Washington counties does not permit a very detailed discussion of this interesting epoch, and for the

same reason the details of the formation are omitted from the columnar section. Throughout this region the sequence of events during the deposition of the Allegheny formation was somewhat as follows:

The deposition of the Homewood sandstone (Pottsville) was followed by a slight subsidence, during which a few feet of clayey sediments were laid down. Then the sea bottom rose approximately to water level and marshy conditions prevailed for a time over large areas. In these marshes extensive peat bogs were formed, in which the remains of many generations of plants accumulated. From time to time different parts of this marsh land were overflowed by water, by which thin layers of sediments were deposited on layers of vegetal matter, these sediments now forming the "partings" or "binders" of the coal beds. After a long period of comparative quiet the region was again depressed and sedimentation was resumed, burying the vegetal matter. During the time that has since elapsed the vegetal deposits have become compressed and hardened into coal seams. By re-elevation of the area, or by accumulation of sediments, the bottom was again gradually raised to water level, restoring the coal-forming conditions, and another coal bed was deposited.

During the Allegheny epoch these conditions were repeated a number of times, so that in some districts from five to ten coal beds were formed. When marshes prevailed, the material that made coal seams accumulated; when the region was depressed, the sand that formed sandstones was deposited; when the water deepened, muds that made shales were laid down; and beneath the deep water that occasionally occupied the basin the calcareous matter of which the various marine limestone beds are made was piled up. At some times these conditions were continuous over wide areas, and then beds of great areal extent were deposited—beds like the Upper Freeport coal, the Vanport ("Ferriferous") limestone, and the Clarion sandstone. At intervening times the basins and marshes were of very local extent, and the beds then formed are mere lentils in the formation and can not be traced for long distances. The fire clays that accompany so many of the coal beds probably owe their character to the action of coal plants on underlying clays, which broke up their stratification and caused changes in their chemical composition. Although the strata in this region were undoubtedly elevated at times during the deposition of the Allegheny formation, the prevailing movement was evidently one of subsidence; each coal seam was formed at the surface and afterwards buried by sediments.

CONEMAUGH EPOCH.

The close of the Allegheny epoch was marked by a change in conditions, which permitted the deposition of about 600 feet of sediments with only a few minor seams of coal. On top of the Upper Freeport coal a considerable thickness of coarse sand was deposited over a large area, forming a sandstone that is known on the surface as the Mahoning sandstone, and to drillers as the Big Dunkard or Hurry-up sand. Locally this sand deposit filled the basin to the surface and upon it thin coal seams were formed. In general, the lower portion of the Conemaugh is very sandy, consisting of a number of lentils of sandstone, overlapping one another. Above the Mahoning the most persistent of these is the Saltsburg lentil (Little Dunkard sand), which represents a thick and extensive deposit in southwestern Pennsylvania.

After the formation of the Upper Freeport coal, marine conditions seem to have recurred a number of times, as salt-water fossils have been found at several horizons in the lower part of the Conemaugh rocks. The Ames ("Crinoidal") limestone, which occurs midway in the formation and is spread over wide areas of western Pennsylvania and eastern Ohio, is full of marine fossils, showing that the sea at that time occupied a large area. This limestone is supposed to mark the last recurrence of marine conditions in the Appalachian coal basin.

The Morgantown sandstone, which lies above the Ames limestone, indicates a period of marked elevation. The series of red shales overlying this sandstone in southwestern Pennsylvania seems to record a time during which the rocks of the land were once more deeply disintegrated, as in the Catskill and Mauch Chunk epochs. These deposits were mostly fine grained. At the close of the Conemaugh epoch the greater part of the basin had once more been brought near water level.

MONONGAHELA EPOCH.

Only the formations deposited since the Conemaugh are exposed in the Rogersville quadrangle. The beginning of the Monongahela epoch was marked by the formation of another great bed of coal—the Pittsburg coal. During the accumulation of this bed the characteristic vegetation of the Carboniferous period was at its fullest development. The Appalachian basin was at that time a level area and the remarkable uniformity in conditions and the long duration of vegetal growth resulted in the formation of this coal over a great area. Such changes as took place—for example, the deposition of mud layers represented by partings in the coal—were also widespread in their extent. The swampy conditions were finally ended by a broad submergence, which caused the deposition of the overlying shale and sandstone; but when the submerged basins were again filled to the surface by sediments swamp conditions were restored in places and the Redstone coal was locally deposited. Where the Redstone limestone is present the water is assumed to have been clear for a time.

After the growth and deposition of the Redstone coal vegetation, the land sank, more limestone was deposited, and mud and sand filled up the basin, forming the surface on which the Sewickley vegetation grew. Again came a period of submergence, during which a thick limestone, with some interbedded shale, was in process of formation for a long time, until it had accumulated to a total thickness of about 150 feet. This is the Benwood (Great) limestone. For the formation of this limestone it seems unnecessary to assume deep-water conditions. The small amount of interbedded shale suggests that the area in which it was deposited was some distance from shore, or that base-level conditions prevailed and very little detritus was being brought into the basin.

Directly on top of the Benwood limestone there was locally deposited a thin coal—the Uniontown. After this there was another submergence, and shale and sandstone and the Waynesburg limestone were laid down. With the deposition of more shale the waters again became shallow and conditions favored another vegetal growth. From this growth the Waynesburg coal originated. The accumulation of this bed, like that of the Pittsburg seam, was frequently interrupted by the deposition of thin beds of mud and clay. With the termination of the vegetal growth forming the Waynesburg coal the Monongahela epoch was ended.

DUNKARD EPOCH.

The Dunkard epoch was opened by another submergence, during which thick beds of sediments were deposited. In some places a few feet of mud accumulated directly on top of the Waynesburg coal. In general, however, a mantle of coarse sand, 40 to 70 feet thick, was spread over the basin. This, represented by the Waynesburg sandstone, subsequently formed the surface on which the Waynesburg "A" coal was laid down. The formation of this coal was interrupted by a submergence which permitted the accumulation of shale, sandy shale, or limestone, according to the varying depth and character of the waters. Coal-making conditions seem to have recurred at intervals, but were local and of short duration. One of the coal beds—the Washington—covers a considerable area, but is much broken up by partings, and indicates a rather broad, swampy area over which layers of silt were frequently swept.

Directly on top of the coal is found the Lower Washington limestone, which indicates clear or deep waters. Over this were spread great thicknesses of shale and fine sandstone. The lower part of the Dunkard formation appears to mark a general deepening of the whole basin, with few interruptions. At times, when the waters became deep enough and clear enough, the Middle Washington and Upper Washington limestones were formed, and on top of these fresh deposits of shale accumulated.

Above the Upper Washington limestone are several feet of rocks, consisting mostly of shale and sandy shale, but containing thin local beds of limestone, sandstone, and coal. In Greene County and in West Virginia red shales are of frequent occurrence, indicating deep weathering of the surface rocks of the adjacent land areas. Sedimentation probably continued until the Appalachian Gulf was in time completely filled. The strata in the deeper portions aggregated an unknown thickness, probably hundreds and perhaps thousands of feet more than the thickest sediments now remaining in the hills of southwestern Pennsylvania and northern West Virginia. This was the end of Paleozoic deposition in this part of the world.

APPALACHIAN REVOLUTION.

The close of the Dunkard epoch is supposed to have marked the end of sedimentation in the northern end of the Appalachian trough and the beginning of a long-continued series of events of an entirely different nature. Ever since the beginning of deposition in the interior sea, subsidence had taken place at intervals and the surface had been from time to time covered with water, in which the sediments from the surrounding land were deposited, until tens of thousands of feet of strata had accumulated. At the close of the Carboniferous period there was a change, and from that time until the present the reverse movement—elevation—has prevailed and dry land has existed continuously. This change from subsidence to uplift ushered in a period of mountain making, during which compressive strains in the earth's crust bent the rocks into great folds. The movements were most pronounced along the southeastern side of the Greater Appalachian Valley. Here the rocks were not only intensely folded, but in broad areas the pressure was great enough to metamorphose them more or less completely. In a measure the Appalachian coal basin seems to have acted as a bulwark against which the rocks were crushed. The pressure extended across the basin, but with greatly decreased effect. The rocks of the coal basin were warped into broad, low folds, fairly typical forms of which occur in the Rogersville quadrangle. The period of uplift and compression which produced these folds is known as the Appalachian revolution.

CENOZOIC ERA.

TERTIARY PERIOD.

In Mesozoic time the land surface was worn down nearly to sea level, forming the Schooley peneplain. This process was ended by an uplift of the plain to a height of 800 feet or more above the sea. On this surface the streams were rejuvenated and erosion commenced anew, with increased velocities. During this period of erosion the harder rocks on the greater folds, like Chestnut Ridge, were left in relief, while the softer rocks east and west of the main ridges were again reduced to a fairly even surface. This old land surface has been called the Harrisburg peneplain, from its development in the vicinity of Harrisburg, Pa. In the Rogersville quadrangle this peneplain is not conspicuous, but remnants of it can be seen throughout the eastern part of the quadrangle in many hilltops and ridges that stand at elevations between 1200 and 1250 feet. It is probable that the western part of the Amity quadrangle was not reduced to a peneplain at this time, but stood somewhat above sea level.

The date of the development of the Harrisburg peneplain is not known with certainty. It was evidently formed later than the Schooley peneplain and earlier than certain broad valleys which seem to mark the closing stages of the Tertiary period. For these reasons it may be referred to early Tertiary time, and probably to the Eocene epoch.

After the Harrisburg peneplain had been formed the surface was raised and again erosion began to dissect it. This uplift seems to have been slight in southwestern Pennsylvania in general, but progressively greater toward the north, so that the Harrisburg surface was deformed. This is indicated by the fact that in the northern part of the State it is 400 to 700 feet higher than in the southern part.

The next succeeding stage is not well marked, but in favorable localities outside this quadrangle there are remnants of a plain surface about 100 feet below the Harrisburg level. This surface, which has been named the Worthington peneplain, probably dates from the later part of the Tertiary period.

Soon after the Worthington stage another uplift of about 100 feet occurred, followed by a brief period of tranquillity, during which the streams cut broad valleys. The broad rock benches of Monongahela, Allegheny, and Beaver rivers, which stand at elevations of 900 to 1050 feet, were formed at this time. In the Rogersville quadrangle this stage is now represented by a few small terraces in the valley of Tenmile Creek at an elevation of about 1000 feet. The formation of this strath probably marked the close of Tertiary time, for on it are found the deposits of the first stage of the glacial epoch.

QUATERNARY PERIOD.

At the close of the Tertiary period another slight elevation of the land occurred, accompanied by a cutting of the larger streams into the bottoms of the broadened valleys mentioned above. At that time all the streams tributary to Monongahela River flowed through Beaver Valley into Lake Erie. When the ice of the pre-Kansan, or first, stage of Pleistocene glaciation advanced into northern Pennsylvania, the streams were ponded between the ice front and the southern and western watersheds of Monongahela and other northward-flowing rivers and their tributaries. On the subsequent lowering of the water local ice dams were probably formed. Whatever the cause, there was an extensive ponding of water, and in the lake or lakes of this time were deposited the clays, sands, and gravels known as the Carmichaels formation, now lying at 950 to 1050 feet above sea level. These are not well developed in the Rogersville quadrangle, but are typical along Monongahela River. The geologic history of western Pennsylvania during Pleistocene time is described in the Kittanning folio.

During Recent time the level of the region has remained substantially as at present and very little erosion has taken place.

MINERAL RESOURCES.

PETROLEUM AND NATURAL GAS.

DISTRIBUTION.

The distribution of oil and gas fields in the region about the Rogersville quadrangle is shown by fig. 5. The position of the Rogersville quadrangle, in the extreme southwest corner of Pennsylvania, is shown, with its productive oil and gas fields. Throughout this folio the term "oil" is applied to petroleum, according to general usage in the producing districts. The term "field" as here used means simply a group of producing wells, or wells which have produced in the past, and it should not be inferred that the territory outside the "field" is unproductive. It is probable that in time the rocks in other sections of this region will be found to contain more or less oil and gas. In order to make the discussion clear, the various fields are here defined and named.

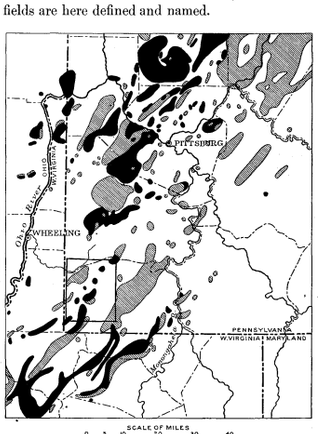

FIG. 5.—Map showing distribution of oil and gas fields in the region about the Rogersville quadrangle.

Black areas are oil fields; shaded areas, gas fields. The location of the Rogersville quadrangle is shown by the rectangle.

In the Rogersville quadrangle oil is usually more restricted in its occurrence than gas, and, so far as known, is limited to an irregular and broken belt that runs southwestward from the northeast corner

of the quadrangle, and follows the Nineveh syncline through Morris, Center, Jackson, Aleppo, and Springhill townships, to the southern boundary of the quadrangle, south of New Freeport and Deep Valley. In its entirety this belt is generally spoken of as the Nineveh field, but for a clear discussion of the oil and gas there is obviously a need of local names to distinguish various parts of the productive region. For this reason the belt as a whole is called in this folio the Nineveh district, and local names are applied to the minor fields, or sections of that belt, which are used in the following discussion.

In the northeast corner of Morris Township lies a small field, known as the Fonner field. To the group of wells within a few miles of Nineveh the name Nineveh field is applied. Between Bristoria and Delphene, in an area between the head of Lick Run and Blacks Creek, in Center, Jackson, Richhill, and Aleppo townships, is the Bristoria field. Within a mile of Aleppo village lies the small group of wells known as the Aleppo field. In Aleppo and Springhill townships, extending from near the head of South Fork southward between New Freeport and Deep Valley to the West Virginia boundary, there is a large field, which will be spoken of as the New Freeport field. The Board Tree field lies on the border of the quadrangle west of Deep Valley. The Lantz field lies southeast of Hoovers Run, just outside the quadrangle. Oil has been found also in several wells on Wright Run in Richhill Township, and on Grays Fork midway between Graysville and Rutan.

In general the gas wells are more scattered than the oil wells, but they can be grouped into two principal fields. One of these—the Richhill field—lies on the crest of the Washington anticline and covers the greater part of northern Richhill Township. In western Wayne Township, extending southward from the head of Pursley Creek along Hoovers Run to the State boundary, lies a field which will here be called the Hoovers Run field.

The structure and economic geology map shows three classes of wells, the symbols being printed in red, green, and black. Those represented in green produce oil or have produced it in the past, those in red are gas wells, and those in black are dry holes or, in one or two instances, wells in which the product is not known.

THE OIL AND GAS ROCKS.

Oil and gas sands.—In western Pennsylvania oil and gas, so far as known, occur in beds of sandstone, or "sands," as they are called by the drillers. To these "sands" have been given various names, which have gradually come into common use. In order to show their relations in the Rogersville quadrangle the following table has been prepared, giving the names used by drillers, the approximate depth of the various beds below the Pittsburg coal, which is used as a datum horizon, and the geologic formation to which the sands belong. The word "sand" is used in the descriptions with the meaning given to it by the drillers—to designate a bed of coarse, porous rock, generally sandstone, which may produce oil or gas.

In the Rogersville quadrangle oil and gas have been found in paying quantities in several of the beds named in the table. The principal oil sands are the Fifty-foot, Nineveh, Gordon, and Fourth. Gas is produced by those mentioned and in addition by the Salt, Big Injun, and Fifth sands. Of the various sands mentioned in the table, it will be noticed that all down to and including the Fifty-foot are supposed to occur in the Carboniferous system, although, as explained on page 6, the base of this system can not be determined with certainty. The Nineveh and all underlying sands so far penetrated by the drill are supposed to occur in the Chemung formation of the Devonian system.

In using the names applied by the drillers to the various sandstones, it is not supposed that all of them are continuous beds under the entire area. Some are doubtless continuous, such as the Big Injun and Salt sands, but others are of the same nature as many sandstone beds which show at the surface as lentils rather than as distinct and persistent beds. In order to show the general nature and correlation of the various beds, 12 deep-well sections are given on the columnar section sheet, and the correlations of the various beds are indicated. The Pittsburg coal, which underlies the entire region, is several feet thick and easily recognized, and for this reason the drillers use it as a datum horizon in measuring to the various beds. The coal ranges from 300 to 1300 feet below the surface.

Table showing drillers' terms for oil and gas rocks, and their thickness and geologic correlation.

Formation.	Name applied by drillers.	Geologic name.	Maximum thickness.[1]	Distance to top of bed from Pittsburg coal.[1]	
				Min.	Max.
			Feet.	Feet.	Feet.
Washington	Washington coal	Washington coal	3	+ 420	550
	Bluff sand	Waynesburg sandstone	60	+ 330	450
Monongahela	Waynesburg coal	Waynesburg coal	5	+ 270	400
	Mapletown coal	Sewickley coal	8	+ 90	120
	Pittsburg coal	Pittsburg coal	10	0	0
Conemaugh	Murphy	Morgantown sandstone	30	— 170	240
	Little Dunkard sand	Saltsburg sandstone	100	— 300	420
	Big Dunkard or Hurry-up sand	Mahoning sandstone	150	— 420	600
Allegheny	Upper Freeport or Connellsville coal	Upper Freeport coal	6	— 570	670
	Gas sand	Freeport, Kittanning, or Clarion sandstone	150	— 650	850
Pottsville	Salt sand	Pottsville sandstone	200 (?)	— 850	950
Mauch Chunk	Red rock or shale	Mauch Chunk shale	150	— 960	1050
	Little lime (or Salvation sand). Pencil cave. Big lime	Greenbrier limestone	100	— 960	1160
Pocono	Big Injun sand	Burgoon sandstone	300	—1070	1300
	Thirty-foot sand	Berea sandstone	100	—1700	1900
	Gantz sand, Fifty-foot sand, Hundred-foot sand		40	—1850	1950
			60	—1900	2030
Chemung	Nineveh or Nineveh Thirty-foot sand		40	—2000	2120
	Red rock	Catskill member	20	—2000	2140
	Gordon Stray sand		40	—2100	2250
	Gordon sand		100	—3080	2290
	Fourth sand		40	—2150	2320
	Fifth sand		40	—2220	2350
	Bayard sand		12	—2330	2480
	Elizabeth sand		10	—2550	2700

[1] Figures are approximate only. + indicates *above* Pittsburg coal; — indicates *below* Pittsburg coal.

Murphy sand.—This name is generally applied to a bed of sandstone in the Conemaugh formation lying from 170 to 240 feet below the Pittsburg coal. This sand is from 5 to 70 feet thick and corresponds in stratigraphic position to the Morgantown sandstone of southwestern Pennsylvania and northern West Virginia.

Little Dunkard and Big Dunkard sands.—In the lower half of the Conemaugh formation lie two rather important sandstones, known to drillers as the Little Dunkard and Big Dunkard. The top of the Little Dunkard is in general between 300 and 420 feet below the Pittsburg coal and the Big Dunkard lies from 420 to 600 feet below the coal. In thickness each of them runs from 30 to 150 feet. The names of these sands were taken from Dunkard Creek, near the mouth of which oil was discovered in 1861. In the Rogersville quadrangle the sands are in general unproductive, but at some places they contain a little gas. In many places they run together and are then known collectively by the name of Dunkard. The Big Dunkard sand is often called the Hurry-up sand.

Gas sand.—A sand near the middle of the Allegheny formation is generally reported as the Gas sand. It is irregular in position and thickness, but at most places lies from 650 to 850 feet below the Pittsburg coal and reaches a maximum thickness of 150 feet. This is not an important sand, but several wells in Richhill Township have found gas in it.

Salt sand.—The Salt sand generally comprises the Pottsville formation and lies from 850 to 950 feet below the Pittsburg coal. In thickness it varies from 70 to 200 feet. In Richhill Township this sand at some places contains gas, but it is elsewhere unproductive. It is a great source of salt water.

Salvation sand.—This is equivalent to the Maxton sand of West Virginia. It occurs in the Mauch Chunk formation, at a varying interval below the Salt sand, and rests almost directly upon the Big lime, being separated from it only by the "pencil cave," a peculiar bed of shale which breaks up into small splinters. In the northern part of this area and in Washington County this bed occurs as the Little lime. This sand is unproductive in this area.

Big Injun sand.—The Big Injun or Mountain sand lies at the top of the Pocono formation and directly below the Big lime. It corresponds with the Burgoon sandstone, found on the surface in portions of west-central Pennsylvania. This bed is everywhere present and is easily recognized by the drillers. In Greene County its thickness varies from 200 to 300 feet, and it lies from 1073 to 1297 feet below the Pittsburg coal. This interval decreases from the southeast toward the northwest, owing to an erosional unconformity at the top of the overlying Mauch Chunk formation. In general the Big Injun does not yield oil, but in one or two wells oil has been found in it. In the Richhill and Hoovers Run fields the sand is a source of considerable gas.

Thirty-foot sand.—In the Pocono formation, about 550 to 620 feet below the top of the Big Injun, lies a very irregular sandstone or group of lentils, known as the Thirty-foot sand. This is often confused with the Gantz sand, but the question of identity can generally be settled by noting the position of the red bed beneath it, described in the discussion of stratigraphy. The Thirty-foot sand corresponds approximately in its horizon with the Berea grit of Ohio and with the Butler gas sand of northern Pennsylvania. So far as known, the Thirty-foot is not productive of oil or gas anywhere in Greene County.

Gantz sand.—The sand next below the Thirty-foot is named from the Gantz farm at Washington, where oil was first produced from this bed. The sand has produced some oil in the Rogersville quadrangle, as explained under Fifty-foot sand. The Gantz is equivalent to the upper portion of the Hundred-foot sand of Beaver, Butler, and Armstrong counties. The lower portion of the Hundred-foot sand is known in Washington and Greene counties as the Fifty-foot sand. The Hundred-foot sand is possibly equivalent to the First sand of Oil Creek. In Washington County and in portions of northern Greene the Gantz and Fifty-foot are distinct sands. Toward the south they run together, however, and over the greater portion of the Rogersville quadrangle the Gantz is not known, but the name Fifty-foot is applied to the sand occupying the Hundred-foot horizon. Where it is present the Gantz sand ranges from 1850 to 1950 feet below the Pittsburg coal, and reaches a maximum thickness of 40 feet.

Fifty-foot sand.—The Fifty-foot sand occupies the lower portion of the Hundred-foot horizon. Its distance from the Pittsburg coal varies from 1900 to 2021 feet, and from the Big Injun sand from 674 to 847 feet. In thickness the Fifty-foot sand at some places amounts to as much as 40 feet. Where developed separately from the Gantz the interval between them may reach an extreme of 40 feet, but it is as a rule considerably less. As has been said, the Fifty-foot sand is considered to be near the base of the Carboniferous system. A great deal of oil has been produced from the Gantz and Fifty-foot sands in the Fonner field, and the Fifty-foot occasionally produces oil and gas elsewhere in the quadrangle.

Nineveh sand.—Near the top of the Devonian system lies a prominent sand, known in this region as the Nineveh or Nineveh Thirty-foot sand. This bed has been erroneously called Gordon or Gordon Stray by most of the drillers in western Greene County, but, as explained under the head of "Stratigraphy," the true Gordon sand lies considerably below this horizon. A few drillers in Richhill Township and elsewhere have correctly identified this horizon and have applied the name Nineveh, or Nineveh Thirty-foot, to the sand occurring in it. For the sake of simplicity, the name Nineveh is the one retained here. It is hoped that the incorrect usage of the terms Gordon and Gordon Stray will be abandoned.

The distance from the Nineveh sand to the Pittsburg coal runs from 1997 to 2121 feet and the sand is from 10 to 40 feet thick. The Nineveh sand can generally be correctly correlated by means of a red shale which occurs directly below it. Sometimes the Nineveh itself is reported as a red sand. This sand is the great oil-producing sand of the Rogersville quadrangle.

Gordon Stray sand.—The term Gordon Stray sand has been variously applied by drillers to the Nineveh sand and to a variable bed that occurs between the Nineveh and the true Gordon. Its use as a synonym of Nineveh should be discontinued. Where applied to a sand between the Nineveh and Gordon, the Stray is considered as merely a split from the true Gordon, and in this sense the name seems to be correctly applied. Only small quantities of oil and gas have been produced from this sand.

Gordon sand.—This sand takes its name from a well at Washington where oil was first produced from this horizon. In that vicinity it is one of the principal oil sands, and in the early days of the field it was naturally supposed that the productive sand at Nineveh was at the same horizon; hence the name Gordon came to be erroneously applied to the Nineveh sand of western Greene County. The Gordon sand occurs near the horizon of the top of the Venango oil group and of the Third sand horizon of Oil Creek. The interval between the Pittsburg coal and this sand ranges from 2083 to 2287 feet, and its thickness reaches a maximum of 100 feet or more. The sand is at some places much broken up and the position of its top is uncertain. In some borings a continuous sand is reported from the top of the Gordon Stray down to the bottom of the Fourth sand, and for this reason it seems probable that these sands are in reality merely splits from the Gordon.

In the Rogersville quadrangle the Gordon does not rank as a principal producing sand, although the Nineveh sand, which contains most of the oil, has been erroneously called Gordon by most drillers. A few wells in various parts of the quadrangle report oil and gas in this sand and also in the Stray and Fourth sands. In many of the wells in the oil district the Gordon has been called Fourth.

Fourth sand.—The true Fourth sand lies 2154 to 2316 feet below the Pittsburg coal and 20 to 120 feet below the top of the Gordon. Like the Gordon Stray, this sand is irregular in occurrence. A little oil has been found in it.

Fifth sand.—From 80 to 180 feet below the top of the Gordon lies the Fifth sand. Its thickness runs from 10 to 40 feet, and its depth below the Pittsburg coal varies between 2225 and 2352 feet. At a few scattered localities in the quadrangle small quantities of oil and gas have been found at this horizon. In the Hoovers Run field it is the principal gas sand, and it produces oil in the Lantz field, just outside the southeast corner of the quadrangle.

Bayard sand.—Only a few wells in the quadrangle are deep enough to reach the Bayard sand, and consequently little is known of it. Where penetrated, it lies about 130 feet below the top of the Fifth sand, and it reaches a maximum thickness of 12 feet. Its depth below the Pittsburg coal varies from 2400 to 2448 feet, and its interval from the top of the Big Injun is from 1168 to 1194 feet. In neighboring quadrangles the Bayard sand is a source of much gas, but in this area only one or two wells in Aleppo Township and one or two in Wayne Township report gas in it. As the sand has not yet been thoroughly tested there is likeli-

hood that further drilling to this horizon may be successful.

Elizabeth sand.—The Elizabeth sand lies 200 to 230 feet below the Fifth and has seldom been penetrated. Where found it lies 2400 to 2500 feet below the coal, and its thickness runs about 10 feet. It is sometimes reported as a red sand. Like the Bayard sand, the Elizabeth produces gas in neighboring fields, but in the Rogersville quadrangle none has yet been discovered in it.

THE OIL FIELDS.

Fonner field.—The Fonner oil field is represented by a group of wells in a small area lying in the extreme northeast corner of the quadrangle and extending outside its limits. Oil was discovered here in 1897 in a well drilled on the farm of William Fonner, and the field has contained some big wells. About 50 barrels of oil a day are still produced from the Gantz and Fifty-foot sands.

Nineveh field.—Oil was struck in quantity in this field on July 26, 1888, in the John H. Smith No. 3 well of the Nineveh Petroleum Company, situated 0.8 mile northwest of Nineveh. This was a large well and began the development of this district. The principal producing sand is the Nineveh, or Nineveh Thirty-foot, as it is often called. When this field was discovered it was supposed that this sand was the same as that which had been struck three years before in the original Gordon well at Washington, and hence the names Gordon, Gordon Stray, and Fourth sands came to be erroneously used in this territory. This field lies in the bottom of the Nineveh syncline, although most of the wells are on the western side of the axis.

Grays Fork field.—Southwest of the Nineveh field, in an area nearly 3 miles long, a number of dry holes were drilled in a vain endeavor to discover the productive belt in that direction. In the vicinity of Grays Fork, at the southwest end of this line of dry holes, a few wells nearly a mile west of the synclinal axis have produced oil from the Nineveh sand.

Bristoria field.—Beyond Grays Fork is another gap of 3 miles in which few holes have been drilled. Between Bristoria and Delphene, and in the vicinity of Higbee, lies the Bristoria field, covering an area of about 6 square miles, in which a large quantity of oil is produced. This field is in Jackson, Aleppo, Richhill, and Center townships, comprising the valley and interstream areas of Job Creek and Long Run. It lies almost entirely east of the Nineveh syncline, though a few productive wells are found west of the axis. Throughout this field most of the oil comes from the Nineveh sand, but one or more wells on the southeastern border of the field obtain it from the Gordon. Gas has been found in a few wells scattered through the field, and on the anticlinal slope along the southeastern border of the oil field in the vicinity of Delphene lies a small gas area. Most of the gas is produced from the Nineveh, Gordon, and Gordon Stray, and, in one or two wells, from the Fourth sand.

New Freeport field.—In Aleppo Township, in the continuation of the Bristoria field beyond its southern end, lies an area about 1½ miles long, parallel with the Nineveh syncline, in which a little oil is produced. Still farther south the productive belt is continued through Aleppo and Springhill townships southward beyond the limits of the quadrangle. As in the other fields in this belt, the Nineveh is the productive sand, although a few wells obtain oil in the Gordon. In the vicinity of New Freeport the Gordon and Fourth sands produce little gas. Operations in the Bristoria and Springhill fields are conducted mostly by the South Penn Oil Company.

Board Tree field.—Just beyond the southwest corner of the quadrangle, near the village of Board Tree, lies the Board Tree field, only one well of which appears within the quadrangle. Most of the oil comes from the Big Injun sand, but the Nineveh and Gordon sands also have produced small quantities.

Aleppo field.—This is composed of a small group of wells lying on the western side of the Nineveh syncline, which obtain their oil mainly from the Gordon and Fourth sands. Some gas is found in the Fifty-foot and Nineveh sands along the upper border of this field.

Wright Run field.—The Wright Run field consists of three wells situated on Wright Run 1¼ miles northwest of Bristoria. The oil is believed to occur in the Gordon Stray or upper part of the Gordon sand.

THE GAS FIELDS.

Richhill field.—The largest producing gas area in the quadrangle is the Richhill field, covering most of the northern half of Richhill Township, west of Graysville, north of Jacksonville, and northeast of Durbin. This field occupies the broad, triangular domelike summit of the Washington anticline. Gas is found at a number of horizons, including the Salt, Big Injun, Nineveh, Gordon Stray, Gordon, and Fourth sands. The principal operations are conducted by the Natural Gas Company of West Virginia.

Hoovers Run field.—In the extreme southeast corner of the quadrangle, extending southeastward from the head of Pursley Creek, on the eastern side of the Waynesburg syncline and along Tustin and Hoovers runs, lies the Hoovers Run field. Most of the gas comes from the Big Injun and Fifth sands, although small quantities are obtained from other beds. The principal operators are the People's Gas Company, Carnegie Natural Gas Company, Fort Pitt Gas Company, and Philadelphia Company.

Delphene field.—On the southeastern border of the Bristoria oil field, in the vicinity of Delphene, along the anticlinal slope for over a mile, is a small field represented by wells that derive their gas mostly from the Gordon Stray sand. The principal operators are the Philadelphia Company and the People's Gas Company.

New Freeport field.—This field covers a small area east of the Springhill oil field and mostly south of New Freeport. A number of wells are operated by the Philadelphia Company. Gas is produced mainly from the Nineveh, Gordon, and Fourth sands.

Scattered gas wells.—In various parts of the quadrangle many wells producing small quantities of gas lie outside the regular fields. The gas in these wells occurs at no particular horizon, traces of it having been found in nearly every sand. It is expected that prospecting for gas along the crests of the anticlines and upper portions of the structural slopes above the oil fields will in time be rewarded. Although the occurrence of oil and gas can not be predicted with any degree of certainty, it would seem desirable to test more thoroughly the crest of the Washington anticline southwest of Jacksonville and the flat-topped southward extension of the Amity anticline in Center, Jackson, and Wayne townships.

GEOLOGIC RELATIONS OF OIL AND GAS.

The anticlinal theory.—A more or less definite relation of oil and gas to geologic structure in the Appalachian field has long been recognized. It has been observed that nearly all the prominent gas pools are situated near the crests of the anticlinal folds, while oil generally occurs part way down the slopes or in the bottoms of the synclines. More frequently salt water occurs in the lowest parts of the synclines and the oil is found only above water level.

According to the anticlinal theory, the oil, gas, and water contained in rocks occur in them in the order of their densities—the water (if present) in the deeper portions of the inclined bed, the oil next above, and the gas nearest the crests of the anticlines. In western Pennsylvania and northern West Virginia these accumulations take the form of belts that are approximately parallel with the geologic axes and run in a general northeast-southwest direction.

Considerable doubt has been thrown on the anticlinal theory by oil and gas operators, on account of various apparent exceptions to its application. By most geologists the theory is now accepted, not, however, as indicating absolutely the limitations of the occurrence of oil and gas, but as expressing the general relations of their occurrence to geologic structure, such relations being subject to many modifying conditions. Some of the most important modifying conditions are (1) the presence or absence of salt water in a given region or in a given sand; (2) the continuity and shape of the anticlines—whether they are rising or pitching; (3) the porosity of the oil rock—that is, its capacity to hold oil; and, where the rocks are saturated, (4) the height of the water level.

Application of the theory in Pennsylvania.—The Pennsylvania folios which have been thus far published show some correspondence between the distribution of these deposits and the geologic structure. The gas fields occur generally on the anticlines, the oil fields just above the upper limit of the water if the rocks are saturated, and in the bottoms of the synclines if water is absent. Taking the Pennsylvania and northern West Virginia fields as a group, the evidence at hand seems to warrant the following generalizations regarding structural distribution:

(1) When not affected by other conditions, accumulations of oil and gas show a definite relation to the structure of the region.

(2) The greatest length of the pools is generally in a direction nearly parallel with the axes of the folds.

(3) Where both oil and gas occur they are distributed according to their densities, the oil being in the lower and the gas in the higher portions of the strata.

(4) When salt water and oil are present the oil lies above water level, except as noted in (5).

(5) Oil may occur on the crests of anticlinal folds below water level.

(6) When salt water is absent the oil occurs more irregularly and its position is more affected by other conditions; it may lie along the synclinal axes or at many points scattered over the slopes of the fold.

(7) Oil may occur on a structural slope at places where the dip changes from gentle to steep, or vice versa.

(8) Gas occurs most commonly on the higher portions of the anticlinal arches, above the upper level of the oil.

(9) Gas also occurs at widely scattered localities, its presence being due to small local folds or changes in porosity.

Structure is not the only condition determining the occurrence of gas and oil. The structure may be favorable, yet neither oil nor gas may occur. The chief condition other than those given above is the existence of rock of such character as to act as a reservoir.

STRUCTURAL RELATIONS OF OIL AND GAS IN THE ROGERSVILLE QUADRANGLE.

With reference to the distribution of oil and gas, certain statements can be made with respect to the several fields. Taking first the oil belt, we find that while the larger pools—the New Freeport, Bristoria, and Fonner fields—lie on the eastern flank of the Nineveh syncline, the Aleppo, Wright Run, and Grays Fork fields are on the western side of the axis. In general, they can all be said to lie nearer the bottoms than the tops of the structural slopes; and at several points south and east of Bristoria the producing wells extend as far down as the center of the basin. In the Nineveh field the oil lies in the bottom of the trough. The Wright Run field occupies a rather peculiar location, midway on the steepest slope between the bottom of the Nineveh syncline and the crest of the Washington anticline.

A rather puzzling feature in this district is the occurrence of several breaks in the productive belt that have no determinable structural relations. Between Nineveh and Grays Fork, especially, many dry holes have been drilled where we should expect to find the fields connected. Such breaks may be due to lack of porosity of the sands or to other unfavorable conditions. A rather noticeable feature is that wells in the synclines occur either on a rising axis, as at Nineveh, or on cross anticlinal rises that connect deeper portions of the trough, as in the vicinity of Bristoria. Few data are at hand regarding the presence of salt water in this basin, as the records seldom report it except in the Salt sand. It is known to be generally absent, however, and the facts outlined indicate that if it occurs at all in the Nineveh sand it is confined to that part of the sand lying within 50 feet above the deeper portions of the basins.

A better illustration of the anticlinal tendency of gas could hardly be given than is furnished by the Richhill gas field, which occurs on a prominent knoblike dome in the Washington anticline. The relations of the Hoovers Run field are somewhat unusual, for not only does it occur much nearer to the synclinal than to the anticlinal axis, but many of the gas wells lie very nearly in the bottom of the syncline. A rather discordant feature is the presence of the Lantz oil field higher up the structural slope, just out of the quadrangle, but the position of this field may perhaps be due to a barrier of impervious sand. The New Freeport and Delphene gas fields lie above the oil-producing areas, as would be expected, on the synclinal slope southeast of the Bristoria and New Freeport oil fields.

COAL.

With the exception of oil and gas, coal is destined to be the most important mineral resource of the Rogersville quadrangle. Owing to the depth of the Pittsburg coal bed below the surface, there are no mines at present, and only a few country banks are in operation, these being on seams of minor importance. The demand for coal is increasing, however, and with the rapid exhaustion of the Pittsburg seam along its outcrop the time will doubtless come when it will be developed in this region by means of shafts.

The only important outcropping coal beds in this quadrangle are the Waynesburg and the Washington seams, though several thinner beds occur. Several hundred feet below the surface lie the Mapletown and Pittsburg coals, and 600 to 700 feet deeper one or more beds of possible value are penetrated by wells.

WAYNESBURG COAL.

Stratigraphic position.—The Waynesburg coal lies at the top of the Monongahela formation, at a distance varying from 270 to 400 feet above the Pittsburg seam. With the exception of a few feet of underlying shale and limestone, the Waynesburg coal is the lowest bed outcropping in the Rogersville quadrangle. It attains its best development in Greene County, and it can nearly always be recognized by an overlying coarse, flaggy to massive sandstone, 20 to 60 feet in thickness. At some places the coal and sandstone are separated by a few feet of black shale.

Distribution.—The outcrop of the Waynesburg coal is shown on the economic geology map by the solid blue line at the contact of the Monongahela and Washington formations. Its outcrop is very small in this quadrangle, being only about 8 miles in length. It is exposed in the western part of the quadrangle, on Enslow and Dunkard forks of Wheeling Creek. On Dunkard Fork the coal first appears at Crabapple, and from there to the State boundary it has been mined at many country banks. On the main creek opposite Durbin is an especially fine exposure showing the coal below a cliff of massive Waynesburg sandstone. On Enslow Fork the outcrop can be seen from the State line for about 2 miles inside the quadrangle, and a number of country banks have been worked from time to time. In this region the Waynesburg sandstone is nearly absent, and its place is taken by shale. Beneath the greater part of the quadrangle the Waynesburg coal lies far below the surface. The depth is calculated to be about 400 feet at Graysville, 500 feet at Nineveh, 350 feet at Rogersville, and 400 feet at New Freeport.

Thickness.—The thickness of the Waynesburg coal ranges from 4 to 6 feet. In general it occurs in two or three benches, separated by clay or shale, as illustrated in fig. 6.

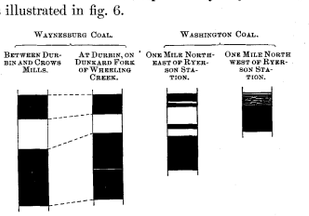

FIG. 6.—Typical sections of the Waynesburg and Washington coals in the Rogersville quadrangle.
Scale, 1 inch = 5 feet.

The thickest recorded measurement of this seam in the area is reported on the border of the quadrangle between Durbin and Crows Mills.

The section (see fig. 6), taken from the Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 67, is as follows.

Section of Waynesburg coal between Durbin and Crows Mills.

	Ft.	In.
Coal	1	4
Clay	1	8
Coal	3	2
	6	2

Directly opposite Durbin the coal is mined under a cliff of massive Waynesburg sandstone. The sandstone forms an excellent roof, so that no timbering is necessary, and this condition is common with the Waynesburg coal. The section here (see fig. 6) measures as follows:

Section of Waynesburg coal at Durbin.

	Ft.	In.
Coal	1	1
Fire clay	1	1
Coal	2	0
Binder		½
Coal	1	8
	5	10½

In this vicinity the thickness of the coal is variable, on account of "rolls," or depressions of sandstone from the roof. In some places these cut out one or more benches of the coal, and elsewhere within a short distance the coal may increase to an unusual thickness.

Quality.—In quality the Waynesburg coal is greatly inferior to the Pittsburg seam. Where analyzed in other districts it always contains a high percentage of sulphur and usually of ash. In western Greene County only one analysis has been made. The sample analyzed was from the bank opposite Durbin. In taking the sample a section 2 inches thick was cut from roof to floor, excluding the fire-clay parting. The sample was then mixed and quartered to the desired bulk and shipped in an air-tight can to the chemical laboratory. It was analyzed at the United States Geological Survey's coal-testing plant at St. Louis.

Analysis of Waynesburg coal from Durbin.

[E. E. Somermeier, analyst.]

Moisture	2.79
Volatile matter	36.05
Fixed carbon	48.35
Ash	12.81
	100.00
Sulphur	3.77

The coal mined along Wheeling Creek is sold to supply the farmers over a considerable area in western Greene County.

WAYNESBURG "A" AND LITTLE WASHINGTON COALS.

Two coal blossoms are seen at many places in the interval of 100 feet above the Waynesburg. These beds are known as the Waynesburg "A" and the Little Washington coals. They are both well exposed in the vicinity of Crabapple, the former just above the Waynesburg sandstone and the latter 40 feet higher. At Ryerson Station the Waynesburg "A" measures 19 inches, of which the upper 5 inches is largely shale. The bed is not known to be better than this in the quadrangle. The Little Washington is at one place a foot thick. It is evident that neither of these can ever be of much value.

WASHINGTON COAL.

Stratigraphic position.—The Washington coal occurs from 115 to 180 feet above the Waynesburg coal and directly below the Lower Washington limestone. Its distance from the Pittsburg coal runs from 420 to 540 feet, and the averages for the various townships are as follows:

Interval between Pittsburg and Washington coals in the Rogersville quadrangle.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	450	526	475	3
Center	431	454	440	3
Richhill	430	473	448	5
Aleppo	420	450	435	2
General average			449	

This bed is much more persistent than any other bed of the Dunkard group, and at some places reaches a thickness of 3 or 4 feet, although much of it is at most places composed of shale partings.

Distribution.—The Washington coal crops out above the Waynesburg bed on Dunkard Fork of Wheeling Creek and its tributaries, and on Crabapple Creek. In the vicinity of Ryerson Station and on Crabapple Creek it has been opened at a number of banks. The beds that contain it outcrop for some distance along Enslow Fork, but here the coal is either thin or absent. On Robinson Fork, in West Finley Township, only 5 inches of coal is reported. In the eastern and southern parts of the quadrangle the Washington coal is buried deep below the surface.

Thickness.—The workable thickness of the Washington coal runs less than that of the Waynesburg bed, since it is generally much broken up by clay and shale. It has been measured at several places, and two sections are represented in fig. 6.

The best section known in the quadrangle is on North Fork, 1 mile northeast of Ryerson Station (see fig. 6). This shows the coal in four benches, the lowest of which amounts to 1 foot 11 inches, as follows:

Section of Washington coal 1 mile northeast of Ryerson Station.

	Ft.	In.
Clay (4 feet).		
Coal		5
Clay		1½
Coal		2
Clay	1	0
Coal		3
Clay		5
Coal	1	11
Clay.		
	4	3½

On a tributary to Dunkard Fork, 1 mile northwest of Ryerson Station, the following section (see fig. 6) occurs:

Section of Washington coal 1 mile northwest of Ryerson Station.

	Ft.	In.
Clay (1 foot).		
Coal		½
Clay		½
Coal		1
Coal and bone		6
Coal	1	6
	2	2

Quality.—At the locality where the last section was taken a sample of the main bench of the coal was collected and sent for analysis to the coal-testing plant of the United States Geological Survey at St. Louis. The sample was taken according to the standard method described in connection with the Waynesburg coal. The composition was found to be as follows:

Analysis of Washington coal from near Ryerson Station.

[E. E. Somermeier, analyst.]

Moisture	2.22
Volatile matter	36.79
Fixed carbon	46.96
Ash	14.03
	100.00
Sulphur	3.79

This analysis shows that the coal is high in sulphur and ash and low in fixed carbon. In burning qualities it belongs in the same class as the Waynesburg. It is used to a considerable extent by farmers in western Washington and Greene counties, but on account of its numerous shale and bone partings it will probably not be of great value in this area.

TENMILE COAL.

Generally speaking, the Greene formation lacks coal beds of workable thickness, although measurements of a foot or more are occasionally reported. The Tenmile, Dunkard, and Nineveh coals are in this formation.

At several points in the northern part of the quadrangle a coal blossom has been noted 50 to 100 feet above the Upper Washington limestone. This coal has about the same stratigraphic relations as the Tenmile coal found on North Branch of Tenmile Creek in the Amity quadrangle, which at some places reaches a thickness of 3 feet. In this quadrangle the bed is best developed near Graysville, where it is about 1 foot thick.

DUNKARD COAL.

This bed outcrops at many scattered points in the quadrangle, but is everywhere thin. The following sections are reported, and may be considered typical:

Sections of Dunkard coal in the Rogersville quadrangle.

Locality.	Thickness, in inches.		
	Coal (upper bench).	Clay.	Coal (lower bench).
Fish Creek near Deep Valley	6	2	5
Woods Run, Jackson Township	11	1	8
Mudlick Fork, Aleppo Township	11	1	10

At several points in Jackson, Aleppo, and Center townships the Dunkard coal has been prospected and burned to a limited extent, but it is of little value.

NINEVEH COAL.

A still higher bed is the Nineveh coal, which occurs at an estimated distance of 900 to 1000 feet above the Pittsburg seam. The maximum thickness seems to be in the vicinity of New Freeport, where 1 foot 10 inches of it is reported.

UNIONTOWN COAL.

Below the Waynesburg the first coal encountered by the drill is a thin bed which has been correlated with the Uniontown, but in this quadrangle it has been reported in the records of only a few wells. With one exception these are all in Richhill Township. The coal is from 229 to 263 feet above the Pittsburg coal and from 53 to 105 feet below the Waynesburg. The averages of the intervals are 238 and 77 feet, respectively. Reported thicknesses of the coal bed vary from 2 to 4 feet, but they are probably exaggerated.

SEWICKLEY (MAPLETOWN) COAL.

The distance of this bed below the Waynesburg coal varies from 187 to 297 feet, and it is 79 to 120 feet above the Pittsburg. In Springhill Township the distance to the Pittsburg coal ranges only between 95 and 119 feet, and 45 of the 74 records averaged in this township give an interval of exactly 100 feet. They are not, however, steel-line measurements.

The thickness of the Mapletown coal is variously reported from 3 to 10 feet. This coal is believed to be identical with the Sewickley coal, which is of workable thickness in many parts of northern West Virginia and in the Monongahela Valley in Pennsylvania.

PITTSBURG COAL.

Depth and intervals.—The Pittsburg coal is one of the most valuable coal beds in southwestern Pennsylvania. Records of oil and gas wells indicate that it underlies the whole of the Rogersville quadrangle at depths ranging from 300 to 1400 feet. It has been extensively mined in portions of Pennsylvania and West Virginia, where it is more accessible than it is here. It occurs at the base of the Monongahela formation, 270 to 400 feet below the Waynesburg coal. The range exhibited by well records is somewhat greater than this, but several records confuse the Waynesburg and Washington coals. The following table gives the maximum, minimum, and average intervals for the various townships.

Interval between Pittsburg and Waynesburg coals in the Rogersville quadrangle.

Township.	Interval, in feet.			Number of records considered.
	Least.	Greatest.	Average.	
Morris	300	328	309	4
Richhill	285	366	318	25
Center	266	380	326	6
Wayne	315	345	328	9
Gilmore			306	1
Jackson	306	359	332	2
Aleppo	271	355	304	8
Springhill	294	400	353	14
General average			322	

By comparison of the figures in this table it will be seen that the lowest measurements are not confined to any one section of the quadrangle, but are rather irregularly distributed. In general, however, it may be said that this interval diminishes from the southeast toward the northwest, as the interval in eastern Greene County is 400 feet and in northwestern Washington it is reported to be about 270 feet.

The lay of the Pittsburg coal in this quadrangle is represented on the structure and economic geology map by contour lines, which show its elevation at vertical intervals of 50 feet. The approximate depth of the coal below the surface at any point can easily be determined from the map by simply subtracting the elevation of the coal as shown by the contours from the surface contour at the point desired.

Thickness.—Little is known regarding the exact thickness and quality of the Pittsburg coal in this quadrangle, but in records of oil and gas wells it is reported to range from 6 to 13 feet. Where this seam outcrops in southwestern Pennsylvania and northern West Virginia it has an average workable thickness of about 6 feet. The bed consists of a "breast coal" and a "bottom coal," separated by a parting of about 2 inches.

Quality.—In order to show the general quality of the bed, three analyses are given of samples of this coal taken at the three mines in it that lie nearest to this quadrangle: (1) At Ellsworth, Washington County, Pa.; (2) at Moundsville, Marshall County, W. Va.; and (3) at Farmington, Marion County, W. Va.

Analyses of Pittsburg coal from mines in vicinity of the Rogersville quadrangle.

	1.	2.	3.
Moisture	1.22	1.08	0.39
Volatile matter	36.38	40.05	35.38
Fixed carbon	56.24	52.22	56.42
Ash	6.26	6.65	7.81
	100.00	100.00	100.00
Sulphur	.84	3.51	.71
Phosphorus	.....	.005	.0215
Calories	7,915	.....	.....
B. T. U	14,247	13,949	.....

1. Ellsworth No. 1 colliery, Ellsworth, Washington County, Pa., 18 miles northeast of Nineveh. Sample collected by F. G. Clapp and F. W. DeWolf. Analyzed by E. E. Somermeier, U. S. Geological Survey coal-testing plant, St. Louis, Mo.

2. Moundsville mine, near Moundsville, Marshall County, W. Va., 14 miles west of Durbin. Sample collected by Mr. S. L. Brady. Analyzed by Prof. B. H. Hite, chief chemist, West Virginia Agricultural Experiment Station, Morgantown, W. Va. (West Virginia Geol. Survey, vol. 2, 1903, p. 205.)

3. Chatham shaft No. 1, one-fourth mile east of Farmington, Marion County, W. Va., 18 miles south of Hoovers Run. Sample collected by Mr. S. L. Brady. Analyzed by Prof. B. H. Hite, chief chemist, Morgantown, W. Va. (West Virginia Geol. Survey, vol. 2, 1903, p. 205.)

From these analyses it will be seen that the coal in eastern Washington County, Pa., and that in northern Marion County, W. Va., are very similar in quality. The analyses indicate a good coal for steaming and one that may be of value as a gas coal, and as the sulphur is below 1 per cent, it may prove acceptable for coking. The Moundsville sample is, however, too high in sulphur for this purpose unless the sulphur can be reduced in amount by washing. In general, analyses of the Pittsburg coal in Washington County, Pa., show an increase in sulphur toward the west, across the county; and in Ohio the coal is generally rather poor. As the Rogersville quadrangle lies midway between the localities of high and low quality, it is not safe to predict whether or not the bed in this area will prove to be a coking coal. It is almost certain, however, to be a first-class steam coal, and probably a good gas coal.

UPPER FREEPORT ("CONNELLSVILLE") COAL.

Below the Pittsburg coal is an interval of over 600 feet in which coals are rarely reported. These rocks compose the Conemaugh formation or "Lower Barren measures." Below them lie about 300 feet of coal measures, which in the Allegheny, Monongahela, and Beaver valleys contain several valuable seams. The only one of these reported in the Rogersville quadrangle is known to drillers as the "Connellsville" coal, and is believed to be equivalent to the Upper (or Lower) Freeport seam of the Allegheny Valley. The interval between this bed and the Pittsburg coal can be calculated from several wells, and in Richhill Township ranges from 639 to 693 feet, averaging 667 feet. In Aleppo Township one record reports it as 635 feet, and in Gilmore Township it is 725 feet. As the interval between the Pittsburg and Upper Freeport coals averages only about 600 feet in eastern Washington County, it seems to increase toward the southwest.

It is possible, however, that the coals in the two areas may not be the same.

LIMESTONE.

A number of limestone beds are exposed in the Rogersville quadrangle, but all of them are thin, rarely exceeding 5 or 10 feet, and are generally interbedded with considerable shale. One of these beds—the Upper Washington—is rather pure in the eastern part of the quadrangle, but toward the west it breaks up, becomes very shaly, and at some places disappears. Where at its best it ought to be worth burning for agricultural lime. Other thin limestones occur locally, and some are persistent over a number of square miles. Some of these are very shaly, but others are worth testing in the kiln. The Upper Washington bed, where at its best, has been already tested, and in some places has been found satisfactory for fertilizer, but in other places it is too much broken up by shale to be used for this purpose.

SANDSTONE.

The sandstone beds in this quadrangle are not economically important. Several beds, the Waynesburg, Fish Creek, and Gilmore sandstones, are at some places very massive, and ought to be valuable for foundations and similar work, though in general they are too friable for heavy construction.

In the northwest corner of the quadrangle, near Deerlick, there is a bed of coarse, yellowish gray, massive sandstone, so soft that it is quarried for sand for use in building. This bed lies about 100 feet above the Upper Washington limestone.

WATER.

The Rogersville quadrangle contains no large streams, but the entire area is cut up by a network of creeks that run in rather deep valleys and are separated by sharp ridges. All except a few of the larger creeks generally run dry in the summer months, and Tenmile Creek and the main forks of Wheeling Creek consist during that time of a series of mudholes. Creek water is put to use only on South Fork of Tenmile Creek, from which the water supply of the town of Waynesburg is taken. This town lies 3 miles east of the eastern boundary of the quadrangle, and has a population of over 3500. On account of the amount of silt in the water and the danger of pollution from villages and farms along the creek the water supply is both disagreeable and unsafe, although it passes through a sand filter before reaching the town. A number of cases of typhoid fever have occurred in recent years.

In the Rogersville quadrangle the domestic water supply is obtained entirely from springs and shallow wells, both of which are abundant. Regarding water-bearing horizons, few data are available. The water wells of the quadrangle are in general too shallow to permit general interpretations as to horizons, and only a few of the oil and gas wells record fresh-water horizons. The Gas and Salt sands contain great quantities of salt water, and in general water from any great depth in this quadrangle is salty and hence is unsuitable for domestic uses. The deeper sands are generally dry. The Waynesburg sandstone is often water bearing and the Fish Creek and other sandstones in the Dunkard group occasionally furnish water.

SOIL.

Conditions in western Greene County are not favorable to agriculture. The limestones which in eastern Washington County attain considerable thickness are here generally thin and their outcrops are less abundant, and hence they have not materially contributed to the fertility of the soil. Over most of the area the soil is shaly in character, but the steepness of the slopes has prevented extensive cultivation. Corn, grass, and grain are raised to a limited extent, especially in the broader valleys, where the soil is alluvial. The forests of the area were long ago removed, and in the past the hillsides have been used for raising sheep, but this industry has greatly declined in importance. Fertilizer has been little used.

November, 1906.

U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR
STATE OF PENNSYLVANIA
REPRESENTED BY
TOPOGRAPHIC AND GEOLOGIC
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1365
Figures
showing heights above mean sea level instrumentally determined

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

DRAINAGE
printed in blue

Streams

CULTURE
printed in black

Roads and buildings

Churches and school houses

Private and secondary roads

Railroads

County lines

Township lines

Triangulation stations

Bench marks

H. M. Wilson, Geographer.
Frank Sutton, Topographer in charge.
Topography by R. D. Cummin and E. G. Hamilton.
Triangulation by Sledge Tatum.

SURVEYED IN 1903 IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

MAGNETIC NORTH
MAGNETIC SOUTH
APPROXIMATE MEAN DECLINATION 1903.

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 April 1905, reprinted Mar. 1907.

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

STATE OF PENNSYLVANIA
REPRESENTED BY
TOPOGRAPHIC AND GEOLOGIC
SURVEY COMMISSION

AREAL GEOLOGY

PENNSYLVANIA
ROGERSVILLE QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

Recent

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

Pleistocene

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

CARBONIFEROUS

Pennsylvanian 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 limestones and beds of coal)*

Cm — Monongahela formation *(Waynesburg coal and a few feet of underlying shale only exposed)*

H. M. Wilson, Geographer.
Frank Sutton, Topographer in charge.
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SURVEYED IN 1903 IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1903.

Scale $\frac{1}{62500}$

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Contour interval 20 feet.

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Edition of Jan. 1907.

Geology by Frederick G. Clapp,
assisted by Frank W. De Wolf,
under the direction of Marius R. Campbell.
Surveyed in 1904.

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U. S. GEOLOGICAL SURVEY
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STRUCTURE AND ECONOMIC GEOLOGY

PENNSYLVANIA
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LEGEND

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Economic and structure data

- X *Coal openings*
- ● *Oil wells*
- ● *Gas wells*
- ○ *Dry holes, or product unknown*

Sections of numbered wells are shown on columnar section sheet

Coal outcrops *(Washington coal, wg; Waynesburg coal, wb; continuous lines represent coal beds of known workable thickness; dashed lines, coals of probably workable thickness)*

500

Structure contours *(showing the lay of the Pittsburg coal and the elevation of its base above sea level; broken lines indicate uncertain location; contour interval is 50 feet)*

H. M. Wilson, Geographer.
Frank Sutton, Topographer in charge.
Topography by R. D. Cummin and E. G. Hamilton.
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COLUMNAR SECTION

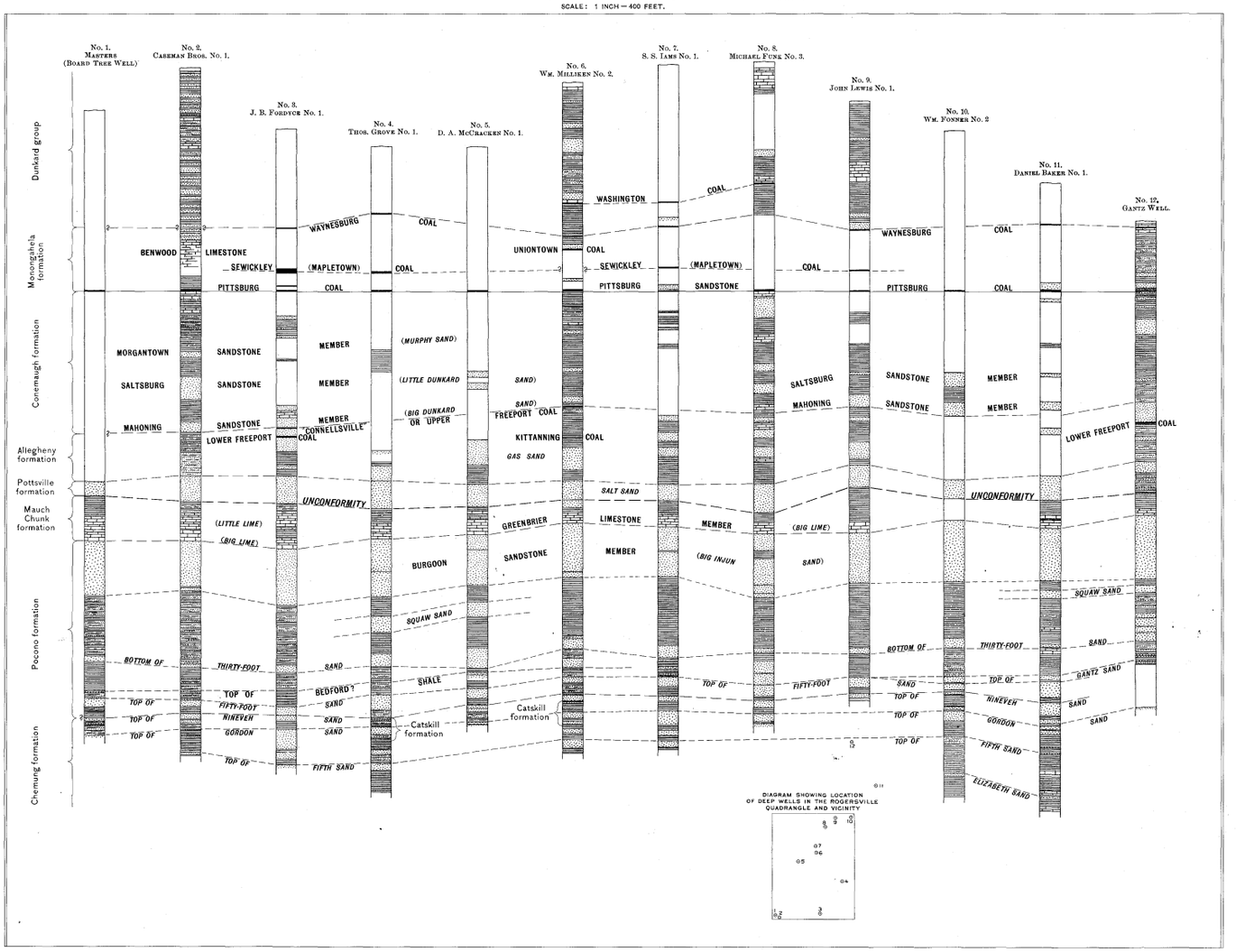
GENERALIZED SECTION FOR THE ROGERSVILLE QUADRANGLE.

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 (DUNKARD GROUP)	Greene formation.	Cg		750±	Windy Gap limestone. Windy Gap coal. Gilmore sandstone.	Dark, bluish black, with minute fossils; western Aleppo Township. Thin and shaly; highest coal of Dunkard group. Coarse and massive sandstone; Gilmore, Springhill, and Aleppo townships.	Soft shale and shaly sandstone with occasional massive sandstones, a few thin limestones, and several thin coal beds of no value; much red shale in thin and nonpersistent beds.
						"Nineveh" sandstone. "Nineveh" coal. "Nineveh" limestone.	Variable. Thin and not persistent. Generally very shaly.	
						Fish Creek sandstone. Dunkard coal. Tenmile coal.	Massive sandstone; Springhill, Jackson, Center, and Morris townships. Thin, but rather persistent. Thin coal; northern part of quadrangle.	
		Washington formation.	Cw		300–400	Upper Washington limestone. Jollytown limestone. Jollytown coal. Middle Washington (?) limestone. Lower Washington limestone. Washington coal. Little Washington coal. Waynesburg "A" coal. Waynesburg sandstone.	Dark, bluish black, compact to shaly; weathers white. Thin, but rather persistent in eastern part of the quadrangle. Thin coal bed. Yellow weathered surface; not persistent. Light gray, mottled or brecciated; northwestern part of quadrangle. Workable coal of fair quality on Dunkard Fork and Crabapple Creek. Very thin coal. Thin coal. Massive to flaggy sandstone; on Dunkard Fork and Crabapple Creek near Durbin.	Alternating and variable sandstones, limestones, and shale, generally soft, except the Waynesburg sandstone, which is rather massive. One rather important coal bed.
	PENNSYLVANIAN	Monongahela formation.	Cm			Waynesburg coal. Waynesburg limestone.	Workable coal of fair quality; on Dunkard Fork and Enslow Fork near border of quadrangle.	Only a few feet of this formation, of limestone, shale, and sandstone, are exposed.

SECTIONS OF DEEP WELLS IN THE ROGERSVILLE QUADRANGLE AND VICINITY.

SCALE: 1 INCH = 400 FEET.



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