DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

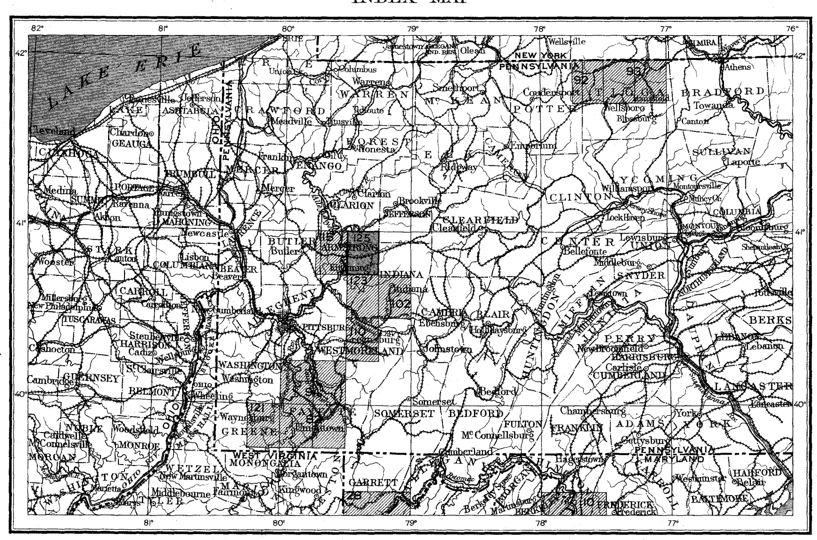
OF THE

UNITED STATES

RURAL VALLEY FOLIO

PENNSYLVANIA

INDEX MAP



RURAL VALLEY FOLIO

OTHER PUBLISHED FOLIOS

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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).

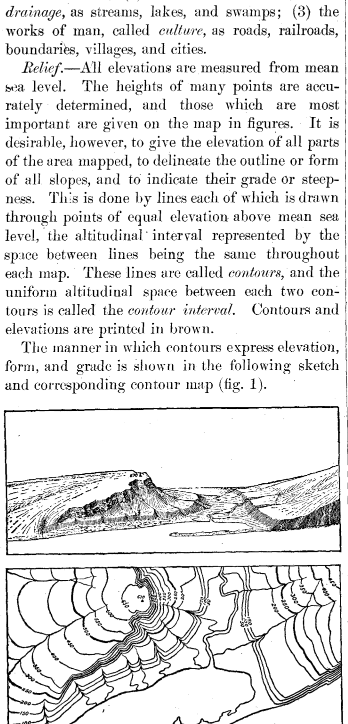

FIG. 1.—Ideal view and corresponding contour map.

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

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

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

SURFACE FORMS.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

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

Economic geology map.—This map represents the distribution of useful minerals and rocks, showing their relations to the topographic features and to the geologic formations. The formations which appear on the areal geology map are usually shown on this map by fainter color patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A mine symbol is printed at each mine or quarry, accompanied by the name of the principal mineral mined or stone quarried. For regions where there are important mining industries or where artesian basins exist special maps are prepared, to show these additional economic features.

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

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

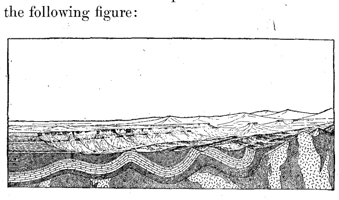

Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

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

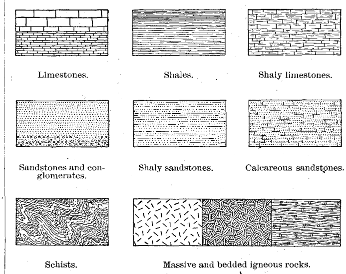

Fig. 3.—Symbols used in sections to represent different kinds of rocks.

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

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

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

On the right of the sketch, fig. 2, the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be

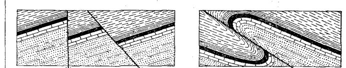

Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

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

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

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

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

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

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

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

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness of each is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest formation at the bottom, the youngest at the top.

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

CHARLES D. WALCOTT,

Director.

Revised January, 1904.

DESCRIPTION OF THE RURAL VALLEY QUADRANGLE.

By Charles Butts.

INTRODUCTION.

Location.—By reference to the key map on the cover of the folio it will be seen that the Rural Valley quadrangle lies in the Allegheny Valley, in the west-central part of Pennsylvania, and extends from latitude 40° 45′ on the south to latitude 41° on the north and from longitude 79° 15′ on the east to longitude 79° 30′ on the west. It includes one-sixteenth of a square degree and its area is about 226 square miles. It is almost wholly in Armstrong County, but the small part lying north of Redbank Creek is in Clarion County. The quadrangle is named from the most important town within its boundaries.

Relations to the Appalachian province.—In its geographic and geologic relationships the Rural Valley quadrangle forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain on the east to the Mississippi lowlands on the west, and from Alabama to Canada.

GEOGRAPHY AND GEOLOGY OF THE APPALACHIAN PROVINCE.

GENERAL FEATURES.

With respect to topography and geologic structure, the Appalachian province may be divided into two nearly equal parts by a line following the eastward-facing escarpment known as the Allegheny Front through Pennsylvania, Maryland, and West Virginia, and the eastern escarpment of the

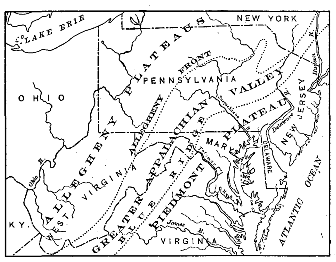

FIG. 1.—Diagram of northern portion of the Appalachian province, showing physiographic divisions.

Cumberland Plateau (see fig. 1) from Virginia to Alabama. East of this line the rocks are greatly disturbed by faulting and folding; west of the line they lie nearly flat, the few folds that break the regularity of the structure being so broad that they are scarcely noticeable.

The general topographic features of the northern part of the province are shown by fig. 6, illustration sheet. Immediately east of the Allegheny Front are alternating ridges and valleys, designated the Greater Appalachian Valley, and still farther east is a slightly dissected upland known as the Piedmont Plain. West of the Allegheny Front are more or less elevated plateaus, which are greatly dissected by streams and broken by a few ridges where minor folds affect the rocks. In contradistinction to the lowlands of the Mississippi Valley on the west and the ridges and valleys of the Appalachian Valley on the east, this part of the province has been called by Powell the Allegheny Plateaus (Nat. Geog. Mon. No. 3, p. 80). The Rural Valley quadrangle is situated in the Allegheny Plateaus, which will therefore be described in detail.

ALLEGHENY PLATEAUS.

The Allegheny Plateaus are characterized by distinct types of drainage, surface features, and geologic structure, which are described below.

Drainage of the Allegheny Plateaus.—The Allegheny Plateaus are drained almost entirely into Mississippi River, but the waters in their northeastern part flow either into the Great Lakes or into the Atlantic Ocean through Susquehanna, Delaware, or Hudson rivers.

In the northern part of the province the arrangement of the drainage is due largely to former glaciation. Before the Glacial epoch all the streams north of central Kentucky probably flowed northwestward and discharged their waters through the St. Lawrence system. The encroachment of the great ice sheet closed this northern outlet, and the existing drainage lines were established.

In the southern half of the province the westward-flowing streams not only drain the Allegheny Plateaus, but many of them have their sources on the summits of the Blue Ridge and across the Greater Appalachian Valley.

Relief of the Allegheny Plateaus.—This division of the province is highest along its southeastern margin, where the general surface rises from the altitude of 1700 feet in southern Tennessee to 4000 feet in central West Virginia, and then descends to 2200 feet in southern New York. The surface also slopes in a general way to the northwest and southwest and merges into the Mississippi and Gulf plains. In the southeastern part of the Plateau region, in Tennessee and Alabama, is the Cumberland Plateau. West of the Cumberland Plateau in Tennessee and Kentucky lies the Highland Plateau, at an altitude of about 1000 feet above the sea. North of these well-defined plateaus to southern New York the region is greatly dissected and its plateau character is apparent only as one takes a wide view from some elevated point and notes the approximately uniform height of the ridges and hills.

The surface of the Cumberland Plateau and perhaps also the summits of the higher ridges and hills, as well as extensive tracts of level surface at high altitudes in a broad belt along the southeastern margin of the Allegheny Plateau region from the Cumberland Plateau to New York, are probably remnants of a peneplain, possibly the Schooley peneplain, developed on the Schooley Mountains of northern New Jersey, where it has been studied and named by W. M. Davis (Proc. Boston Soc. Nat. Hist., vol. 24, p. 377). In the Allegheny and Monongahela valleys of western Pennsylvania, including the surface of the Rural Valley quadrangle, the higher divides and ridges probably approximately coincide with the surface of a second peneplain, younger than the Schooley peneplain and at a lower level. This peneplain has recently been studied by Campbell (Bull. Geol. Soc. America, vol. 14, pp. 277–296) and named by him the Harrisburg peneplain because it is well developed near Harrisburg, Pa. Along the Monongahela, Allegheny, and Ohio valleys there has been recognized a third peneplain. This is lower, younger, and less extensive than the Harrisburg peneplain. It has been named by the writer the Worthington peneplain (Kittanning folio), because it is well developed between the town of Worthington and Allegheny River in Armstrong County, Pa.

Stratigraphy of the Allegheny Plateaus.—The rocks of this region are mostly of Carboniferous age. Around the northern end and along the southeastern margin of the plateaus the Carboniferous rocks are bordered by the upper formations of the Devonian system, which extend beneath Carboniferous rocks throughout the northern half of the region. The Carboniferous rocks are divided into two series, the Mississippian series below and the Pennsylvanian series above. The rocks of the Mississippian series are mainly sandstones and shales in the northern part of the region, but there are thick limestones in the southeastern and southwestern parts. The rocks of this series outcrop around the margins of the plateaus and underlie the rocks of the Pennsylvanian series in the interior of the region. The rocks of the latter series are coextensive with the Appalachian coal field, the northern part of which is shown on the map forming fig. 7 of the illustration sheet. This series of rocks consists essentially of sandstones and shales, but contains extensive beds of limestone and fire clay. The Pennsylvanian series is especially distinguished, however, by its coal seams, one or more of which is present in nearly every square mile of its rocks from northern Pennsylvania to central Alabama. The rocks of the Rural Valley quadrangle include portions of both series.

Structure of the Allegheny Plateaus.—For the purpose of this folio the discussion under this head may be confined to the Appalachian coal field.

The geologic structure of the rocks of the Appalachian coal field is very simple, since they form, in a general way, a broad, flat, canoe-shaped trough. This is particularly true of the northern extremity of the field, as may be seen in the illustration just referred to. The axis of this trough lies along a line extending southwestward from Pittsburg across West Virginia to Huntington on Ohio River. The rocks lying southeast of the axis dip northwest; those lying northwest of the axis dip southeast. In Pennsylvania the deepest part of the trough is in the southwest corner of the State and the inclination of the rocks is generally toward that point. About the northern end of this canoe-shaped trough the rocks outcrop in a rudely semicircular belt, and at all points dip toward the lowest part of the trough.

Although in general the structure is simple, the eastern limb of the trough is crumpled into a number of parallel wrinkles or folds that make the detailed structure somewhat complicated and break up and conceal the regular westward dip. These undulations are similar to the great folds east of the Allegheny Front, but they are on a very much smaller scale and have not been broken by faults. These minor folds are present along the southeastern margin of the basin, from central West Virginia to southern New York. Across the northern extremity of the basin the minor folds are developed in large numbers, and the folded region extends at least halfway across Pennsylvania near its northern boundary. In the southern part of the State there are only six pronounced anticlines, two of these disappearing near the West Virginia line. Farther south the number is less, until, on Kanawha River, the regular westward dip is interrupted by only one or two folds of small proportions. Close examination shows that west of the Allegheny Front each trough, as well as each arch, lies lower than the one on the east, so that formations or beds which are over 2000 feet above sea at the Allegheny Front lie below sea level in the central part of the basin.

GEOGRAPHY.

DRAINAGE.

The Rural Valley quadrangle is drained by Allegheny River and its tributaries. The river flows within the quadrangle for only a short distance, along the western side. The northern part of the quadrangle is drained by Redbank Creek, a stream about 75 miles in length, which rises in the northwest corner of Clearfield County and joins the Allegheny at Redbank Junction, about 3 miles west of the quadrangle. The great loop in Redbank Creek in the vicinity of Climax is known as Anthonys Bend. South of Redbank Creek flows Mahoning Creek, a stream of similar size, having its source in western Clearfield County and joining the Allegheny at Mahoning. Mudlick Creek, in the northeast corner of the quadrangle, and Scrubgrass Creek, which enters the Mahoning from the south near its mouth, are important tributaries of the Mahoning. Pine Creek, which enters the Allegheny at Mosgrove, lies almost wholly within the quadrangle and, with its two branches, North Fork and South Fork, drains a considerable area in the center of the quadrangle. Cowanshannock Creek rises a short distance east of the quadrangle, flows nearly west, and enters the Allegheny at Cowanshannock, about one-half mile west of the quadrangle. Huskins Run and Mill Run are small tributaries of the Cowanshannock on the south. Garrett Run drains a small area in the southwest corner, and the north branch of Plum Creek in the southeast corner of the quadrangle.

The difference between the meandering courses of the larger streams, Redbank and Mahoning creeks, and the comparatively direct courses of the smaller streams, Pine and Cowanshannock creeks, is a striking feature of the drainage of the quadrangle. Crooked Creek, some distance south of the quadrangle, is comparable in size with Redbank and Mahoning creeks, and it is also characterized by a highly meandering course. An explanation of these phenomena will be offered further on.

Drainage relations, present and past.—The Allegheny is now tributary to the Ohio, and this in turn to the Mississippi. It is the main headwater tributary of the Ohio and drains an area of about 11,500 square miles, of which 2000 square miles lie in southwestern New York and 9500 square miles in northwestern Pennsylvania. Some of its affluents in Cattaraugus and Chautauqua counties, N. Y., and Erie County, Pa., have their sources on the southern slope of an elevation which overlooks Lake Erie at points only 7 to 15 miles distant from the lake, yet they take a course directly away from the lake and form no part of the St. Lawrence drainage.

As was shown many years ago by Carll (Second Geol. Survey Pennsylvania, Rept. III, 1880, pp. 352–355) and later by Chamberlin and Leverett (Am. Jour. Sci., 3d ser., vol. 47, 1894, pp. 247–283), the apparently anomalous course of Allegheny River is due to the fact that it was formed by the union of a number of independent streams, part of which originally flowed northward into the basin of Lake Erie. As shown by the sketch map, fig. 2, the upper part found outlet to the northwest by Salamanca to Gowanda and thence down Cattaraugus Valley; the middle portion, from a point as far south as Emlenton, passed through

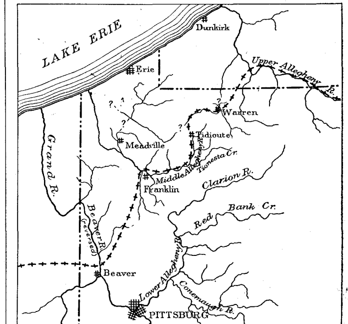

FIG. 2.—Sketch map showing the probable pre-Glacial drainage of western Pennsylvania. The terminal moraine is shown by a broken crossed line.
(After Frank Leverett, with addition of terminal moraine.)

Venango, Crawford, and Erie counties, Pa., along a channel now utilized in part by French and Conneaut creeks to enter the Erie basin just east of the Ohio-Pennsylvania State line, and the waters of the Clarion and the lower Allegheny with its tributaries followed the present course of drainage to the mouth of Beaver River, where they apparently turned to the north and followed an old valley occupied in part by Beaver and Grand rivers to reach the Lake Erie basin. While, therefore, the streams within the Rural Valley quadrangle are following the old courses, their present relation to the drainage of the continent is very different from that which they held before the Glacial epoch. The Allegheny is also a much larger stream at present than in pre-Glacial times, the present watershed down to and including Redbank Creek being about four times the area of the pre-Glacial watershed which had its discharge through the lower Allegheny.

RELIEF.

The surface of the Rural Valley quadrangle is hilly. The valleys are generally narrow and rather deep, and are bounded by steep walls. On the uplands there is a more level or gently undulating surface, and farming is confined largely to such areas. The valley slopes are gentler toward the headwaters of the smaller streams and along their tributaries, where there is much arable land. The steep sides of the larger valleys are generally forested.

Harrisburg peneplain.—To a superficial view the present irregular surface of this quadrangle offers but little suggestion that its condition was once very different. A close examination of the topographic map will reveal the fact that in the southern part of the quadrangle there are many hilltops, ridges, spurs, and divides at an altitude of about 1340 feet, and that in the northern part similar features exist at an altitude of 1460 feet, while in the intermediate region intermediate altitudes occur over much of the area. Probably three-fourths of the whole would lie at or below the surface of a plane inclined from 1340 feet in the southern part to 1460 feet in the northern part of the quadrangle. Above such a plain would stand at greater or less heights considerable areas, the largest of which lie in a general way along a line running from Blanket Hill through Muff and Belknap. There are smaller areas of elevated land toward the southeast corner and along the margin of the quadrangle.

If, now, we conceive the parts of the quadrangle that lie below the imaginary plane described above to be so raised by filling as to coincide approximately therewith, the higher areas to remain as at present, there would result an undulating surface that could properly be called a peneplain. This is the Harrisburg peneplain, briefly described in the "Introduction."

The Harrisburg peneplain was probably the result of subaerial erosion that acted for a long period, during which the crust of the earth in this region moved neither up nor down. This peneplain was nearly horizontal, and stood much lower than the present general surface. Above the average level of the peneplain stood considerable areas in the northern part of the quadrangle and along the axis of the Greendale anticline, from Blanket Hill to Belknap. The rocks in some of the areas, and probably in all, are harder and more resistant to erosion, and so were not worn down to the general level, yet, had they been stationary long enough, even these slight eminences would have been eroded away. Such a plain could have been formed by marine erosion, but there is no evidence that this peneplain was formed in that way. It might also be coincident with the surface of some resistant stratum, such as a hard sandstone. In the northwest corner of the quadrangle, in the vicinity of Widnoon and Kellersburg, the Freeport sandstone may have been influential in determining the surface, and in the northeast corner the Mahoning sandstone, 100 feet or more higher stratigraphically, exercised a like influence; yet generally in this region the peneplain appears to have been developed on hard and soft strata alike.

Worthington peneplain.—About 100 feet below the Harrisburg peneplain there are evidences, in divides and in flat surfaces, of a second partly developed peneplain. This is the Worthington peneplain, mentioned in the "Introduction." It is not so conspicuously developed in this quadrangle as in the Kittanning quadrangle on the west, but traces of it may be seen in the southwest corner, in the flat ridges and spurs at about 1240 feet, and farther north, in the vicinity of Templeton, in similar features at about 1300 feet. The level tracts between Mahoning and Scrubgrass creeks north of Goheenville probably represent the same surface.

Parker strath.—On both sides of the river at Mosgrove and on the west side opposite Templeton there are nearly level shelves of rock covered with gravel and sand. These shelves stand about 200 feet above the river and have an elevation above sea level of about 980 to 1000 feet, though there is a small area east of Mosgrove where a cut of the Buffalo, Rochester and Pittsburg Railroad reveals the top of the rock terrace at 960 feet. These rock shelves are remnants of a former broad, flat bottom of the Allegheny Valley, which was bounded by high, steep walls. The broad bottom was a consequence of a low gradient of the river, which must have existed for a long time, during which the river was more active in widening than in deepening its valley, according to well-known laws of stream action. Such shelves exist along the course of the river from Parker, in northern Armstrong County, to Pittsburg. At Parker their elevation is 1020 to 1040 feet, and at Pittsburg 890 feet, while at intermediate points they have intermediate elevations which show a uniform but low grade between Parker and Pittsburg for the old valley floor.

It has been customary to call such a broad valley floor a gradation plain, but the propriety of using the word plain for so limited a feature is questionable and on that account, as well as for the sake of brevity, the term *strath* was introduced in the Kittanning folio. This name is used in Scotland for a similar feature, though the term is not restricted to that use. This strath is well preserved in the rock terrace at Parker, from which place it is named. It was developed not only along the river but also along some of its tributaries. Thus along Mahoning Creek there are a number of terraces covered with creek gravels and silts which show that the creek formerly ran upon them. Such terraces may be seen at Eddyville, Putneyville, and in the vicinity of Mahoning Furnace. The top of the rock terrace forming the floor on which the gravels lie has an elevation of about 1040 feet at Eddyville, 1020 feet at Mahoning Furnace, and about 1000 feet at Dee. The Parker strath is represented by an almost continuous terrace along the north side of the South Fork of Pine Creek west of Pine Furnace. Here the rock top of the terrace stands at about 1000 feet and is covered with silt containing much roughly waterworn material. This strath seems to be represented along Cowanshannock Creek from Greendale to the eastern margin of the quadrangle by a succession of terraces that stand somewhat above the level of the modern flood plain but gradually merge into it. The same is true of the North Branch of Plum Creek.

Abandoned valley of Mahoning Creek.—About 1 mile southwest of Mahoning Furnace is an isolated knob cut off from the surrounding hills on the south by a broad valley, which is now occupied by very small streams. This valley could not have been formed by these streams and was once occupied by the Mahoning itself, the knob being connected by a neck to the spur on the north side of the creek, just as the knob three-fourths of a mile still farther west is now connected to the hill on the south. The curves of the valley show that the creek impinged on both sides of the connecting neck and gradually wore it through, thus opening a more direct course, which it has since followed, leaving its old course unoccupied. A little farther west is another knob connected with the southern hillside by a low neck, and this neck is covered with sand and waterworn bowlders which show that the creek formerly flowed across it. The creek did not succeed in establishing itself in this course, however, so the western knob was not completely cut off.

GEOLOGY.

STRATIGRAPHY.

The rocks in this quadrangle comprise those not exposed at the surface and those that outcrop. The former are revealed in deep wells sunk for gas or oil (see well-section sheet); the latter can be studied directly.

ROCKS NOT EXPOSED.

SOURCES OF KNOWLEDGE.

Information concerning these rocks is derived entirely from the records or logs of deep wells bored for gas or oil and is more or less imperfect. In many cases records have been carelessly kept, beds important from a geologic standpoint, such as bands of red rock or a bed of limestone, have been overlooked or not recorded, and frequently only the oil or gas sands have been noted, thus leaving great blanks in the logs. The methods of measurement introduce some errors. While measurements to the oil and gas sands are mostly made by steel line and are accurate, the depth and thickness of other beds are generally determined by counting the turns of the cable on the bull-wheel shaft, and errors may easily occur. In very deep wells the stretching of the cable might be the cause of an error of considerable magnitude. The difficulty of identifying rocks by the relative ease with which the drill penetrates them or by the drillings brought up in the sand pump is also probably a source of error, especially with observers having no scientific training. To this fact may be and probably often are due in part the lithologic differences recorded in wells drilled in contiguous areas. It may thus happen that important beds that are not recorded are not really absent from the section, but have been overlooked. In other cases a heavy sandstone in one well might change to a highly arenaceous shale or shaly sandstone in an adjacent well and thus be recorded as slate or shale. At best, observations on rocks in deep-well sections must be confined almost wholly to their lithologic character; only in very rare instances can anything be learned of their fossils, a knowledge of which is almost indispensable to the correct determination of the age and stratigraphic position of the rocks.

THICKNESS.

The thickness of the rocks revealed by the drill below the lowest horizon of exposed rocks in the quadrangle is about 2400 feet. The top of the unexposed strata thus penetrated lies at river level near Grays Eddy and a well 2400 feet deep in the Allegheny Valley at that point would pass through them. The character of these rocks is best shown by the well sections given on the well-section sheet. Three of the wells whose sections are shown are the deepest of which we have records in the quadrangle. These are the Colwell well, on the west bank of the Allegheny, opposite Templeton, the Colwell No. 1 well at Mahoning Furnace, and the Moore well at Smeltzer. Of these the Colwell No. 1 well penetrates deepest into the underlying strata, but its record is not complete, and it is of less value in giving a knowledge of the deeper rocks than either of the other two, the records of which are complete and detailed.

CHARACTER AND SUBDIVISIONS.

These unexposed rocks fall naturally into three well-differentiated groups. In general the following strata are encountered from the top downward; (1) 700 to 800 feet of gray shale and sandstone; (2) 300 to 400 feet of strata characterized by the presence of more or less red rock, presumably red shale; and (3) 1500 to 2000 feet of prevailingly dark shale with thin sandstone layers and occasional thicker beds of sandstone to the lowest horizon reached.

GRAY SHALE AND SANDSTONES.

The gray shale and sandstones contain several members of sufficient importance to warrant separate description. With the exception of these members the group is composed mainly of gray sandy shale with occasional heavy sandstones.

Burgoon (Mountain) sandstone.—At the top of this group lies about 100 to 175 feet of heavy sandstone, which is the lower part of the Mountain or Big Injun sand of the driller, the upper 225 feet of which is exposed in the Allegheny Valley on the arch of the Kellersburg anticline. For reasons fully stated in the Kittanning folio, it is proposed to use the geographic name Burgoon sandstone for this stratum.

Patton shale.—In many wells a thin band of red shale occurs just below the base of the Burgoon sandstone. This is a widely distributed stratum and merits attention on account of its importance as a horizon marker. This bed was first described by Richardson (Indiana folio) and was named by him the Patton shale on the assumption that it is the same as the red shale that outcrops at Patton station on Redbank Creek in Jefferson County.

Lower sands (gas sands).—In some of the well sections shown on the well-section sheet a sandstone noted about 150 feet below the Mountain sandstone is called the First sand, but it is by no means certain that the first sand of one well is the same as the first sand of another. This sandstone is sometimes regarded as the equivalent of the Pithole grit of Venango County and the Berea grit of Ohio, but there is no conclusive evidence that that horizon is represented in this region. The bottom of this group of gray shales and sandstones is prevailingly sandy and several beds are distinguished. These are the Murrysville gas sand, about 300 feet below the Mountain sand; the Second or Hundred-foot sand, about 450 feet below the Mountain sand; and the Thirty-foot sand, just below the Hundred-foot sand. The top of the Second or Hundred-foot sand is near the top of the Venango oil sands of the oil regions.

RED ROCKS.

Below the gray rocks occur several hundred feet of strata characterized by more or less of what the drillers call red rock, presumably red shale. The proportion of red rocks as well as the extent of the interval in which they occur differs much, as can be seen on the well-section sheet. In some records no red rocks are noted; in most, the part of the section through which they are noted is 200 to 350 feet in thickness. The total thickness and the distribution of these red beds vary greatly. In some wells (as in Nos. 1, 3, and 9) they occur as scattered beds of greater or less thickness separated by beds of dark shale and sandstones; in others (as in No. 15) they occur as an unbroken mass 300 feet thick; in still others (as Nos. 7 and 12) no red beds at all are noted. It seems hardly credible that they are absent in such wells; it is far more probable that they occur as thin beds which were either not observed or not recorded.

Oil sands.—Associated with the red rocks are the coarse oil-bearing sandstones known as the Stray, Third, and Fourth oil sands, with the overlying thin sandstones known as the Blue Monday and Boulder sands. Generally they are not well developed in the Rural Valley quadrangle.

DARK SHALES AND THIN SANDSTONES.

The remaining 1500 to 2000 feet of strata comprising the third group and extending to the bottom of the deepest well are composed mainly of gray shales interbedded with thin sandstone layers, to which the drillers apply the name "slate and shells," the sandstone layers being the shells. Occasionally throughout this group thicker strata of sandstone occur, but these are rarely noted as reaching 50 feet in thickness.

Speechley and Tiona sands.—In the midst of the third group and from 500 to 700 feet below the red beds occurs a group of these sands, the upper members of which are known as the Speechley and the lower as the Tiona sands.

GENERAL CORRELATION.

As will be shown in the discussion of exposed rocks, the Burgoon (Mountain) sandstone certainly belongs to the Pocono formation, but the lower limit of the Pocono can not be determined with certainty. This question has been fully discussed in the Kittanning folio, where it is shown that the rocks of group 1 down to the top of the red rocks or to the base of the Hundred-foot sand are probably Pocono, the red rocks of group 2 probably Catskill, and the 1500 to 2000 feet of gray shales and sandstones of group 3 probably Chemung. If this interpretation is correct the Devonian-Carboniferous boundary would coincide with the stratigraphic plane separating the Hundred-foot sand and the red rocks.

ROCKS EXPOSED.

Carboniferous System.

GENERAL STATEMENT.

All the hard rocks outcropping in this quadrangle belong to the Carboniferous system, but certain unconsolidated deposits belong to the Quaternary. The Carboniferous rocks are divided into two series, the Mississippian series below and the Pennsylvanian series above. The Mississippian series is not generally coal bearing, but in certain parts of the Appalachian region it includes workable coal beds of limited extent. The Pennsylvanian series includes the coal-bearing rocks or Coal Measures of the Appalachian coal fields, and is typically developed in Pennsylvania. Both series are made up of a number of separate formations, which in turn are composed of various members of local importance. In this quadrangle the Mississippian series is represented by the

Pocono formation, while the Pennsylvanian is represented by the Pottsville, Allegheny, and Conemaugh formations.

POCONO FORMATION.

The occurrence of rocks belonging to this formation in the Allegheny Valley has been a disputed question. W. G. Platt (Second Geol. Survey Pennsylvania, Rept. H5) maintained that they are present in the region, while Lesley held the contrary opinion and believed that all the Pocono rocks of Platt were really of Pottsville age. The question has been finally set at rest by investigations made in the region by Campbell and White, who, on the evidence of fossil plants, have determined the presence of at least 200 feet of Pocono rocks along the Allegheny River north of Mahoning. A full discussion of the subject, together with the evidence in the case, has been presented in the text of the Kittanning folio and will not be repeated here.

Character and distribution of Pocono.—So far as exposed, the Pocono formation consists of a heavy bed of gray to greenish sandstone, the Mountain or Big Injun sandstone of the driller. This sandstone has been named by the writer (Kittanning folio) the Burgoon sandstone. In places, as at Mahoning and at Cosmos, it includes beds of shale, which are generally greenish and sandy, and which may reach a thickness of 40 feet. Thin seams of impure coal also occur in the bluff north of Mahoning. As shown in the description of the unexposed rocks, this sandstone is nowhere fully exposed in the quadrangle. Its greatest exposed thickness is about 260 feet, in the bluff of the Allegheny on the arch of the Kellersburg anticline. This sandstone outcrops in the Allegheny Valley from Templeton, where the top is near water level, to the western margin of the quadrangle, where its top reaches a height of about 260 feet above the river. It is exposed along nearly the whole length of Redbank Creek within the quadrangle. Its top is but little above water at Lawsonham. It rises gradually to a height of 100 feet in the vicinity of Leatherwood and to 200 feet in the vicinity of St. Charles; then it descends rather rapidly and goes below water level about midway between Climax and the southern point of Anthonys Bend. It rises above water again on the east side of the bend near the tunnel, and continues a few feet above water to the northern margin of the quadrangle. It is finely displayed near the eastern end of the tunnel between Lawsonham and Leatherwood, in the bluff south of the latter place, and above the railroad at Climax. It is also exposed along Mahoning Creek from McCrea Furnace, about 1 mile south of Eddyville, to the eastern margin of the quadrangle. It is well displayed in an exposure at Redbank station on the Allegheny Valley Railroad, where probably the whole of the sandstone in the cliff is Burgoon.

MAUCH CHUNK FORMATION.

The only bed so far known in the quadrangle that may with probability be referred to this formation is a stratum of red sandstone, about 15 feet thick, noted in Peter Heilman well No. 2, near the southern margin. It will be seen on the well-section sheet that this red bed occurs at the horizon of the Mauch Chunk, to which it is here doubtfully referred. If the rock is really Mauch Chunk, it is only a remnant that has escaped the erosion which has, so far as known, removed the formation from the rest of the quadrangle, and its preservation may be due to the fact that it is sandstone which resisted erosion more strongly than the shale of which the formation usually consists in the nearest region on the south. Platt (Second Geol. Survey Pennsylvania, Rept. H5) referred the gray shale appearing beneath the heavy beds of sandstone in the mouth of the ravine at Grays Eddy to the Mauch Chunk formation, but it has been definitely determined, however, that the overlying sandstone is Pocono.

POTTSVILLE FORMATION.

STRUCTURAL RELATIONS OF THE POTTSVILLE.

The Pottsville rests unconformably on the rocks below, but is conformable with the succeeding formation. Not only is the Mauch Chunk formation generally absent in the region, but the top of the Pocono as it exists farther east and south has been eroded. This would appear to be attested by the absence of the Loyalhanna (Siliceous) limestone, which is taken to represent the top of the Pocono, in regions where the full thickness of the formation is preserved. It thus happens that the Pottsville formation was deposited upon the eroded surface of the Burgoon sandstone, which in this region forms the top of the Pocono, so that there is an unconformable contact between the two formations. It is not possible to establish this unconformity on lithologic or structural grounds, for the coarse sandstone at the base of the Pottsville lies upon sandstone of apparently identical character at the top of the Pocono without any visible discordance in the dip of the rocks of the two formations. The stratigraphic evidence for this unconformity is corroborated by paleobotanic evidence, which, having been presented fully in the Kittanning folio, will not be repeated here. It will be sufficient to state that a good Pottsville flora has been found down to a certain horizon in the rocks, a short distance below which more or less perfectly preserved remains of Pocono plants have been found. The dividing line is thus fixed within narrow limits at 240 feet below the Vanport (Ferriferous) limestone, which, being an easily traceable bed, is used as a reference stratum throughout the region.

The top of the Pottsville can be definitely located by a heavy sandstone that can generally be found about 100 feet below the limestone wherever the horizon of the sandstone is exposed. This would make the thickness of the Pottsville 140 feet, and since, on account of the conditions described above, it is impossible to trace the boundary between the Pottsville and Pocono formations, the former has been somewhat arbitrarily mapped as having that thickness, the top being taken as 100 feet below the Vanport limestone.

CHARACTER AND DISTRIBUTION OF POTTSVILLE.

The Pottsville in this region contains three members, the Connoquenessing sandstone below, shale bearing the Mercer coal and fire clay in the middle, and the Homewood sandstone at the top. The formation is exposed along the Allegheny from about 1 mile south of Templeton to the western margin of the quadrangle, along the full course of Redbank Creek, along Mahoning Creek, except a short stretch in the bottom of the Fairmount syncline, and for a short distance on the South Fork of Pine Creek where it crosses the axis of the Greendale anticline.

DESCRIPTIONS OF MEMBERS OF THE POTTSVILLE.

Connoquenessing sandstone.—This is generally a coarse, gray, heavy-bedded sandstone. It has this character below the south end of the road along the bluff from Templeton to Mahoning. At the north end of the road, just south of Mahoning, it rises above the road, the heavy rocks below the road to railroad grade belonging to the Pocono formation. In the bluff west of Grays Eddy the Connoquenessing is about 50 feet thick and contains beds of rather coarse conglomerate. At Climax it is exposed above the western end of the tunnel as a white, siliceous sandstone, which has been used to some extent in the manufacture of silica brick. It is finely exposed as a coarse, thick-bedded, gray sandstone in the bluff at the north end of the bridge at McCrea Furnace, about a mile south of Eddyville; in the cut for the wagon road up the bluff of the Mahoning, just west of Eddyville; and along the gorge of Pine Run for some distance above its mouth.

Mercer shale.—This is a composite member, probably varying from 30 to 50 feet in thickness. It consists mostly of dark shale. The shale frequently carries one or more thin coal seams. A workable coal seam occurs in Mercer County, from which the name was derived. In this quadrangle the top of the shale, with thin pockets of coal at the base of the overlying sandstone, may be seen in the road along the bluff between Templeton and Mahoning. At Climax the following section is exposed:

Section at Climax.

		Feet.	Inches.
Homewood sandstone		15+	
Mercer shale	Sandy shale	10	
	Thin coal		
	Sandy shale	28	
	Coal	1	6
	Fire clay	10+	
Connoquenessing sandstone			

The bed of fire clay contains both flint and plastic clay. This clay also occurs in good thickness on the south bluff of Redbank Creek about one-half mile below St. Charles. It is correlated with the Mount Savage clay of Maryland.

Near McCrea Furnace a bed of sandy limestone 6 to 10 feet thick occurs. Platt regarded this as the siliceous limestone at the top of the Pocono and the underlying sandstone as Pocono. The writer, however, has recently discovered Pottsville lepidodendra in this sandstone, which seems to establish the fact that the limestone is Pottsville, and since it occurs about 140 feet below the Vanport limestone there is little doubt that it represents the Mercer limestone.

Homewood sandstone.—This is generally coarse, gray sandstone, though in places it becomes laminated. Its top lies about 100 feet below the Vanport limestone, and it is about 40 feet thick. In the river bluff above Mahoning and at Grays Eddy, as well as in the vicinity of Lawsonham on Redbank Creek, it is thick bedded. In the bluff of Redbank Creek at the apex of Anthonys Bend it is laminated. At New Bethlehem the coarse, thick sandstone showing in the railroad cut north of the creek and just off the quadrangle is probably the Homewood.

Large blocks of coarse sandstone from this member occur in the ravine just east of Templeton, and it is exposed along the road from Templeton to Mahoning. It shows well just above water on Mahoning Creek below the mouth of Scrubgrass Creek, and at the forks of the road in the valley about three-fourths of a mile southeast of Kellersburg. A laminated sandstone below the bridge at Mahoning Furnace and a hard, white, quartzitic sandstone apparently 50 feet thick in the bluff south of the bend below Putneyville are probably Homewood. In the road near the top of the bluff of the Mahoning, about one-half mile north of Eddyville, it is exposed as a coarse, thick-bedded sandstone. The thickness exposed is about 15 feet, and this is probably near the top. It shows on the bank of Pine Run about midway between the mouth and Charlestown, at which point it is coarse but thin bedded. It has not been specially noted above Eddyville except in the ravine of Glade Run, where a sandstone about 40 feet vertically below the road may represent the bottom of the Homewood.

The Pottsville showing on the South Fork of Pine Creek, already mentioned, is the Homewood sandstone, which is coarse and rather thick bedded.

ALLEGHENY FORMATION.

GENERAL CHARACTER AND DISTRIBUTION.

This formation succeeds the Pottsville conformably and extends upward to the top of the Upper Freeport coal. It is composed of sandstones, limestones, shales, clays, and coals, aggregating about 350 feet in thickness. The coal seams, though varying from a few inches to 5 feet in thickness, are the most persistent members of the formation, and occur in it from top to bottom, at intervals averaging about 40 feet. The intervening strata are generally shale, which is, perhaps, prevailingly gray and sandy, though both dark- and light-colored clay shale occurs. Within the shale comparatively thin layers of sandstone are common, and at certain horizons lenses of sandstone, varying much in texture and bedding, frequently replace the shale and are classed as members of the formation.

These lenses may reach a thickness of 40 feet or more and may extend over many square miles.

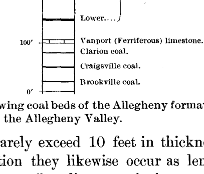

FIG. 3.—Section showing coal beds of the Allegheny formation in the Allegheny Valley.

The limestones rarely exceed 10 feet in thickness. With one exception they likewise occur as lenses at definite horizons. One limestone is, however, a persistent bed, and has been traced over nearly the whole quadrangle. The fire clay occurs as the underclay of the coal seams. These underclays are coextensive with the coal seams, and the thickness of any particular bed varies greatly. Twelve feet is the maximum thickness observed. The foregoing section, fig. 3, will give a good idea of the general relations of the coal seams.

The rocks of this formation form the surface over a large area in the northwestern part of the quadrangle, along the crest of the Kellersburg anticline, and in an area extending along the crests of the Greendale and Brookville anticlines from the northeast corner of the quadrangle to Cowanshannock Creek. They are also exposed along the valleys of all the streams where they cross the Fairmount syncline. In the southeast corner of the quadrangle, and on the higher ground in the Fairmount syncline, they are concealed by the rocks of the Conemaugh formation.

DESCRIPTIONS OF MEMBERS OF THE ALLEGHENY.

Brookville coal.—This is generally a worthless bed lying from a few feet to about 30 feet above the base of the Allegheny, the interval being occupied by shale and fire clay. The coal blossom may be seen in many places close above the top of the Homewood sandstone. What appears to be this coal occurs in workable thickness along the upper portion of Mahoning Creek and its tributaries within the quadrangle.

Clarion sandstone.—At the old mill on Cowanshannock Creek 1 mile above its mouth, near the margin of the quadrangle the following section (fig. 4) is exposed:

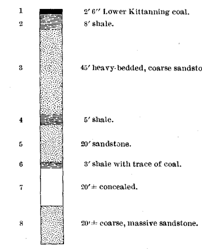

FIG. 4.—Section at old mill on Cowanshannock Creek, 1 mile above its mouth.

In this section the thicknesses of the concealed interval (7) and the sandstone below (8) were estimated and may be considerably in error. The sandstone (8) shows in the bed of the creek and in a ledge washed by the water, whence have come the great bowlders of coarse, white sandstone that fill the channel at the old mill. Near the mouth of the creek the Vanport limestone is about 50 feet below the Lower Kittanning coal. In the section above no trace of the limestone was detected, and its place is apparently occupied by the shale marked 4. The shale with traces of coal (6) probably represents the Clarion coal, and the sandstone at the bottom of the section (8), which may occupy most of the concealed interval also, is probably the Clarion sandstone described in the Pennsylvania report on Armstrong County. Its bottom would lie at least 60 feet below the Vanport limestone, and its thickness may reach 40 feet. An interesting feature of this section is the fact that nearly the entire interval of over 100 feet below the Lower Kittanning coal is filled with coarse, heavy sandstone, and this is a good illustration of the variable nature of Coal Measure stratigraphy.

The coarse, massive character of the Clarion sandstone at this place led Platt to call it Pottsville, and he was led into the same error by the great blocks of very coarse sandstone in the ravine of Camp Run south of McCrea Furnace. These also come from the Clarion sandstone, which crops out near the top of the hill close by the highway where it turns eastward up Mahoning Valley. The size of the blocks would indicate a thickness of 20 feet. The ledge of sandstone along the highway south of Mahoning Creek just below the bridge at Mahoning Furnace is probably Clarion. The sandstone forms a ledge about 40 feet high on the north bank of the Mahoning between the two ravines about $1\frac{1}{2}$ miles below Mahoning Furnace. It seems to be almost if not quite continuous vertically with the Homewood sandstone at these places. The coarse, heavy, white sandstone in the road about one-half mile south of New Bethlehem is also Clarion.

Craigsville coal.—This name was used in the Kittanning folio and was given to a coal that in the vicinity of Craigsville occurs about midway between the Brookville and Clarion coals. In the section exposed in the bluff just above Templeton, a small coal about 1 foot thick occurs in this position. It has not been noted elsewhere and is probably of no consequence in the quadrangle. The Clarion sandstone is not developed where this coal occurs, but the horizon of the coal is apparently in the part of the section occupied by the sandstone where present.

Clarion coal.—The position of this coal is 50 to 70 feet above the Brookville coal and 15 to 25 feet below the Vanport limestone. It is of no value in the quadrangle so far as known. One foot is the greatest thickness noted. In places, as at Mahoning and Templeton, the Clarion fire clay underlies the coal.

Vanport limestone.—This is universally known throughout western Pennsylvania as the Ferriferous limestone, because it bears upon its upper surface the buhrstone iron ore that was once extensively used in the manufacture of iron. It has been an important guide in drilling operations, for when its position is known the driller can estimate the depth to the gas and oil sands.

The Vanport is a bluish gray limestone of a good degree of purity, running generally over 90 per cent carbonate of lime. Fossils are fairly plenty in it and show that it is of marine origin. It runs quite uniformly about 8 feet in thickness wherever it has been observed. Its horizon is above water on the Cowanshannock from about 1 mile east of the western margin of Valley Township to the western boundary of Cowanshannock Township. It is known to be present from its western outcrop to a point about 1 mile east of Greendale, but it is not known east of that point and it is apparently cut out by a heavy sandstone which occurs at its horizon in this locality. On the South Fork of Pine Creek it is revealed on the crest and flanks of the Greendale anticline. It rises to view at Pine Furnace, reaches an elevation of 150 feet above the creek about 1 mile west of Oscar and descends below water level again about one-half mile west of Echo. It is not known to be present everywhere along this creek, but probably it is. It is above water for about 3 miles along North Fork of Pine Creek on the western flank of the Greendale anticline, where it shows its usual thickness. On Scrubgrass Creek it rises to the surface about one-half mile east of Goheenville and remains above the stream for about 3 miles to the eastward. On Allegheny River it is not known on either side from the western margin of the quadrangle to a point about 2 miles south of Templeton, where it appears, rises rapidly toward the Kellersburg anticline, and can be followed along both sides of the river to the bend above Grays Eddy, beyond which point it is not known. It is known along much of the length and is probably present throughout the full length of Mahoning and Redbank creeks.

The local absence of the limestone is commonly attributed to erosion. This matter has been discussed somewhat at length in the Kittanning folio, and reasons were advanced there for believing that its absence is due rather to lack of deposition.

Kittanning sandstone.—This sandstone occurs between the Lower Kittanning coal and the Vanport limestone. It sometimes lies immediately upon the limestone and in places apparently cuts out that stratum entirely. It forms a conspicuous ledge along the west side of the Allegheny opposite Mosgrove and southward. It is here coarse and massive and a thickness of about 20 feet is exposed.

At Pine Furnace and at the mouth of Deaver Run the sandstone may be seen immediately on top of the limestone. It is here 20 to 30 feet thick. On Hays Run and on the east side of the river about 1 mile north of Mosgrove a heavy sandstone that overlies the Lower Kittanning coal is possibly to be regarded as an upper portion of the Kittanning sandstone. On the Cowanshannock, at the old mill about 1 mile above its mouth, and again in the vicinity of Greendale, this sandstone is coarse and heavy and apparently cuts out the Vanport limestone. At any rate the limestone can not be found and the sandstone occurs at its horizon.

Lower Kittanning coal.—This occurs 20 to 40 feet above the Vanport limestone, and with the exception of the local development of sandstone above described, not only at the localities mentioned, but possibly at others also, the interval between the coal and limestone is occupied by shale and fire clay. The coal itself runs from 3 to 4 feet thick along the northern margin of the quadrangle and west of a line drawn roughly from Kittanning through Kellersburg. It seems to be 3 feet or more thick along the Mahoning and its tributaries east of Putneyville. Outside of these portions of the quadrangle, so far as known, the Lower Kittanning is thin and of little value. Nothing definite is known of it in the southern and southeastern parts of the quadrangle, where it lies deep below the surface, though an occasional well record in this region shows a coal of good thickness that appears to be the Lower Kittanning. The coal is generally underlain by a bed of plastic clay of variable thickness.

Middle Kittanning coal.—This coal lies from 30 to 50 feet above the Lower Kittanning coal, from which it is usually separated by shale. On Scrubgrass Creek below Goheenville a thick bed of black shale overlies the Lower Kittanning coal and above the shale is a bed of heavy gray sandstone 20 feet thick. The coal is generally thin but is probably persistent throughout the quadrangle. In the hill south of Mahoning Furnace, on both forks of Pine Creek, and on the North Branch of the South Fork of Pine Creek for several miles above Echo the coal is from 2 to 3 feet thick.

Upper Kittanning coal.—From 40 to 60 feet above the Middle Kittanning coal lies the Upper Kittanning coal. The two are separated by shale. This coal is about 18 inches thick at a few points on Mill Run and on the Cowanshannock. It is fairly well developed along the South Fork of Pine Creek in the vicinity of Pine Furnace and on the North Fork from the mouth of Bullock Run eastward to where the creek is crossed by the highway southwest from Goheenville. It is a thin bed in the vicinity of Widnoon. In the northeast corner of the quadrangle, north of Mahoning Creek and east of Anthonys Bend, this coal locally swells to unusual thickness and is accompanied in such places by a thick bed of cannel coal and shale. This characteristic has led to its being called the "pot vein."

Freeport sandstone.—This occupies a position between the Upper Kittanning and Lower Freeport coals. It is present on the hills in the northwestern part of the quadrangle in the vicinity of Widnoon and Tidal. It is particularly heavy and conspicuous at the head of a ravine south of Mahoning Creek about 1 mile east of the northwest corner of Wayne Township. It is apparently 40 to 60 feet thick there. On the north side of Mahoning Creek opposite the mouth of this ravine, near the top of the bluff, there are great masses of sandstone which probably came from this stratum. The Freeport sandstone shows in good thickness in a ravine east of Templeton, at the mouth of Bullock Run, where it lies on the top of the Upper Kittanning coal, and at Pine Furnace, where it either is in contact with the Upper Kittanning coal or closely overlies it.

Lower Freeport coal.—From 40 to 50 feet above the Upper Kittanning coal lies the Lower Freeport coal. Its thickness reaches in places 4 feet. Where the Freeport sandstone is absent the interval is occupied by shale. The coal is apparently persistent over a considerable area extending southward from West Valley to Blanket Hill and has been opened and worked at a number of places. It is a coal of considerable value along the northern margin of the quadrangle east of New Bethlehem and it is known locally in the northeastern corner of the quadrangle as far south as Goheenville and Belknap.

Butler sandstone.—At the point where the highway running southwestward to Kittanning crosses Hays Run a heavy sandstone 8 to 10 feet thick occurs between the Upper and Lower Freeport coals. This is the Butler sandstone. In the bluff of the Allegheny south of the large island midway between Mosgrove and Templeton this sandstone, with the two coals above and below, is exposed and is about 10 feet thick. It reaches its best development, however, in the vicinity of Deanville, where it is a coarse, gray, conglomeratic sandstone at least 20 feet thick, underlying the Upper Freeport coal. It crops out as a ledge 20 feet high on the brow of the bluff of the Mahoning south of Deanville and to it is due the flat-topped spur at that place. It is particularly heavy on the hill just northwest of Deanville. It shows along the Indiana pike where it crosses the head of the first run northwest of Blanket Hill and is there coarse and heavy.

Freeport limestone.—This underlies the Upper Freeport coal and is generally separated from it by a few feet of fire clay. The limestone is bluish, bedded in layers 1 to 2 feet thick, and reaches a maximum thickness of 8 to 10 feet within the quadrangle. It is not known to contain marine shells and is possibly of fresh-water origin. Along Garrett and Rupp runs it is present and is quarried to a considerable extent. It is recorded in many wells along the southern margin of the quadrangle. It is quarried at points along the road south of Cowanshannock Creek in southern Rayburn Township and also on Hays Run above the point where the road southwest to Kittanning crosses. North of the South Fork of Pine Creek it occurs on the hills from Oscar to Dayton, and along North Fork it occurs very generally as far east as Muff, where it just catches the higher hilltops. It is also present in the hills in the vicinity of Goheenville and southward and in the hills south of Putneyville.

Freeport fire clay.—This is apparently present and from 2 to 6 feet thick under the Freeport coal throughout the quadrangle. It is almost everywhere plastic and of no especial value.

Upper Freeport coal.—This occurs at an interval varying from 20 to 60 feet above the Lower Freeport coal. On Hays Run, on the river midway between Mosgrove and Templeton, and in the hill south of Dee, an interval of 20 feet was observed. Farther east, in the region from West Valley to Blanket Hill, an interval of 60 feet prevails uniformly. From New Bethlehem eastward, except at the localities where the Butler sandstone is well developed, this interval is mainly 40 feet. The Upper Freeport coal is generally 3 to 4 feet thick throughout the quadrangle so far as known. It has been eroded from all of Madison Township on the crest of the Kellersburg anticline, but is present on the higher ground in the Fairmount syncline between Redbank and Mahoning creeks. It is cut out by the streams that cross the Fairmount syncline south of the Mahoning, but large areas of it are preserved under deep cover in the highlands between the streams. Along the crests of the Greendale and Brookville anticlines north of South Fork of Pine Creek, only small patches are preserved on the higher hill tops. Southeast of the Greendale anticline, the coal, dipping toward the Apollo syncline, soon disappears beneath the surface and is deeply covered in the southeast corner of the quadrangle. On the South Branch of North Fork of Pine Creek it goes below water one-half mile east of Bryan, on Cowanshannock Creek it disappears at Yatesboro, and on Huskins Run it goes under at Blanco.

This is an appropriate place to discuss the Gallitzin coal. Platt identified the coal at the Yatesboro No. 2 mine, which is said to be on the Patterson farm, as the Gallitzin, which he claimed occurs 50 feet above the Upper Freeport coal and has a considerable extent in the upper Cowanshannock Valley. The coal at the Yatesboro No. 2 mine, however, lies about 240 feet above the Vanport limestone, as shown by several gas wells in the locality. This is the usual distance between the limestone and the Upper Freeport coal in the Cowanshannock region, a fact that points strongly to the conclusion that the coal in question is Upper Freeport. Furthermore, Yatesboro No. 2 mine is at nearly the same elevation as Yatesboro No. 1 on the south side of the creek and in strike with it. Yatesboro No. 1 mine is conceded to be in the Upper Freeport, and it is highly probable that the seam at Yatesboro No. 2 is the same. On these grounds Platt's identification is believed to be erroneous. No coal was observed in the region 50 feet above the Upper Freeport, but a thin seam occurs about 100 feet above, which is described further on as the Brush Creek coal and which, in position relative to the Upper Freeport coal, corresponds with the Gallitzin coal of Cambria county.

CONEMAUGH FORMATION.

GENERAL CHARACTER AND DISTRIBUTION.

In this quadrangle the Conemaugh is mostly sandy shale with thin sandstone layers. Bands of red shale of variable thickness and number occur about 250 feet above the base of the formation in the southern and southeastern part of the quadrangle. In many places lenses of sandstone of variable texture and thickness occur near the base of the formation; in the midst of the formation a thin-bedded sandstone occurs over small areas; and in the southwestern part of the quadrangle coarse sandstone caps a number of the higher hills. About 30 feet above the base of the formation a thin coal occurs at a few localities, and there is a persistent but generally thin seam 100 feet above the base. Lenses of dark limestone 6 inches to 1 foot thick, full of marine fossils, occur locally a little over 100 feet above the base. The formation is entirely eroded from the northwest corner of the quadrangle on the Kellersburg anticline, and only small patches of it remain on the Greendale anticline between Pine Creek and the high knob 1 mile northeast of Muff, beyond which the Conemaugh does not occur. Large areas of Conemaugh rocks occur between the streams crossing the Fairmount syncline. Rocks of this formation form the surface of a wide strip along the southern margin of the quadrangle and occupy most of the surface of Cowanshannock Township and the southeast corner of Wayne Township.

DESCRIPTIONS OF MEMBERS OF THE CONEMAUGH.

Mahoning sandstone.—Near the base of the Conemaugh is a heavy sandstone usually called the Mahoning sandstone. Much confusion exists as to what beds should be included under this name. So far as the writer can discover, the name was first used by Lesley (Manual of Coal and Topography, 1856, p. 97) for a sandstone composed of two beds 35 feet thick, separated by 25 feet of shale. I. C. White (Bull. U. S. Geol. Survey No. 65, p. 95) describes it in almost identical terms, but makes the sandstone members 40 to 50 feet in thickness, with a bed of shale between, the whole varying in thickness from 100 to 150 feet. In an earlier work (Second Geol. Survey Pennsylvania, Rept. Q, p. 36) the same writer restricted the name to the lowest member of the triple group. For reasons fully set forth in the Kittanning folio, the name Mahoning is restricted by the writer to sandstones occurring between the Upper Freeport coal and the Brush Creek coal which lies about 100 feet above the Upper Freeport, as will be shown beyond. The Mahoning sandstone is a variable stratum; over most of the quadrangle there is nothing to indicate its presence, probably because it is entirely wanting or very thin, but locally it is thick and heavy. In the bluff before mentioned, midway between Mosgrove and Templeton, the sandstone is 50 feet thick and rests on the Upper Freeport coal. In the western part of Mahoning Township its presence is indicated by large bowlders of coarse sandstone that strew the surface in many places. It is here 40 to 60 feet above the Upper Freeport coal. The considerable areas of nearly flat land in this region are probably due to the presence of this sandstone. On the road from Oakland to Putneyville, near the top of the hill 1 mile northwest of Putneyville, the Mahoning is well exposed in the road cut as a coarse, very heavy-bedded sandstone 40 to 50 feet thick, and is separated from the Upper Freeport coal by about 20 feet of shale. On the ridge north of McNees the stratum takes the form of conglomerate, large blocks of which occur near the crest of the ridge and run down the north side nearly to Cowanshannock Creek. About 1 mile northwest of Blanket Hill, north of Mill Run, and 100 feet above it, the sandstone crops out in a bold ledge 20 feet thick.

Thin coal.—It may be appropriately mentioned here that a small coal was observed on the Indiana pike just east of the forks of Rupp Run, 30 feet above the base of the formation. It is about 1 foot thick. The blossom of a coal apparently in the same position was observed a short distance west of Bryan.

Brush Creek coal.—A thin coal varying from 80 to 100 feet above the Upper Freeport coal occurs at several points in the southern part of the quadrangle. This is very probably the same as the Brush Creek coal described in the Kittanning folio. It was observed on the Indiana pike on the hillside above the head of Rupp Run, where it is 90 feet above the Upper Freeport. Its blossom occurs at a number of points along the ridge road in Rayburn and Valley townships from one-half mile west of the boundary line in Rayburn Township to about 1 mile east of West Valley. At one point on this road it has been opened and is reported to be 2½ feet thick. It appears to be here 80 to 100 feet above the Upper Freeport coal. The blossom of this coal shows at several points along the road from Yatesboro to Smeltzer, and about one-fourth mile east of Rural Valley the coal was seen in the road and is about 15 inches thick. It has been opened near the forking of Cowanshannock Creek at the road corners where the road starts south to Atwood along the western margin of the quadrangle and was reported 20 inches thick. The Upper Freeport coal is reported to have been reached in a diamond-drill hole near this opening at 100 feet in depth, showing that the interval between the two coals here is about 100 feet, and that accords well with drill records at Rural Valley. There are traces of this coal in the road east of Bryan. This coal corresponds exactly in character and position with the Gallitzin coal in Cambria County, which was described by the geologists of the Pennsylvania Second Survey as occurring 50 feet above the Upper Freeport, but which the writer has recently found to be almost exactly 100 feet above the Upper Freeport coal in that region.

Saltsburg sandstone.—A sandstone that is generally soft and friable, but sometimes hard, which occurs along the ridge in Rayburn and Valley townships and along the ridge road nearly east of Templeton toward Goheenville, may represent the Saltsburg, since it occurs about 160 to 200 feet above the Upper Freeport coal. The horizon of this sandstone passes through the hills in the southeastern part of the quadrangle, but there is no evidence of its presence there.

Red shale and higher sandstones.—The most distinctive stratum of the Conemaugh formation in the southeastern part of the quadrangle is a more or less constant bed of red shale that appears to lie about 250 feet above the Upper Freeport coal. This occurs on the hills at a number of places from north of Bryan to the region east of Blanco, and also in the vicinity of Blanket Hill and southwestward. Along the southern margin of the quadrangle a number of hills have a coarse, thick-bedded sandstone cropping out near their summits or capping them. The sandstones at the various points are similar in lithologic character, but if the interpretation of the structure of the region, as made out from well records, is correct, they can not be regarded as belonging to the same stratum, since they vary in position from 220 to 450 feet above the Upper Freeport coal. It is possible that the higher of these sandstones is the Morgantown, since it occupies nearly the stratigraphic position of that stratum as it occurs in Fayette and Westmoreland counties.

Quaternary Deposits.

CARMICHAELS FORMATION.

Along several of the tributaries of the Allegheny, and especially along Mahoning Creek, there are thin deposits of alluvium and stream-worn material consisting of pebbles and rounded bowlders, some of them rather large, that lie considerably above the present streams. The bottom of these deposits varies in height above the streams, from 20 feet on the headwaters of the Cowanshannock to 100 feet or more on Mahoning Creek. They lie upon remnants of the Parker strath along the tributaries of the river, and while of the same age as the deposits described in the next paragraph they differ from them chiefly in that they are of local derivation solely and contain no admixture of foreign material. The name Carmichaels was applied by Campbell (Masontown-Uniontown folio) to terrace deposits of local origin, and of probable Kansan age, along Monongahela River, which are particularly well developed at Carmichaels, above Brownsville. The name has been extended to embrace all deposits of like origin and age in the western part of the State, but it must not be inferred that the deposits bearing this name are alike either in character, thickness, or mode of accumulation in different localities.

GRAVEL AND SILT OF GLACIAL DERIVATION.

Deposits of Kansan or pre-Kansan age.—This material occurs as the covering of the remnants of the Parker strath which form the rock shelves already described, at Mosgrove and Templeton, on the west side of the river. It is composed of stratified clay, sand, and gravel which extend from the rock shelves at 980 feet to the altitude of 1050 feet, at which elevation the top of the deposit forms well-marked terraces at various points. This would give a thickness of 70 feet to the deposits. Scattering pebbles occur at greater elevations and indicate a greater thickness of the deposits originally. The character of the deposits is well shown in a deep cut of the Buffalo, Rochester and Pittsburg Railroad just west of the quadrangle, where they are exposed to a depth of at least 50 feet. The greater part of the deposits is composed of medium to fine gravel, a small portion of which consists of pebbles of crystalline rocks. Leverett (Kittanning folio) estimates that such material constitutes on the average but a fraction of 1 per cent of the whole. The greater number of the pebbles are quartzite and Medina sandstone, but there are also pebbles of granite, gneiss, diorite, and other rocks. On account of the advanced state of decay of many of these pebbles, Leverett (Kittanning folio) believes that the deposits in which they occur belong to the earlier stages of Glacial time and are at least as old as the Kansan drift of the interior, or possibly of pre-Kansan age.

Deposits of Wisconsin age.—Allegheny River is bordered by a narrow deposit composed mostly of silt and sand, whose greatest thickness probably does not exceed 50 feet. This material is all that remains of a deposit that once probably filled the whole bottom of the valley to a depth of at least 50 feet, and that was deposited during the latest, the Wisconsin, stage of glaciation. Since its deposition, this material has probably been cut away and redeposited more than once by the river and so mixed with flood-plain alluvium that the two are indistinguishable, and they have therefore been mapped together as alluvium.

ALLUVIUM.

This consists of fine material laid down by the present streams at times of overflow, and is present to a greater or less width along most of the length of the principal streams well up toward their headwaters.

STRUCTURE.

Method of representing structure.—The rocks of the Rural Valley quadrangle are moderately folded into low anticlines and shallow synclines. On the structure and economic geology sheet the lay of the rocks is represented by contour lines drawn upon the top of the Vanport (Ferriferous) limestone, as a reference surface. Each contour line is drawn through points having the same altitude, and in this quadrangle the contour interval or vertical distance between any two contours is 50 feet. The positions of these points are determined in several ways. The elevation of the limestone is frequently determined by actual observation of its outcrop. Its depth below the surface is shown in many deep wells, from which its elevation can be determined. Where its elevation can not be ascertained by one of these means the elevation of some other stratum, such as a coal seam or sandstone, is observed and the elevation of the limestone is then calculated from the known interval between the two. If the limestone horizon is above the surface, the interval is added to the elevation of the stratum at the observed point; if the limestone is below the surface the interval is subtracted. This method is based upon the assumption that an interval measured at any point will remain constant over the adjacent region. If the interval at any point should differ from the assumed interval, the given elevation of the reference surface will be in error by the amount of the difference. It is believed, however, that the error will in no case amount to a contour interval. In other words, the elevation of the Vanport limestone at any point on this quadrangle will not differ by more than 50 feet from the elevation shown by the structure contours.

Former views of structure.—It seems well to preface to the detailed description of the structure an outline of the same as made by previous surveys, particularly by the Pennsylvania Second Survey. Platt (Second Geol. Survey Pennsylvania, Rept. H5, pp. 38–46 and map p. 26) described a number of anticlines and synclines in this quadrangle that lie in regular order, as follows, beginning at the northwest and passing to the southeast: The Lawsonham syncline, passing through Lawsonham; the Kellersburg anticline, passing through Kellersburg; the Stewardson Furnace anticline, a short axis in the vicinity of Dee; the Centerville syncline; the Anthonys Bend anticline; the Fairmount syncline, passing through Fairmount on Redbank Creek north of the quadrangle; the Greendale anticline, passing through Greendale; the Brookville anticline, at the head of Little Mudlick Creek; the Leechburg syncline; the Glade Run anticline, following Glade Run south of Mahoning Creek; the Apollo syncline, passing near Rural Valley; and the Fort Barnet anticline, in the vicinity of Smeltzer. The axes of the anticlines and synclines are described and mapped as following in general straight courses extending about N. 30° E.

The result of the present survey, so far as regards structure, differs materially from those described above, as will be shown below. The structure will be described in detail, beginning at the northwest and proceeding to the southeast corner of the quadrangle.

Bradys Bend syncline.—The axis of the Bradys Bend syncline, which is delineated on the map of the Kittanning quadrangle on the west, passes near the northwest corner of the Rural Valley quadrangle. Platt describes the Boggsville syncline as continuing through Lawsonham and called this supposed syncline the Lawsonham syncline. As shown in the Kittanning folio, the Boggsville syncline disappears in the vicinity of Limestone Run on the flank of the Kellersburg anticline, while the Bradys Bend syncline, instead of extending in a straight northeastern course, curves eastward and can be followed across the northern part of the Kittanning quadrangle to the vicinity of Lawsonham, in the northwest corner of the Rural Valley quadrangle. Whether the axis of the Bradys Bend syncline passes near Lawsonham or not can not be stated at present, since the region to the north has not been surveyed. It seems probable, however, that the axis runs somewhat north of that place.

Kellersburg anticline.—In the northwest corner of the quadrangle the Vanport limestone has an elevation of 1150 feet; thence it rises southeastward to the crest of the Kellersburg anticline, where, in the vicinity of Kellersburg and northeastward, it reaches an altitude of 1400 feet. The axis of this anticline crosses the western margin of the quadrangle about three-fourths of a mile north of the river and follows a nearly straight course about N. 60° E., passing through Kellersburg and crossing Redbank Creek between Climax and St. Charles. Platt (Second Geol. Survey Pennsylvania, Rept. H5) describes two separate anticlines in this vicinity—the Kellersburg anticline and the Anthonys Bend anticline. The former he supposed to die out in the vicinity of Limestone Run, in the Kittanning quadrangle on the west, and the latter likewise to die out near the apex of the big bend in Redbank Creek from which it received its name. There is, however, no evidence for the existence of two anticlines in the locality. From this axis west of Climax numerous observations on the limestone, where revealed by old ore strippings and in natural exposures, show that it dips regularly to the southeast until it disappears in the bluff at the southern point of Anthonys Bend at an altitude of 1130 feet.

At a point just north of the quadrangle, about 2 miles a little east of north of Climax, the limestone is quarried at an elevation of 1360 feet. Just southeast of New Bethlehem an old ore pit shows its altitude to be 1100 feet. Between the two points observations appear to show conclusively that neither the Anthonys Bend anticline nor the Centerville syncline, as mapped and named by Platt, are really present. Instead of two anticlines with straight axes, there is in reality but one anticline, which is appropriately named the Kellersburg anticline.

Fairmount syncline.—As mapped by Platt, the axis of this syncline follows Allegheny River from the mouth of Glade Run, in the Kittanning quadrangle, which joins the Rural Valley quadrangle on the west, to the mouth of Garrett Run and continues thence in a nearly straight line to Redbank Creek near Fairmount. In a general way this location is correct, but the axis is not straight. From the mouth of Garrett Run its course is about N. 30° E. to Scrubgrass Creek; thence it swings gradually eastward to a course about N. 60° E., which it follows to about 1 mile east of Mahoning Furnace, where it curves northward and leaves the quadrangle in a nearly north course. The position of this axis is well determined by the opposing dips of traceable coal beds, and at the point where it crosses Scrubgrass Creek it is fixed within narrow limits by the opposite dips of the rocks in the bed of the creek and on the valley walls. From this point to the bottom of the syncline the northern margin of the quadrangle appears to flatten out and the position of the axis is not quite so well established. Observations on the limestone on Mahoning Creek and on Redbank Creek, where it is exposed between Fairmount and Oak Ridge, and also on the Upper Freeport coal in a number of banks and in the Fairmount Company's mines, all indicate that the axis can not be far from the position shown on the map.

A peculiarity of this syncline is the oval depression on Pine Creek at the mouth of Bullock Run. This is formed by a low anticline which crosses the syncline south of Hays Run. The existence of this anticline is proved by stratigraphic tracing, as well as by the fact that two wells on the Starr farm just south of Hays Run found the limestone at an elevation of 870 feet, while it dips northward along the axis to 800 feet north of Pine Creek, and southward to 650 feet on the southern margin of the quadrangle.

Greendale anticline.—Southeast of the axis of the Fairmount syncline the rocks rise to the crest of the Greendale anticline as far north as Mahoning Creek and to the crest of the Brookville anticline north of that creek. The axis of the Greendale anticline enters the quadrangle from the south about 1½ miles southwest of Blanket Hill and follows in general the northeast course mapped by Platt through Greendale to a point about 1½ miles southwest of Muff. From this point Platt mapped it as continuing in a straight line to the head of Scrubgrass Creek, where he made it die out. Numerous observations on the Upper Freeport coal, however, show a regular dip both northwest and southeast from a line passing from this point through Muff toward Belknap. Along the road from one-half mile southwest of Muff to the high knob at the locality known as Concord Church, the records of nearly a dozen wells show the elevation of the limestone to be nearly 1400 feet, and wells northwest of these, toward Goheenville, show a regular dip of the limestone to the altitude of 1050 feet and those to the southeast, toward Echo, show a similar dip to the altitude of 1000 feet. Following the line indicated above northeastward to Belknap the Lower Kittanning coal occurs at an elevation of about 1420 feet and still farther northeastward along the same line the coal has been opened near the road intersection at the H. S. Pontius farm and at an intermediate point, at both of which its altitude is 1420 feet. Still farther northeastward, on the road following the top of the bluff of Mahoning Creek, at a point nearly south of the mouth of Glade Run, the limestone has been quarried at the altitude of 1440 feet. From the line thus traced out the strata dip in both directions, as is proved by abundant observations made upon the outcrop of the limestone and the Lower Kittanning and Upper Freeport coals, as well as by the elevations of the limestone shown in a number of wells on both sides of the anticline. Platt described the Glade Run anticline as beginning near Echo and running northeastward through Wayne Township to the vicinity of the mouth of Glade Run. No trace of such an anticline was detected in the vicinity of Echo during the present survey, and it is well established by the facts cited above that there is but one anticline in the region curving in harmony with the Kellersburg anticline. This anticline is named the Greendale anticline because it passes near Greendale. It presents a number of irregularities south of Pine Creek which can best be understood by a study of the map.

Brookville anticline.—In the northeastern corner of the Rural Valley quadrangle lies the southwestern point of the Brookville anticline in substantially the position mapped by Platt. This anticline plunges rapidly southwestward and disappears as a distinguishable feature near the mouth of Little Mudlick Creek. The Brookville anticline is separated from the Greendale anticline by a narrow depression running eastward from the Fairmount syncline in the vicinity of Putneyville and passing off the quadrangle at McWilliams.

Apollo syncline.—Platt described the Leechburg syncline as lying next east of the Greendale anticline, as extending northeastward and separating it from the Glade Run anticline, and then leaving the county to the east of the Brookville anticline. In the survey of the Elders Ridge quadrangle no trace of this syncline could be detected, and it certainly does not extend into the Rural Valley quadrangle (see Elders Ridge folio). The Apollo syncline, however, described and mapped by Platt as lying to the west of the Leechburg syncline and separated therefrom by the Apollo syncline in southern Armstrong County, has been traced into the southern part of the Rural Valley quadrangle (loc. cit.). The axis of this anticline enters the Rural Valley quadrangle about 1 mile east of the western boundary of Plum Creek Township and extends northeastward, passing about one-half mile southeast of Blanco and becoming indistinct in the flat-lying strata near Rural Valley. There appears to be a very shallow synclinal depression between Smeltzer and Bryan that is in line with the direction of this syncline and may be regarded as an extension of it.

Roaring Run anticline.—Platt mapped this anticline south of the Rural Valley quadrangle and a a short distance north of Crooked Creek. It is shown in the Elders Ridge folio, however, that this is a strongly marked and easily traceable feature as far north as Blanco, in the Rural Valley quadrangle. The axis of the anticline enters the quadrangle about 1½ miles west of the axis of the Apollo syncline, and its existence is amply demonstrated by a number of wells drilled in the region. The position of the limestone in the Espey well, on the axis of the syncline one-half mile southeast of Blanco, is about 850 feet above the sea, and a little more than a mile to the southeast its position is, in the Bell and Wagoner wells, about 1000 feet above the sea, showing a sharp rise of 150 feet. The rise of the strata, however, does not continue much, if any, beyond this point, since, if it did, the Upper Freeport coal would crop out on the hillside to the southeast. Instead of such an outcrop there is evidence that the coal is considerably below the surface west of Green Oak. The rocks therefore dip rapidly to the southeast from the Roaring Run axis. On evidence furnished by gas wells this anticline is believed to curve sharply to the west near its point and, like the Apollo syncline, to become lost about 1 mile northeast of Blanco in the nearly horizontal strata along the valley of upper Cowanshannock Creek.

Structure of the southeast corner.—As intimated above, the rocks of the southeast corner of the quadrangle lie nearly flat, and owing to the scarcity of well records and to the absence of traceable beds the structural details can not be made out with as much certainty as could be wished. This applies to the region roughly bounded by the 850-foot contour line along the bases of the Roaring Run and Greendale anticlines. It is believed that the rocks south of Cowanshannock Creek dip regularly toward a depression which extends from Green Oak to the vicinity of Gastown on the Elders Ridge quadrangle. A number of wells near Atwood show a slight anticlinal structure in that vicinity, which may be more pronounced in the territory lying farther east. The Moore well, several diamond-drill holes, and the Brush Creek coal bed show a similar anticlinal structure along the North Branch of Cowanshannock Creek. This is possibly the vanishing southwest end of the Port Barnet anticline, mapped by Platt. Both of these anticlines are very low and of little importance within this quadrangle.

Dip of the rocks.—The dips throughout the quadrangle are generally low. The highest are found on the southeastern flank of the Kellersburg anticline and probably do not exceed 3 to 4 degrees.

Pitching axes.—A notable feature of the anticlines and synclines of the region is the general southwestern pitch of the axis. The axis of the Fairmount syncline on the limestone pitches from the elevation of 1070 to 650 feet, and that of the Greendale anticline from 1440 to 1000 feet between the northern and southern margins of the quadrangle. The pitch, however, is not always uniform. The crests of the anticlines, as that of the Greendale anticline in the vicinity of Belknap and Muff, in some places run nearly level for long distances. In other places they slope, as does the Greendale anticline south of Pine Creek and south of Cowanshannock Creek. The regular southwestward pitch of the Fairmount axis is interrupted by the cross-anticline south of Rayburn Township, already described.

Course of structure lines.—A notable feature of the structure of the quadrangle is the deviation of the anticlinal and synclinal axis from straight lines. In general each axis is composed of reversed curves. In some cases the axial lines are decidedly sinuous, as, for example, that of the Greendale axis south of Pine Creek. The failure to recognize these facts and the assumption that the folds follow definite northeast-southwest courses have led to serious errors in previous attempts to determine and map the structure, and to no little confusion to those engaged in drilling for gas and oil.

GEOLOGIC AND GEOGRAPHIC HISTORY.

The geologic and geographic development of the Appalachian province in its earlier stages, as generally understood by geologists, will first be outlined, and then the history of the northern end of the bituminous basin in which the Rural Valley quadrangle is situated will be given in greater detail.

PRE-CHEMUNG DEPOSITION.

The oldest rocks known in the Appalachian province are the crystalline rocks of the Blue Ridge and of the Piedmont Plateau on the east. These are believed to have formed the oldest land of which there is any record on this continent. The western shore of this land area lay in the present position of the western flank of the Blue Ridge, and the land extended to an unknown distance eastward, possibly far beyond the present shore of the Atlantic. To the northeast, in the Adirondack Mountain region, lay another area of crystalline rocks. West of the Adirondacks, reaching to the vicinity of Lake Superior, was the southern shore of a vast land area, now occupied by the crystalline rocks of Canada. The rocks of the two regions last mentioned are of the same age as those of the Blue Ridge. Thus in earliest geologic time there existed a land mass having a rudely V-shaped form and inclosing within its arms a body of water known to geologists as the Interior Paleozoic Sea. Into this sea discharged rivers bearing the sediments of which the sedimentary rocks of the Appalachian province are composed. The earliest of these sediments were laid down along the ancient shore line and constitute the oldest sedimentary rocks of the province. From this time forward the filling up of the interior sea progressed steadily from the shores of the ancient land toward the center, and the rocks of the systems and formations older than the Chemung were laid down in succession.

CHEMUNG DEPOSITION.

As shown in the discussion of the rocks revealed in drilling oil and gas wells, the lowest strata penetrated by the drill should probably be assigned to the Chemung formation. In regions where rocks of this formation come to the surface they are composed largely of rapidly alternating beds of shale, sandstone, and impure shell limestone, the shale predominating. There are many evidences of shallow-water accumulations, and the abundance of fossils indicates that the conditions were favorable to life and that the sea floor swarmed with living beings. The observed facts indicate a broad expanse of comparatively shallow water which was receiving sediments from the adjacent lands, sometimes finer, sometimes coarser; now in abundance, now more sparsely; the kind and rate of sedimentation varying rapidly and producing the rapidly alternating strata and layers of the formation.

CATSKILL DEPOSITION.

Before the beginning of Chemung deposition—indeed, soon after the close of Hamilton time—the Catskill phase of sedimentation began at the northeast extremity of the Appalachian Gulf, in eastern New York, with the deposition of the Oneonta beds. From this time onward the deposition of these rocks continued, being contemporaneous at first with the marine Portage, later with the Chemung, and at the top probably with the bottom of the Mississippian deposits. At the same time the Catskill sediments spread farther and farther westward and southwestward, and toward the end the finer sediments extended into western New York and Pennsylvania.

Thus it happens that the Catskill rocks, which have a probable thickness of several thousand feet in the Catskill Mountain region, where sedimentation was continuous from the beginning, grow thinner from the bottom upward as they extend westward, until they are represented in western Pennsylvania and New York by only a few hundred feet of rocks characterized by beds of red shale.

The red rocks of the Catskill formation in the Rural Valley quadrangle occur near the top of the formation, and, judging from their character in western New York, they are probably soft, fine shales resulting from the consolidation of the finer material that was borne by the water farthest from the eastern shores of the Appalachian Gulf, where it was discharged by the rivers of the bordering lands. The red rocks of the western margin of the formation lie in detached beds or lenses of greater or less extent and thickness in the midst of gray shales and sandstones that possibly had a different source. This mode of occurrence indicates that they were transported intermittently at times of flood when stronger currents bore the sediments farther westward, or at times of great storms, when the supply of sediment was greater. At times toward the close of the deposition of the red rocks, great beds of coarse gray sandstones that form the reservoirs for oil and gas in this part of western Pennsylvania accumulated.

POCONO DEPOSITION.

After the deposition of the Catskill red rocks, fresh-water conditions probably prevailed generally throughout the northern end of the Appalachian Gulf, but there was a decided change in the character of the material brought in. It is prevailingly gray instead of red. In the part of Pennsylvania in which the Rural Valley quadrangle is situated, the heavy sandstones known as the Hundred-foot and Butler gas sands were among the first strata deposited. These were followed by gray shales with occasional beds of red shale of local extent and sporadic sandstone lenses. During the later part of Pocono time vast quantities of coarse sand were brought into the Appalachian Gulf and spread widely over the sea bottom, forming the coarse Burgoon (Mountain or Big Injun) sandstone. As the deposition of this coarse sandy material was drawing to a close a large quantity of carbonate of lime was deposited with the sand, making the Loyalhanna (Siliceous) limestone, which is a widely extended and highly characteristic stratum at the top of the Pocono throughout southwestern Pennsylvania.

EARLY POTTSVILLE EROSION INTERVAL.

The thickness of the Mauch Chunk formation is over 2000 feet in northeastern Pennsylvania, and diminishes in thickness westward. On the Allegheny Front west of Altoona it is 180 feet. At Blairsville, as recorded in deep wells, it is about 50 feet. On Allegheny River in Armstrong County and farther west the Mauch Chunk is absent.

These facts indicate an uplift that raised above water a large land area extending from southern New York at least to the region of the Rural Valley quadrangle and as far east probably as the Allegheny Front. From this land area the Mauch Chunk and possibly the upper part of the Pocono were eroded before the deposition of the overlying Pottsville. Just when this uplift occurred can not be definitely determined, but it presumably took place during the latter part or at the close of Mauch Chunk time.

POTTSVILLE DEPOSITION.

The Pottsville is one of the most important and interesting epochs in the history of the province, since in it the accumulation of coal began on a large scale. Assuming that the movements of the earth's crust indicated in the preceding paragraph took place, there would exist at the beginning of Pottsville deposition a deep trough in eastern Pennsylvania and farther south, bordered by land on both sides around the northern end and on the southeast. From these border lands, which were probably high on the southeast, the rapid streams brought in immense quantities of coarse material, including a large portion of quartz pebbles, which form the thick and extensive beds of coarse conglomerate of the Pottsville formation. It is believed that the Pottsville sediments were derived largely from the southeastern side of the trough, because there is no near-by source of quartz pebbles on the other side.

While 800 or 900 feet of sediments accumulated in the Southern Anthracite field, the land surface on the west had probably been worn down nearly to sea level and then submerged, so that toward the close of Pottsville time sedimentation was resumed over the former land area. The submergence of the old land surface west of the Rural Valley region preceded by considerable time that of the Rural Valley quadrangle, for there accumulated along the western boundary of Pennsylvania a bed of sandstone and a bed of coal—the Sharon conglomerate and coal that underlie the lowest Pottsville rocks of the Allegheny Valley. Thus it happened that the Connoquenessing sandstone, the lowest Pottsville stratum of the Rural Valley quadrangle, was deposited upon the surface of the Burgoon (Mountain) sandstone at the top of the Pocono formation. After the deposition of the Connoquenessing there was a change to quieter conditions, under which the Mercer shale, limestone, clay, and coal were deposited. This period was followed by one of more active sedimentation, during which the Homewood sandstone was laid down, this marking the last episode in Pottsville history in western Pennsylvania.

ALLEGHENY DEPOSITION.

The Allegheny epoch was marked by very rapidly alternating conditions, the most important of which resulted in the formation of the coal seams. The origin of the coal and the method of its accumulation in seams of great areal extent are subjects that have provoked much discussion. That coal is of vegetal origin hardly anyone would now venture to question. As to the method of accumulation of the vegetal matter there is great difference of opinion. It seems safe to say that in the main the coal seams of the Appalachian province were formed in marshes near sea level and often extended over thousands of square miles.

The sequence of events during the deposition of the Allegheny formation in the Rural Valley and surrounding regions was somewhat as follows: The deposition of the Homewood sandstone was followed by a slight subsidence and the accumulation of 10 to 30 feet of clayey sediments. The sea bottom was raised approximately to water level and marshy conditions resulted over a large area. Upon this marshy land the remains of many generations of plants formed an extensive peat bog. From time to time different parts of this marsh were flooded and thin layers of sediment were deposited, which form the partings or binders of the resulting coal bed. In the case under consideration there was so little vegetal matter that the resulting coal bed is generally thin. In places there was more vegetal matter and a coal bed of workable thickness was formed. After a long period of comparative quiescence the region was depressed, sedimentation was resumed, the vegetal matter was buried, and under the pressure of the rocks subsequently deposited, was compressed and hardened into the coal seam now known as the Brookville coal. The subsidence which led to the formation of the Brookville coal was accompanied by a deposition of shale and in places of the Clarion sandstone. By this filling or by reelevation the bottom was again raised to water level, coal-forming conditions were restored, and the material of the Clarion coal bed was laid down. The deposition of this coal bed was followed by another subsidence, apparently of considerable extent, which admitted sea water to a large area, over which the Vanport limestone was deposited. This limestone is known to have been laid down in salt water, as it contains fossil shells or the solid parts of other animals that live only in salt water, and it is probably composed almost entirely of carbonate of lime derived from such sources. This subsidence was apparently of great extent, for the limestone seems to have been deposited in water of considerable depth and at some distance from shore, as its purity indicates that it received no admixture of sediments from the surrounding land. Whatever may have been the case, the bottom was raised to water level again, partly at least by sedimentation and probably also by elevation, another period of coal-making began, and the Lower Kittanning coal accumulated. By a repetition of such periods of oscillation and repose the Middle Kittanning, Upper Kittanning, Lower Freeport, and Upper Freeport coal beds with their under clays and the intervening beds of sandstone, shale, and limestone were formed.

While the strata may have been elevated at times during the deposition of the Allegheny formation, the prevailing movement was evidently one of subsidence, for each coal seam was formed at the surface and then buried.

Certain practical deductions are derivable from an understanding of the formation of the coal seams. It is a rather current belief in western Pennsylvania that the thickness of a coal seam is proportionate to the size of the hill containing it. Another belief widely held is that a bad streak or area in a coal seam is in some way related to an adjacent valley and that better conditions would be encountered on the opposite side. The fallacy of such ideas is at once apparent when it is understood that the thickness, quality, and condition of a coal seam were determined ages before the hills and valleys were formed.

CONEMAUGH DEPOSITION.

At the close of Allegheny deposition a marked change in the conditions of vegetation and deposition continued during the laying down of the 600 feet or more of the sediments of the Conemaugh formation. Marine conditions seem to have prevailed locally after the formation of the Upper Freeport coal seam, for salt-water fossils are occasionally found in the roof shales of that bed. In the Kittanning region coal-forming conditions were reestablished for a brief time after about 70 feet of sands and clays had been deposited. At this time the Brush Creek coal was formed. In other parts of the bituminous coal field, particularly in Somerset County, coal-forming conditions were repeated at several horizons in the Conemaugh formation, and several beds of coal of considerable extent and value accumulated. In the Kittanning region thin beds of black limestone with an abundance of marine fossils from 100 to 150 feet above the Upper Freeport coal indicate another incursion of sea water for a short period. Over a large part of western Pennsylvania and eastern Ohio the presence of the Ames (Crinoidal) limestone, lying from 250 to 300 feet above the Upper Freeport coal and containing many marine fossils, shows that the sea once more spread over a large area. This limestone is said to mark the last recurrence of marine conditions in the Appalachian basin. Throughout much of the area over which the Conemaugh formation extends the conditions were favorable to the accumulation of thick deposits of coarse sand, from which the Mahoning, Saltsburg, Morgantown, and Connellsville sandstones were formed. In the Kittanning quadrangle most of the Conemaugh deposits subsequently hardened into shale.

MONONGAHELA DEPOSITION.

The deposition of the Conemaugh formation was succeeded by that of the Monongahela and Dunkard formations, which occur in the southwest corner of Pennsylvania but which have been eroded from the Rural Valley quadrangle. The beginning of the Monongahela deposition was marked by another great period of coal formation—that of the Pittsburg coal. While the Pittsburg coal is not found in the Rural Valley quadrangle, it has probably but recently (in a geologic sense) been removed, since it is present a few miles to the southeast, in the Elders Ridge quadrangle. The formation of the Pittsburg coal was followed by a series of events similar to those outlined in the history of the Allegheny formation.

DUNKARD DEPOSITION.

After the deposition of the Monongahela the shales, sandstones, limestones, and thin coals of the Dunkard group were laid down. The luxuriant vegetation, so characteristic of the Carboniferous period, gradually diminished and finally became extinct, and this great period, so important in the history of the earth, came to an end.

THE APPALACHIAN UPLIFT.

With the close of the Dunkard epoch, sedimentation in the northern end of the Appalachian trough came to a close and a long-continued series of events of a totally different kind began. A period of elevation, which has continued to the present, was inaugurated by an epoch of mountain making, and the sedimentary rocks in the Greater Appalachian Valley of the Appalachian province were folded into a series of high anticlines and deep synclines, and those lying west of the Allegheny Front were folded into the low anticlines and shallow synclines of the bituminous coal.

Schooley peneplain.—With the emergence of dry land, degradation began. Eventually the elevation of the province was arrested, a long period of quiescence ensued, and it is believed that the surface of the Appalachian province was eroded approximately to a horizontal plain nearly to sea level. This is called the Schooley peneplain because remnants of it are well preserved in the Schooley Mountains of New Jersey. No portion of it is preserved in the Rural Valley quadrangle. This peneplain was completed before the end of Cretaceous time at least, for in New Jersey and Alabama it is found extending beneath deposits of Cretaceous age.

Harrisburg peneplain.—After the reduction of the Appalachian province to form the Schooley peneplain an uplift occurred and erosion once more became active. Later the uplift ceased and extensive areas were again reduced to an approximately flat surface, which has already been described as the Harrisburg peneplain. It is believed that the formation of this peneplain occurred in early Tertiary time. During this period of erosion the softer rocks of the Greater Appalachian Valley were worn away, leaving the harder rocks to form the ridges. All of the Schooley peneplain surface was removed from the Rural Valley region, but the quadrangle was not reduced to a perfect plain. Probably it was upon the surface of this peneplain that the meandering courses of the larger streams like Redbank and Mahoning creeks were established. The straighter courses of the smaller streams like Cowanshannock Creek, may have been due to the fact that they had not eroded their valleys to gradients so low as those of the larger streams.

Worthington peneplain.—As the elevation mentioned in the preceding paragraph proceeded the streams renewed their activity and the former flat surface was soon furrowed by valleys. When the land had risen about 100 feet above its former position the upward movement seems to have halted for a period, during which the Worthington peneplain was developed. This probably occurred in the latter part of Tertiary time.

Parker strath.—Another uplift followed, during which the streams of the region cut deep valleys below the Worthington peneplain. The upward movement then ceased and the larger streams, especially Mahoning Creek and the Allegheny, which then consisted only of Clarion River and that part of the present Allegheny below the mouth of the Clarion, excavated valleys of considerable width. This period of repose was probably of considerable duration, for the Clarion–Allegheny, though a small stream, succeeded in eroding a valley in places 1¼ miles wide with a floor of very low gradient, a work which can be done by a stream of its size only in a very long time. Late in the development of this strath there was apparently an uplift of small extent, marked by a substage already described, during which the lower valley floor preserved at Ford City and Manorville was eroded. The formation of this strath probably marked the close of Tertiary time, for its further development was arrested by the events of the Glacial epoch, which are described in the succeeding paragraphs.

KANSAN OR PRE-KANSAN DEPOSITION.

The further development of the Parker strath was arrested probably at the beginning of the Glacial epoch by the invasion of the ice sheet of the earliest stage of glaciation known to have affected this region. This ice sheet, moving from the north, transported great quantities of rock débris from the region over which it passed and deposited much of it as gravel, sand, and silt over the glaciated area. This constitutes the Kansan or pre-Kansan drift sheet. This drift sheet covered an area in northwestern Pennsylvania extending to a line roughly drawn from the point where Beaver River intersects the northern boundary of Beaver County through Kennerdell, Oil City, Tionesta, and Warren, following thus the north side of the Allegheny from Oil City northeastward (see fig. 2). From this drift sheet great quantities of material were washed down the Allegheny and deposited by the overloaded waters upon the Parker strath. The deposition of this material continued until 100 to 130 feet had accumulated in the valleys, as is indicated by the fact that stream-borne pebbles are now found at some places on the hillsides 130 feet above the strath. Contemporaneously with the deposition of the glacial gravels the Carmichaels formation was locally deposited.

Drainage modifications.—With the advent of a warmer climate the ice sheet receded, leaving the surface covered with drift and all the old valleys filled to great depths. This valley filling was so great in many places that the streams were deflected from their pre-Glacial courses and new drainage relations, described on a former page, were established.

Interglacial valley erosion.—After the drainage changes at the close of this earliest stage of glaciation the Clarion–Allegheny River, now the lower Allegheny, enlarged to four times its original volume, was flowing upon a bed of glacial débris. This material was attacked by the river and mostly removed, only those portions being left which have been described as covering the remnants of the Parker strath. The work of the river did not end, however, with the removal of these deposits; it continued until a trench over 200 feet deep had been excavated in the rock below the level of the strath.

WISCONSIN DEPOSITION.

Between the earliest stage of glaciation already described and the latest, or Wisconsin stage, two intermediate stages, the Illinoian and Iowan, have been recognized in the upper Mississippi Valley. No drift belonging to either of these stages is certainly recognized in western Pennsylvania, and it is presumed that these stages did not reach the region. During the Wisconsin stage the ice again invaded northwestern Pennsylvania and deposited its load of drift over approximately the same area as that covered by the earlier drift. Its margin lay nearly parallel to the margin of the older drift, but not quite so far southwest. The outwash from this drift consisted of coarse pebbles and bowlders near the ice margin, but farther south, within the limits of this quadrangle, it consisted mainly of fine silts, which covered the bottom of Allegheny Valley to a depth of about 50 feet. Since that time the river has been occupied in eroding its present channel in these deposits and probably reworking them to a greater or less extent.

RECENT DEPOSITION.

During post-Glacial time the alluvium forming the modern flood-plains was deposited by the streams as they overflowed their banks from time to time, just as they may be observed to do at the present day.

MINERAL RESOURCES.

In the preparation of this section the reports of the Second Geological Survey of Pennsylvania have been freely drawn upon and acknowledgment will usually be made by referring to the letter designating the volume used, as H5 for Platt's report on Armstrong County.

COAL.

In this quadrangle there are six coal seams that are workable either generally or locally. They are, beginning with the lowest, Brookville, Lower Kittanning, Middle Kittanning, Upper Kittanning, Lower Freeport, and Upper Freeport. Of these the Lower Kittanning and Upper Freeport are by far the most important. These coals generally have a shale roof and a clay floor, so that in these respects the conditions are favorable to mining.

Brookville coal.—So far as known, this coal is of workable thickness only along the upper portion of Mahoning Creek. What is regarded as this seam is recorded in a number of wells along North Fork of Pine Creek. The coal is in two benches, separated near the middle by a hard, slaty parting 2 to 8 inches thick. It varies in thickness from 2 to 4 feet. It is hard, lustrous, and splintery. Nothing is known of its qualities as fuel.

While some traces of the Brookville coal are generally present wherever its horizon is exposed, the indications are that outside of that part of the quadrangle outlined above it is thin and worthless.

This coal is opened at water level on the south side of Mahoning Creek about 1½ miles in a direct line below Putneyville at the mouth of a ravine locally known as Sandy Hole. At this point the coal is 3 feet 10 inches thick, with roof and floor of shale (see sec. 1, coal-section sheet). A short distance below this point, on the south bluff of the Mahoning, this seam is reported to have been worked and to exhibit about the same section as at the above point. At the big bend below Putneyville, above mentioned, the section of the seam, as well as the physical qualities of the coal, is the same as that just described (see sec. 2).

In the west bluff of Pine Creek just north of the road intersection midway between Charlestown and the mouth of the creek it is 1 foot 8 inches thick and is separated in the middle by 2 inches of shale (see sec. 3). About one-fourth mile west of McWilliams what is probably the Brookville coal is partly exposed at water level at the base of a heavy sandstone. From 2 to 3 feet are exposed. This coal is hard and brittle (see sec. 4).

A coal that is probably Brookville is reported to have been opened in the bluff below the road about one-half mile west of Eddyville. In the bed of a ravine east of Mahoning about a mile above Eddyville a coal has been opened about 100 feet vertically above the road. This coal was not visible when visited, but is probably the Brookville. At McCrea Furnace also a coal is reported that was believed to be the same. In the ravine of Camp Run 1 mile south of McCrea Furnace a coal has been worked that is reported to be in two benches, and on that account, as well as on account of its stratigraphic position, it is believed to be the Brookville.

Craigsville and Clarion coals.—Neither of these seams is known to be of workable thickness within this quadrangle, and they may therefore be omitted from this discussion.

Lower Kittanning coal.—This is one of the most important coals of the quadrangle. It is thickest in the part of the quadrangle west of a line roughly drawn from Kellersburg to Kittanning, over a limited area in the vicinity of New Bethlehem, and along Mahoning Creek from Putneyville eastward and south of Mahoning Creek to the vicinity of Belknap. Coal is reported in a few wells in the southern part of the quadrangle at what is probably the horizon of the Lower Kittanning, but such reports are too unreliable to be depended upon to show the thickness and probable value of the coal. The seam is best developed in Madison and Washington townships, where it generally is a good clean coal from 3 to 4½ feet thick.

In a broad belt east of the line described above to the Little Mudlick Creek and southwest of New Bethlehem all observations indicate that the seam varies from a few inches to 2½ feet in thickness and contains smaller proportions of good coal than in other parts of the quadrangle. East of Putneyville and southward to Belknap the coal appears to be about 3 feet thick and, so far as observed, is nearly all good. At Cingler's bank, 1 mile northwest of Widnoon, the coal is 4 feet thick (see sec. 5). In a bank near the top of the hill east of the road about 1 mile nearly east of Grays Eddy a thickness of 2 feet 8 inches was measured (see sec. 6). At Duncan's bank, one-half mile south of Redbank Creek and 1 mile above Lawsonham, the coal is from 4 feet to 4 feet 6 inches thick, with no partings. Farther east, at McGinnis's bank, in a ravine north of the road about 1½ miles west of Kellersburg, there is a thickness of 3 feet 9 inches of clear coal.

Between this point and Kellersburg a decided change in the thickness and character of the coal takes place. At Bish's bank, just east of Kellersburg, a layer of bone appears at the top, and the total thickness is much diminished, as shown in sec. 7. The miner at this bank reported an average of only 2 feet of good coal. This change is still more apparent farther east, where, in the bluff at the southern end of Anthonys Bend, the seam is entirely worthless, as shown in sec. 8. Still farther east the coal thickens again, and at the Fairmount No. 5 mine, which is 1 mile east of New Bethlehem, on the northern margin of the quadrangle, the seam has 3 feet of good coal (see sec. 9). Along Redbank Creek east of this point and north of the quadrangle the Lower Kittanning has been mined to a considerable extent, but seems to be inconstant in thickness, the mining operations being confined to areas of locally thick development. Just off the northern boundary of the quadrangle, in a run $1\frac{1}{2}$ miles west of the eastern margin, the coal appears to be about 2 feet thick and the same thickness was observed in an old opening near the head of Little Mudlick Creek. The blossom of this coal shows at several points in the road down Little Mudlick Creek. The coal is reported to be $2\frac{1}{2}$ feet thick at the forks of Camp Run northeast of Putneyville, and it was observed in the ravine just north of Putneyville, where it was pinched out to a thickness of from 4 to 6 inches. At Foreman's bank, about $1\frac{1}{2}$ miles west of Eddyville, the coal has a thickness of 3 feet 6 inches.

About 1 mile south of Foreman's bank, at the road crossing, near head of run in southeast corner of Mahoning Township, the following section is exposed:

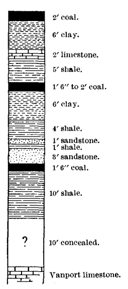

Fig. 5.—Section of Lower Kittanning coal 2 miles southwest of Eddyville.

It is somewhat difficult to interpret this section. The lower and middle coals fall within the usual limits of the Lower Kittanning coal above the Vanport limestone, but the upper coal is higher above the limestone than the Lower Kittanning is found elsewhere in the quadrangle, yet the interval is less than that between the Vanport limestone and the Middle Kittanning coal. The assumption therefore that these thin beds really represent the Lower Kittanning coal split into three benches seems the most probable. Such cases are known to occur elsewhere in this and other seams. Such a condition could have been produced by a local rapid deposition of sediment during the accumulation of the coal seam which interrupted the continuity of the accumulation at this point. At a bank on the spur between the two branches of Pine Run about 2 miles northeast of Eddyville the coal is 3 feet 4 inches thick, and shows several thin partings (see sec. 10).

In the area lying between Mahoning Creek and Belknap the Lower Kittanning coal has been opened at a number of places, but all openings had been abandoned and nothing could be learned of the thickness of the coal. It seems probable, however, that it is of sufficient thickness to warrant working under more favorable conditions. The cheap supply of natural gas and the proximity of the more profitably mined Upper Freeport coal interfere with the mining of the Lower Kittanning in this region.

At Goheenville there is an abandoned opening in the Lower Kittanning. At an opening three-fourths of a mile below Goheenville the coal is 2 feet to 2 feet 2 inches thick (see sec. 11).

On Scrubgrass Creek 2 miles below Goheenville the coal is exposed at creek level at the mouth of a ravine and is 2 feet 6 inches thick (see sec. 12.)

At a bank on the run one-half mile east of Templeton the coal is 2 feet 5 inches thick and much broken by thin partings, as shown in sec. 13. See analysis No. 1 of the table for the composition of the coal in this region.

In Washington Township about 1 mile southwest of Mahoning a thickness of 4 feet 8 inches was measured in a working bank. Six inches of this thickness at the top is bone (see sec. 14). This measurement probably fairly represents the thickness of the Lower Kittanning in Washington Township. At Peart's old opening, just east of Allegheny River and 2 miles above Mosgrove, the coal shows a thickness of 3 feet 6 inches and is overlain by a heavy sandstone which is present over a considerable tract in this part of the quadrangle. On the North Fork of Pine Creek the coal is similarly overlain by heavy sandstone and has a thickness of 3 feet.

On Hays Run 1 mile above its mouth the heavy sandstone is also present above the coal, which is more or less broken up, especially at the top, pockets and small seams being included in the bottom of the sandstone itself. The imperfect section shown in sec. 15 was measured there. On the South Fork of Pine Creek nearly opposite Pine Furnace the Lower Kittanning coal is reported to be 2 feet 6 inches thick by Platt (H5, p. 122). At Gillis's bank, 1 mile above Pine Furnace, the coal is reported to be of good thickness but divided into two benches by a parting in the middle 1 foot thick. Above the road north of Oscar the coal has been worked more or less. Some of the banks were inaccessible, but one measurement was obtained which is given in sec. 16.

Nothing definite is known of this coal on Cowanshannock Creek. Its horizon lies above water level across Valley Township, and for one-half mile into Cowanshannock Township. In the cut for the projected electric railroad about three-fourths mile east of the west side of Valley Township a coal about 10 inches thick was exposed which seems to be in the position of the Lower Kittanning. Nearly on the eastern margin of Valley Township there is an old opening in this coal. This seems to be Rhea's old bank, described by Platt (H5, p. 96). The coal was reported by Platt to be very irregular in thickness, varying from $2\frac{1}{2}$ to 4 feet. Its composition is shown in analysis No. 2 of the table of analyses of coals.

The coal is extensively worked in the northwestern part of the quadrangle in Madison Township and to a less extent in Washington Township. The development is mostly confined to country banks, however. The only developments on a commercial scale are at Avondale, near Lawsonham, where the Avondale Coal Company has a mine, and at Mahoning, where the Mahoning colliery is operating.

Middle Kittanning coal.—This is not an important seam in the quadrangle. While it probably persists throughout as a seam a few inches in thickness, it is known as of possible value at only a few points, where it reaches a general thickness of 2 to 3 feet and in exceptional cases is thicker.

Its blossom was observed in the road about 1 mile due south of Mahoning Furnace, where a thickness of from 2 to 3 feet was indicated. In this vicinity it was reported to have been worked and to have a thickness of 3 feet. On the North Fork of Pine Creek it is exposed at a few points. Near the mouth of the run, at the first road intersection above Bullock Run, what is probably the Middle Kittanning coal has been stripped and is 2 feet thick (see sec. 17). A mile farther up the creek, in the road on the south, this coal shows about 3 feet thick.

On the South Fork of Pine Creek what is probably the Middle Kittanning seam has been worked at several points above Echo. Platt (H5) published a section (see sec. 18) of what he identified as this coal on the Kline farm, between Echo and Belknap, but its exact location can not be determined. Two miles above Echo where the railroad crosses North Branch the coal is opened and has a thickness of 2 feet 8 inches (see sec. 19). What is probably this coal has been worked at two other points, at least, on this stream. One of these is just below the road at the point where the fourth road to the north above Echo intersects the North Branch road. The coal was reported 28 inches thick here. About 2 miles farther up the branch, near the intersection of the sixth road to the north above Echo, there is another abandoned opening in what appears to be this coal, and the coal was reported to be 5 feet thick, with thick partings. There are a number of abandoned openings at railroad grade on the south side of the creek near this point in what appears to be the same seam.

On Cowanshannock Creek little is known of this coal. In a ravine $1\frac{1}{2}$ miles east of Stone House the coal was exposed and is 18 inches thick (see sec. 20).

Upper Kittanning coal.—This is an important coal in the northeastern part of the quadrangle in Mahoning and Redbank townships, between the North and South forks of Pine Creek in Boggs and Wayne townships, and near Echo and Yatesboro. Its general thickness varies from a few inches to 3 feet, but in local basins of small extent it is 10 to 15 feet thick, a mode of occurrence which has caused the seam to be called the pot vein. In these basins the seam consists of one or two benches of cannel and of bituminous coal. What is probably this coal also shows at several points on Mill Run in Kittanning Township. In Madison Township it is thin so far as known. In the vicinity of Tidal 2 feet 6 inches of bony, worthless coal is exposed in the road, which is probably Upper Kittanning (see sec. 21).

At Widnoon it was reported to have been found with a thickness of 18 inches in digging the cellar of a house. Near the summit of a knob about $1\frac{1}{2}$ miles south of Widnoon this coal makes a good showing, but its thickness could not be determined. High up on the hillside near the mouth of the run flowing southward from Deanville it was exposed to a thickness of 2 feet, and it may be thicker.

This coal reaches its maximum development in Mahoning and Redbank townships, where it occurs in several apparently isolated deposits of unusual thickness. The seam is distinguished in this part of the quadrangle by the fact that it consists of one or two benches of cannel coal or shale and one or two benches of bituminous coal. These characteristics are shown in the following sections.

At the old Anthony mine, east of the narrows of Redbank Creek in Mahoning Township, Platt reports the following section (see sec. 22):

Section of Upper Kittanning coal at the Anthony mine, east of the narrows, Mahoning Township (H5, p. 198).

	Feet.	Inches.
Cannel slate	0	6
Soft slate and bony coal	0	4
Coal	3	6

At the Bostonia mine, 2 miles south of New Bethlehem, in Mahoning Township, an effort was once made to mine this seam extensively, but the effort was a failure. The following section of the coal at this mine was published by Franklin Platt, who identified it as the Lower Freeport (see sec. 23):

Upper Kittanning coal at the Bostonia mine, south of New Bethlehem (H, p. 240).

	Feet.	Inches.
Cannel slate.		
Cannel coal	8	0
Bituminous coal	2	0

He describes the cannel bench as holding its thickness along the main entry, but thinning out along the cross headings so that beyond the limits of the cannel bench the seam consists only of the 2-foot bituminous bench. Platt (loc. cit.) published analyses by McCreath of samples taken from the different benches of coal at this mine, which are given in the table beyond. About 3 miles southeast of the Bostonia mine this coal is mined at the Brooks bank, on Cathcart Run north of Putneyville. At this bank the seam reaches a thickness of 15 feet and is composed of two benches of cannel coal or shale and two of bituminous coal, as shown in the section below (see sec. 24):

Upper Kittanning coal at the Brooks bank, near the head of Cathcart Run, north of Putneyville (H5, p. 178).

	Minimum.		Maximum.	
	Ft.	*In.*	*Ft.*	*In.*
Cannel shale	5	1	5	1
Bituminous coal	1	0	1	0
Cannel coal	0	10	7	0
Bituminous coal	2	0	2	0
Total	8	11	15	1

An analysis of the cannel shale at this bank is given below. On the east side of Little Mudlick Creek this coal reaches a good development and it is of better quality than elsewhere. It has been worked for years at the Thompson and Wynkoop banks, in which the seam has the section given in the tables below (see also secs. 25 and 26).

Upper Kittanning coal at the Thompson bank, on Little Mudlick Creek (H5, p. 178).

	Minimum.		Maximum.	
	Ft.	*In.*	*Ft.*	*In.*
Slate roof				
Bituminous coal	4	0	4	0
Cannel coal	0	2	8	0
Bituminous coal	1	11	1	11
Total	6	1	13	11

Upper Kittanning coal at the Wynkoop bank, on Little Mudlick Creek (H5, p. 178).

	Minimum.		Maximum.	
	Ft.	*In.*	*Ft.*	*In.*
Slate roof				
Bituminous coal	2	2	2	2
Cannel coal	1	0	6	0
Bituminous coal	0	6	1	0
Total	3	8	9	2

East of Charlestown and probably off the quadrangle, this seam is found to thicken up again over a small area. It has been worked at a bank on the Jacob Schieck farm, where the section is similar to those given above (H5, p. 182).

Platt, writing twenty-five years ago, stated that this seam had not been found on the west side of Pine Run in the vicinity of Charlestown and McWilliams, nor on the west side of Little Mudlick Creek, though diligent search had been made by the farmers of both those localities. The present writer has found nothing indicating any recent discovery of the coal in these areas. It seems likely, therefore, that the seam as developed at the Thompson and Wynkoop banks does not extend through the hill to the valley of Pine Run, nor does it extend from the locality of the Brooks bank, on Cathcart Run, to the valley of Little Mudlick Creek. Whether it extends from the region of the Bostonia mine to that of the Brooks bank with anything like the thickness existing in those places is unknown, but the presumption is against such a conclusion. As stated above the greatest thickness at Bostonia persists only along the main heading, which followed the longer axis of the trough, while on the cross headings it thins rapidly to nothing. Platt describes the thick coal on the east side of Little Mudlick Creek as lying in a series of troughs running in a northeast-southwest direction and thinning on each side in the transverse direction, a feature that is well shown in the Thompson bank, where the main entry is driven in a southeast direction. At the mouth of the entry the cannel is but a few feet thick, but at a distance of 100 feet in it thickens to 8 feet and the floor of the seam descends a corresponding amount. From this point the floor rises along the main entry, the cannel thins gradually and finally disappears, leaving only the bituminous bench. In the center of this depression side headings had been driven off from 50 to 100 feet, but no thinning of the cannel occurred. In other workings in this vicinity the bituminous bench had been worked across the comparatively narrow ridge into the next adjoining trough.

It thus appears that in these limited areas of special thickening, the increase in the thickness is brought about by the presence of lenticular beds of cannel above a bench of bituminous coal or intercalated between two benches of the same. In all cases the roof of the seam is said to form a regular surface, while the increased thickness of the seam where the lenses of cannel are present is accommodated by depressions in the floor of the seam.

As shown above, the lateral extent of these troughs must be comparatively limited; the longitudinal extent, so far as the writer is aware, has in no case been determined. Nor is it known whether there may not be other deposits of a similar nature in this region that do not crop out and have never been discovered. These matters could be determined only by diamond drilling or by following out the seam under the surface.

Platt (H5, p. 179) expressed doubt whether the cannel of these localities is to be regarded as a true cannel coal at all and he called it a cannel slate with a conchoidal fracture. In addition to its conchoidal fracture it is without luster. It thus possesses the physical characters by which cannel coal is usually defined. Further, that it is a coal and not a slate is conclusively shown by the following analyses:

	1.	2.	3.	4.	5,
Fixed carbon...	27.00	53.132	52.306	46.194	52.757
Volatile hydrocarbons......	59.60	37.830	32.665	30.490	37.930
Moisture	1.30	1.610	.640	.510	1.120
Ash	12.10	6.750	13.345	22.230	6.705

1. Breckenridge cannel of Kentucky.
2. Cannel bench at the Thompson bank.
3. Upper cannel bench at the Brooks bank.
4. Upper cannel bench of the Bostonia mine.
5. Upper bituminous bench of the Thompson bank (see sections above).

Analyses 1 from Geol. Survey Kentucky, Rept. on western coal field. Analyses 2 to 5 from Second Geol. Survey Pennsylvania, Rept. H5, p. 180.

Analysis 4 is of a sample of what is probably the poorest grade of cannel in the region under discussion, yet it contains over 76 per cent of combustible matter, while the cannel from the Brooks bank contains over 85 and that from the Thompson bank over 91 per cent of combustible matter, so that it is certainly improper to call any of this cannel a slate. It is a coal which in some places contains an unusually high percentage of ash. In the cannel from the Brooks bank, however, the percentage of ash is but little greater than in the Breckenridge coal, which may be taken as a typical cannel, while the cannel from the Thompson contains a much smaller proportion of ash than the Breckenridge cannel. So far as content of ash is concerned, then, most of the Upper Kittanning cannel in this region is not very different from well-recognized cannel coals of other regions if it be assumed that the above analyses fairly represent its character. There is, however, one marked difference between this cannel and a typical cannel, and that is in the relative proportions of fixed carbon and volatile hydrocarbons. Nearly all coals having the physical qualities of cannel contain 45 per cent or more of volatile hydrocarbons and a less amount of fixed carbon. In the Breckenridge cannel the volatile matter is more than twice that of the fixed carbon. In the cannel of this region, on the contrary, the fixed carbon runs about 1½ times the amount of volatile matter. In this respect, therefore, this coal is not entitled to be called a cannel at all. It differs in no way from the upper bituminous bench of the Thompson bank, the composition of which is shown in analysis 5. In fact, except for its high percentage of ash in some cases, it is almost identical in character with most of the bituminous coal from the other seams of the region, as may be seen by a study of the analyses given in the table beyond. It might be best described by saying that it is a coal with the physical characters of cannel and the chemical composition of a more or less impure bituminous coal of the ordinary type of the region.

Judging from the analyses of this coal there appears to be no reason why it should not make a fairly good fuel for use where the disposal of the ash is not a factor to be considered. It could not serve the ordinary purposes of a cannel coal. It is too poor in hydrocarbons to use in the manufacture or enrichment of illuminating gas, or for the distillation of oil and probably it has not the property of burning freely in an open grate, which makes cannel so desirable for domestic use. Furthermore, on account of its high percentage of ash it would not command so high a price in the market as the purer coals with which it would have to compete, and there is therefore no probability of its being mined on a commercial scale so long as the better coals of the region are unexhausted. It will doubtless continue for some time to be a source of local supply for domestic use.

In the region of Pine Creek the Upper Kittanning coal is fairly persistent and of moderate thickness. In the road running northward from Pine Creek over the hill about three-fourths mile above its mouth the coal shows about 3 feet thick. At the mouth of Bullock Run it has been opened at road level underneath the heavy Freeport sandstone. The coal was not fully exposed and could not be measured, but a thickness of about 2 feet was seen. On the South Fork of the creek north of Pine Furnace the coal was once mined. Platt published a section of the coal at this mine, which is shown in sec. 27. North of the creek and about 1 mile west of Pine Furnace the coal was once extensively mined for coke for use in the furnace. The coal here was reported by Mr. John P. Painter, superintendent of the furnace, to make good coke, but to be very expensive to work, since it was only 2 feet 8 inches thick and often cut out by the overlying sandstone. Platt called this coal Lower Freeport. He collected samples which upon analyses by McCreath gave the result shown in No. 10 of the table.

This coal is exposed at the forks of Deaver Run about 1 mile northeast of Pine Furnace. It is here about 2 feet thick. Farther up Pine Creek, on the road to Goheenville, the coal is exposed in the road, where it is about 2 feet thick. It was worked at one time on the east side of the ravine, where it was reported to be 2 feet 6 inches thick. At Echo this coal is worked extensively at the Beck bank, where it is 2 feet 8 inches thick (see sec. 28). On Cowanshannock Creek at the road on the Rayburn-Valley township boundary line the coal is reported 1 foot 6 inches thick; in the ravine one-half mile east of Stone House it is about the same thickness, and by the roadside 1 mile west of Yatesboro, in the B. Schreckengost bank, now open, it is reported to be about 3 feet thick. The coal at this bank was erroneously identified by Platt as the Lower Freeport. A sample from this bank analyzed by McCreath gave the result shown in analysis 11. On Mill Run about 2½ miles above McNees what appears to be the Upper Kittanning coal shows a thickness of about 2 feet. On the first road north above McNees, just north of the run, this coal has been opened and is 1 foot 6 inches thick (see sec. 29).

It seems reasonable to conclude from our present knowledge of the Upper Kittanning coal that it will never become commercially of much importance, but that it will locally afford a considerable supply of fuel for domestic consumption.

Lower Freeport coal.—This coal is more persistent as a workable bed than either the Middle or Upper Kittanning, but is subject to considerable variations in thickness within rather narrow limits. Where workable its thickness varies from 2 to 4 feet and it is generally a bright, clean coal.

In the road south of Anthonys Bend it shows a thickness of 2 feet and in the road immediately south of Oakland the same thickness was observed. Farther south, near Mahoning Furnace, Platt obtained the section shown in sec. 30. At the Fairmount No. 1 mine, east of New Bethlehem, the opening of which is just north of the quadrangle, the coal is 3½ to 4 feet thick but very badly cut up by clay veins. In this region the interval between the Upper and Lower Freeport coals is 40 feet. Analysis 13 of the table, by McCreath, is an analysis of a sample of this coal from the neighboring Bostonia mine. At Oak Ridge mine No. 2, in the western part of Redbank Township, about 1 mile south of the north boundary of the quadrangle, a thickness of 4 feet 6 inches was measured (see sec. 31). The coal in this mine is reported much cut out and too thin to mine at the south end of the property. About 1 mile southwest of Oak Ridge mines a diamond-drill boring passed through 37½ inches of coal on the Smellen farm and 41 inches of coal on the Money farm which in both borings was regarded as Lower Freeport. In a ravine about 1½ miles a little northwest of Goheenville and in the southwest corner of Mahoning Township the coal is reported to be 5 feet thick. A thickness of about 3 feet was observed, but it is not known whether the full thickness is exposed. One-fourth mile north of Echo the seam is 2 feet 5 inches thick (see sec. 33). In a road near the head of Deaver Run the coal is exposed and about 2 feet thick. About 1 mile south of Oscar, in Valley Township, just west of the boundary of the quadrangle the coal is opened and is 2½ feet thick (see sec. 32).

On Cowanshannock Creek the Lower Freeport seems to be of fair thickness and very pure. It is persistent in Valley and Kittanning townships, where it lies 60 feet below the Upper Freeport coal. There are a number of working banks, and the coal is reported to make excellent fuel. On the first road north of Cowanshannock Creek in the western part of Valley Township there is an old opening in this coal one-fourth mile north of the creek. On the next road to the east, on the Robinson farm, the coal is now worked and is reported to be 2 feet 6 inches thick. At the James Adams bank, 1 mile north of Cowanshannock Creek on the first road east of Stone House, it is also 2 feet 6 inches thick (see sec. 34). At Bear's bank, on Long Run three-fourths mile east of the Adams bank, the coal is 2 feet 8 inches thick with a thin parting 8 inches from the bottom (see sec. 35). At Yatesboro No. 2 mine, at Yatesboro, the Lower Freeport coal is reported to be 2 feet 6 inches thick and to lie 35 feet below the Upper Freeport coal.

On the south side of Cowanshannock Creek the coal has been worked to some extent along Mill Run. A coal is exposed and has been opened in the road one-fourth mile east of McNees that seems to be the Lower Freeport coal, though it is apparently about 75 feet below the Upper Freeport coal. One-half mile above McNees is an old opening on the hillside north of the run that is probably in this coal. In the bed of the first run south of this, above McNees, the Lower Freeport is exposed 60 feet below a bank in the Upper Freeport. The thickness of the coal could not be determined here, but was probably 2 to 3 feet. At the Simon Ruffner bank, about 2½ miles above McNees, the coal has a thickness of 2 feet 6 inches (see sec. 36). Another opening one-half mile north of the Ruffner bank shows an identical section. About a mile east of the latter point, on Spra Run, the coal is 2 feet 7 inches thick at a working bank (see sec. 37). At the Moses Beer Bank, on a branch of Huskins Run about 1 mile a little northwest of Blanco, the Lower Freeport coal is 2 feet 4 inches thick (see sec. 38).

The Lower Freeport coal is worked on a commercial scale only along the northern border of the quadrangle at the Oak Ridge mine and at mines 1 and 2 of the Fairmount Mining Company.

Upper Freeport coal.—This is by far the most valuable coal seam in the quadrangle, although its area is considerably less than that of any other. It has been entirely eroded from the northwest corner of the quadrangle, including most of Madison Township. It is present throughout the entire length of the Fairmount syncline, except where it is cut out by the transverse streams and their small tributaries. It has been eroded from most of the surface of the Greendale anticline north of Pine Creek, only small areas remaining on the higher ridges and hilltops. It is present and well under cover in the southeast corner and along the southern margin of the quadrangle, including the southeast corner of Wayne Township, nearly all of Cowanshannock Township and a large portion of Kittanning Township.

This coal is reported to be excellent for steaming and heating purposes, but contains too much sulphur to be suitable for making gas or coke. It is very persistent in thickness and, so far as the writer knows, is nowhere too thin to mine. It is locally affected by "rock faults," or rolls, which greatly increase the expense of mining. At some places, as in the Mosgrove mine, the "faults" appear to be true horsebacks, resulting from the filling in of a stream channel cut into the coal and the subsequent consolidation of the filling into shale or sandstone. At the Fairmount Mining Company's mines in the Upper Freeport east of New Bethlehem these "rock faults" have been encountered throughout operations covering an area of at least 2 square miles. They are different from horsebacks in their extent and are of different origin. The coal here has the usual maximum thickness of 4 feet, but it does not hold this thickness far in any direction. In a few feet or rods it thins to a few inches or disappears entirely, its place being taken by the shale of the shale roof. In a short distance the coal reappears at the bottom of the seam and rapidly regains its full thickness. These changes are repeated over and over again in all directions, so that the seam is composed of irregular deposits of coal alternating with shale, the shale making probably more than a third of the whole. It seems probable that the vegetal matter of the coal accumulated in small irregular areas that were surrounded by water in which clay was simultaneously being deposited, for there are evidences along the lateral contact of the shale with the coal of an interfingering of the two substances, as if both were accumulating at the same time. The only other explanation that seems at all probable is that the coal accumulated uniformly over the whole area and was subsequently eroded by currents of water in the places now occupied by shale, but it is difficult to see how erosion could have produced such irregularities as exist over so large an area. The form and arrangement of the shale deposits replacing the coal certainly do not suggest such an origin. At any rate it is evident that the present condition of the coal seam in this locality is due to accidents of its original accumulation and not to any subsequent upheaval of the rocks or to volcanic action as some have supposed. On account of this supposition operations have been pushed southward in the hope of reaching improved conditions in the coal to the south of a ravine cutting the property. It is of course perfectly possible that better conditions may exist south of the ravine, but it is evident that there is no possible connection between the character of the coal seam and any features of surface relief whatever. These features came into existence ages after the character of the coal seam was fixed.

The Fairmount Mining Company is planning to abandon its present operations east of New Bethlehem and to open a new mine near the site of the old Bostonia mine south of New Bethlehem. At an opening recently made there the seam is 4 feet thick and apparently clean coal. At the Redbank Coal Company's mine near this point Platt reported the seam to be 4 feet thick, with 6 inches of bone at the top (see sec. 39). McCreath analyzed a sample from this mine with the result shown in No. 14 of the table beyond. At the Oak Ridge mine No. 5 the coal is 3 feet 5 inches thick (see sec. 40). The coal in this mine is said to be free from the "faults" described above that exist in the Fairmount mines a short distance to the west.

Over the remainder of the quadrangle this coal shows such uniformity in thickness and character that extended comment seems unnecessary. On the ridge about 1½ miles due south of Kellersburg it is 2 feet 10 inches thick. At Reedy's bank, 1 mile north of Deanville, the coal is 4 feet 4 inches thick with 1 to 2 inches of bone at the top and a thin parting 1 foot above the bottom (see sec. 41). At a bank in a ravine 1½ miles southwest of Oakland the coal is 3 feet 9 inches thick, but is broken by a number of thin partings, some of which may reach a thickness of one-half inch. At a bank in the run about 1 mile east of Templeton the coal is 3 feet 1 inch thick with 2 inches of bone at the top (see sec. 42). A sample collected near Stewardson Furnace, now Dee, had the composition shown in analysis 15 of the table. At Austin's bank, south of Scrubgrass Creek 2 miles above its mouth, the Upper Freeport seam shows 3 feet of clean coal. At Mahoning Furnace the Upper Freeport was once mined extensively and made into coke for use at the furnace. The seam here is reported to be 3 feet 11 inches thick. The coal made rather tender coke, but it answered all the requirements of the small stack at which it was used. Its composition at this place is shown in analysis 16 of the table (Platt, H5, p. 160). At Kuhn's bank, near Goheenville, the coal is reported to be 3 feet 4½ inches thick. At the Kammerdiener bank, 2 miles east of Goheenville, it is 3 feet 8 inches thick (see sec. 43) and on the John Reeseman farm, near McCrea Furnace, Platt reports it 4 feet thick with a thin parting near the middle (H5, p. 146; see sec. 44). At Smith's bank, at the head of Sandy Hole, one-half mile south of Mahoning Creek and 1½ miles southwest of Putneyville, the coal is 3 feet 10 inches thick (see sec. 45). At Butler's bank, on Pine Run east of Charlestown, Platt (H5, p. 182) reports the coal 3 feet 10 inches to 4 feet thick (see sec. 46).

On the bluff of the Allegheny 1½ miles south of Templeton the Upper Freeport coal was measured in a bank and found 2 feet 2 inches to 2 feet 4 inches thick. On Bullock Run 1½ miles above its mouth, the coal is 2 feet 6¾ inches thick and is immediately overlain by the Mahoning sandstone. The coal here is considerably broken by thin partings (see sec. 47). About the headwaters of Pine Creek in Wayne Township, the coal is confined to a few small areas on the higher hill tops. It is generally, however, of good thickness. At Bowser's bank, on the high knob 1 mile east of Muff, the coal is 4 feet 4 inches thick (see sec. 48). At a bank 1½ miles west of Dayton it is 4 feet thick (see sec. 49). At the Cook bank, 2 miles southeast of Echo, it is reported by Platt (H5, p. 111) to be 4 feet 1 inch thick with a 1-inch parting of slate 8 inches from the bottom (see sec. 50).

At the Mosgrove mine, at Mosgrove, the coal is reported to be badly cut up by horsebacks (rock faults) and more expensive to mine than in other localities. At an opening into this mine on Hays Run a thickness of 3 feet 6 inches was measured with a 1-inch parting 4 inches from the bottom (see sec. 51). No. 17 of the table is an analysis of this coal. At the Fritz bank, one-half mile north of Cowanshannock Creek, near the western margin of the quadrangle, the coal is 5 feet 4 inches thick, but much broken by thin partings (see sec. 52). At a bank one-half mile south of Cowanshannock Creek and 1 mile east of the margin of the quadrangle a thickness of 3 feet 8 inches was measured, the lower 4 inches of which is composed of coal, clay, and bone. At the Daniel Rosenberger bank, one-half mile east of McNees, the seam has the section shown in sec. 53. Near the point where the Indiana pike crosses the head of the run, one-half mile west of Blanket Hill, the coal is only 2 feet 1 inch thick under a heavy sandstone (sec. 54). The thinness of the coal here suggests the possibility of a thinning in the neighborhood of Blanket Hill, where it is little known. At Yatesboro the coal is being mined extensively at the Yatesboro No. 1 and 2 mines and has the thickness and character shown in secs. 55 and 56. Yatesboro No. 2 mine is said to be on the Patterson farm, mentioned by Platt in his Report H5. As shown on a preceding page Platt regarded the Upper Freeport at this place as a higher coal lying 30 feet above the Upper Freeport and called it the Gallitzin coal. He was possibly led into this error by identifying the Lower as the Upper Freeport coal, the Lower Freeport lying at this place 30 feet below the Upper. No. 18 of the table is an analysis of a sample from the old Patterson bank, collected from a heap at the mouth of the mine. At Blanco the Upper Freeport coal is 4 feet thick (sec. 57). Analysis No. 19 is of a sample from the Beers bank in this vicinity.

The coal is worked at a number of banks on Garrett Run and appears to be above the usual thickness. At the Hobaugh bank, near the junction of the two branches of the run, the coal is 6 feet 6 inches thick with a number of partings, as shown in sec. 58. At the Jacob Stitt bank, 1 mile above Heilman, it is 3 feet 11 inches thick and has 9 inches of bone at the top (see sec. 59).

The Upper Freeport coal is extensively mined at Yatesboro by the Cowanshannock Coal Company. Two mines are now in operation, equipped with all modern appliances, and the output is large. The Pittsburg Plate Glass Company operate a well-equipped mine at Mosgrove; and the Fairmount Mining Company and the Oak Ridge Mining Company are operating on a large scale in the northern part of the quadrangle. The coal is said to yield from 3600 to 5000 tons of run-of-mine coal to the acre. It is marketed in the north and east and very largely used for steaming.

Brush Creek coal.—This coal has been opened and worked in but one or two places in the quadrangle. It has recently been worked by Mr. Ellenberger just north of the ridge road and south of the head of Hays Run in the eastern part of Rayburn Township. He reports it 2 feet 6 inches thick and of excellent quality. The blossom of this coal shows at a number of points along the road east of Ellenberger's to a point about 1 mile east of West Valley and it is possible that it is locally of workable thickness. It was also opened near the head of Cowanshannock Creek east of Rural Valley and reported 20 inches thick, and it probably rarely exceeds this thickness in the quadrangle.

PETROLEUM.

Petroleum, which is so important a product in the Kittanning quadrangle, is produced in the Rural Valley quadrangle in only three wells, and in those in very small quantities, so that it may be ignored as a resource of the quadrangle. The three wells in which oil occurs are the Rupp well in northeastern Rayburn Township, the Brown well in northwestern Kittanning Township, and the Cline well in Wayne Township 1 mile north of Echo.

NATURAL GAS.

This occurs in greater or less abundance over a large part of the quadrangle, and has been an important product during the last ten years.

GAS FIELDS.

The territory of the quadrangle falls into two main gas fields, as shown on the sketch map, fig. 6. One of these lies in the northwestern part of the quadrangle, in the townships of Madison, Washington, and East Franklin; the other extends from the southern margin of the quadrangle in Kittanning Township in a curving direction northeastward to Mahoning Creek in the northeastern part of Wayne Township. It includes most of Kittanning and Valley townships, southeastern Boggs Township, northwestern Cowanshannock Township and most of Wayne Township, and lies in a broad belt extending between the southwest and northeast corners of the quadrangle. In addition to these main fields there are several subordinate ones. Between Oakland and Mahoning Furnace, in Mahoning Township, there is a small field that has apparently no connection with any other. There is a small independent field in Redbank Township, in the northeast corner of the quadrangle; a small field in northern Plum Township which is connected by light wells with the main field in the northeast; and a small disconnected field at Atwood, in the southeast corner of the quadrangle.

GEOLOGIC OCCURRENCE.

The gas in this quadrangle occurs in porous sandstone strata that lie at considerable depth below the surface. These sands are not all equally productive in every well. In some wells one sand, in others another, and in still others two or more sands are productive. In descending order these sands are known to the driller as (1) the Murrysville, or Butler sand; (2) the Hundred-foot sand; (3) the Thirty-foot sand; (4) the Fifth sand; (5) the Speechley sand, and (6) the Tiona sand.

The Murrysville and Hundred-foot sands have been the main producers in the past, but so many wells have been drilled into them that their production has diminished greatly and is still diminishing at a rapid rate. One company reports a falling off of 20 per cent within the last year. Comparatively few wells have procured a good flow of gas from the Thirty-foot and fewer still from the Fifth sand. The Fourth sand is not a gas-producing sand. Within the last few years much drilling has been done to the Speechley sand, but apparently without particularly satisfactory results except in the vicinity of Muff and possibly Goheenville. One of the largest producing companies of the region reports that it shut off all its shallow-sand wells during the past year and supplied its entire needs from the deep-sand wells in the vicinity of Muff. Other companies, however, have not been so fortunate. In the vicinity of Goheenville the Tiona sand has recently attracted considerable attention and some good wells are reported in it.

STRATIGRAPHY OF THE GAS SANDS.

In this discussion the Vanport (Ferriferous) limestone is used as a reference stratum, as shown on the structure and economic geology map. The reader is referred also to the well-section sheet, in the back of the folio.

Murrysville (Butler) sand.—This sand, named from Murrysville, Westmoreland County, lies about 300 feet below the bottom of the Burgoon (Mountain, Big Injun) sand and its depth below the Vanport limestone varies from 797 feet in the Laura Pontius well, in Wayne Township, to 939 feet in the J. Peters well, in Cowanshannock Township. In 45 wells selected from different parts of the quadrangle the mean interval between the Murrysville sand and the limestone is 858 feet. The variation of more than 100 feet in this interval would suggest the possibility that the sand noted in the different wells as the Murrysville is not a continuous stratum over the quadrangle, but rather a series of lenticular beds occurring at the same general horizon. In drilling a well it is the custom to call the first gas-bearing sand the Murrysville, and such a sand may perhaps occur in one well at one horizon and in another at a somewhat higher or lower horizon, and may not be continuous between the two. This supposition seems to be borne out by the fact that in some wells (Nos. 1, 2, and 4) the Murrysville sand is very thin. Its maximum known thickness is 109 feet, in the Robert Lynes well (No. 19). Its average thickness in 44 wells is 49 feet.

Venango oil sands.—This group is of particular interest because from its lower sands is obtained the oil of the Venango-Butler oil fields. As shown on a preceding page, under the heading "Rocks not exposed," the rocks of this group lie partly in the Pocono formation and partly in the Catskill formation. At the top of the group lies the Hundred-foot sand, which is the same as the First sand of Venango County and Second sand of northern Butler County. The bottom of the group is the Fourth sand, the lowest of the oil-producing sands of the oil regions. It is not a prominent bed in the quadrangle and in most wells is not noted at all.

In 16 wells the interval between the Vanport limestone and the bottom of the Fourth sand varies from 1262 to 1435 feet, the average interval being 1352 feet. In the same wells the thickness of the Venango oil sands varies from 306 feet to 485 feet, the average being 386 feet.

Hundred-foot sand and Thirty-foot sand.—The depth of these sands below the Vanport limestone varies. In the Houser heirs' well, near Goheenville, it is 872 feet; in the J. Peters well, near Blanco, it is 1052 feet, and its mean depth in 45 wells is 954 feet. In some wells the Hundred-foot sand is separated from the Murrysville sand by 50 to 60 feet of shale; in others these sands are in contact or are separated by only a few feet of shale. The former condition is shown in the Moore well (No. 20 of the well-section sheet), the latter in the Lynes well (No. 19). The Hundred-foot sand varies in thickness from 145 feet in the Peter Heilman well (No. 9) and the J. A. Colwell well (No. 3) to 20 feet in the Mateer well (No. 4). Its average thickness in 43 wells is 76 feet. Its great thickness in the Colwell and Heilman wells is due to the merging of the Hundred-foot and Thirty-foot sands, on account of the absence of the shale that usually separates them. The Thirty-foot sand is not therefore everywhere a distinct bed, though usually it is separated from the Hundred-foot sand by a bed of shale which in some wells has a thickness as great as 50 feet, as for instance in the McAfee well (No. 5 on well-section sheet).

The lower portion of the Venango oil sands.—In this quadrangle this is composed mostly of shale, and the coarse sandstones known as the Stray, Third, and Fourth sands, which form the reservoirs of oil in the oil regions, are generally absent or thin.

Fifth sand.—Not far below the bottom of the red rocks lies the Fifth sand, which in an occasional well produces gas in paying quantities. It is not important, however, as a gas producer.

Speechley sand.—At intervals below the Venango oil sands that vary greatly in different wells lies a sand that is locally an important gas producer. This is called the Speechley sand because it is correlated by the operators with the sand of that name in Venango and Forest counties. Whether this correlation is correct or not there is no means of determining at present. The interval between the Venango oil sands and the Speechley is filled with shales and thin sandstones, with an occasional thicker sandstone, as shown in well sections Nos. 3, 13, 14, and 20. The thickness of these intervening beds differs in different wells. In No. 12 it is 750 feet, in No. 3, 830 feet, and in No. 14, 925 feet. Five wells give an average of 863 feet. In No. 12 there was probably an error in the identification of the Fourth sand; a lower sand, possibly the Fifth, was perhaps mistaken for it. The interval between the Speechley and the Vanport limestone is much more constant. It varies in 6 wells between 2210 and 2240 feet, its average being 2227 feet. In 10 wells in the Kittanning quadrangle the mean interval is 2200 feet. The Speechley rarely exceeds 50 feet in thickness. In the Colwell well (No. 12) two benches of sandstone in contact are recorded, the lower of which is called the Speechley. It seems more likely that the two should be regarded as the Speechley, and that it has here an unusual thickness. One hundred feet below the Speechley there is recorded in the Moore well (No. 20) a thin sand called the Second Speechley.

Tiona sands.—Within 150 feet below the Second Speechley lie the First and Second Tiona sands. This name probably expresses the belief that these sands are to be correlated with the Tiona oil sands of Warren County. Correlation over so long a distance has, however, but little value. The sand noted near the bottom of the Colwell well (No. 3 of well-section sheet) is probably one of the Tiona sands, while the thin sand 150 feet above is probably the Speechley. It appears that generally the interval extending 200 feet below the first Speechley sand is marked by beds of sandstone of greater or less development, one or more of which may be locally good gas producers.

RELATION OF GAS ACCUMULATION TO STRUCTURE.

A study of the distribution of wells on the economic map will show that the majority of the producing wells are located on the crests and flanks of anticlines. None are found in the deepest part of the synclines, though there are apparent exceptions to this rule. For instance, the two wells on the Star farm, south of Hays Run, are on the axis of the Fairmount syncline but on the crest of a low cross anticline that separates the depression on Pine Creek from the portion of the syncline farther south. The wells in the vicinity of Mosgrove and on Garrett Run, though near the synclinal axis, are still about 100 feet above the bottom of the syncline. Southeast of Blanco there are two light wells in the Apollo syncline, but here again is a low cross anticline. In the vicinity of Rural Valley there are a few wells in the flat-lying strata fringing the base of the anticline, but dry holes have been the general result of drilling at greater distances from the anticline. A few wells have been obtained in the vicinity of Atwood, but the records of these wells indicate a slight anticlinal structure at that place. The wells in the southeast corner of the quadrangle are near the crest of a pronounced anticline.

The conclusion can be pretty safely drawn that gas has in the main accumulated along the anticlines and that the synclines are practically barren, though how far down on the flanks of the anticlines gas may have accumulated in paying quantities only the drill can determine. It is now a generally accepted theory that structure exercises an important influence on the accumulation of gas and oil, which tend to gather on the crests and along the flanks of the anticlines—gas at the top, oil next below, and water at the bottom, this distribution being in accordance with the relative densities or specific gravities of the substances. This is known as the anticlinal theory. Structure, however, is not the only determining factor in the accumulation of gas, for dry holes are occasionally drilled on the axis of an anticline, as is shown in this quadrangle by the Ruffner well, in Kittanning Township, and the H. S. Pontius well, in Wayne Township east of Belknap. In such places the sands may be absent or not of sufficiently open or porous character to receive the gas and yield it up readily when tapped.

It has been customary in the past to locate wells with reference to a line drawn at some particular angle from a successful well, as along a line extending through a well at an angle of N. 30° E. or N. 45° E., probably on the assumption that structure lines followed the straight courses mapped by the Second Pennsylvania Survey. The better knowledge of the structure of the region now available shows the futility of such a method.

For information concerning the stratigraphic relations of oil and gas sands the reader is referred to the matter under the heading "Rocks not exposed" in the discussion of the stratigraphy of the region.

POSSIBLE EXTENSION OF GAS FIELDS.

The anticlinal theory seems to be supported by all the developments in this quadrangle, and the directions in which future drilling may be done with reasonable hope of success can readily be determined by means of the structure-economic map, which shows the position of the anticlines whereon most of the existing wells are located. The writer would venture to suggest a few areas in which drilling might be done with favorable results. One such area of large extent lies along the southeastern flank of the Kellersburg anticline, extending from Mahoning to New Bethlehem. Another extends along the northwestern flank of the Greendale anticline from Goheenville to the eastern margin of the quadrangle. Another area of considerable breadth, mostly untested, extends southward by Belknap to North Branch of South Fork of Pine Creek. Those interested can easily find other gaps of apparently undrilled territory along the anticlines.

CLAY.

The economically important clays of the quadrangle occur in the Pottsville and Allegheny formations. Only two seams, the Mercer, in the Pottsville, and the Clarion, in the Allegheny, are worked. The workable areas appear to be of comparatively small extent and within them the Mercer ranges in thickness from 6 to 12 feet, and the Clarion from 6 to 8 feet.

Mercer fire clay.—This occurs in the shales intervening between the Homewood and the Connoquenessing sandstone and is correlated with the Mount Savage fire clay of Allegany County, Md. In this quadrangle the clay is found only at Climax and at St. Charles. It is uncertain whether the clay is continuous between these two places. The superintendent at the Climax Brick Works reports that after much prospecting he has satisfied himself that the clay does not crop out between them.

At St. Charles the bed runs about 6 feet thick so far as examined, the lower $2\frac{1}{2}$ feet being flint clay. At Climax the bed has twice that thickness and is composed of flint and plastic clay in varying proportions. The relations of the two kinds of clay also vary greatly. The flint clay may be at the top, middle, or bottom; it may be wanting altogether in parts of the bed, or it may make up the full thickness in other parts. The same statements would also hold for the plastic clay. The supply at St. Charles is said to be holding out well toward the south and west, and it is also satisfactory at Climax, though it is said to be cut out by rock in certain directions.

At Climax three grades of clay are used. Grade No. 1 is a flint clay from which bricks are made that are used in furnaces where the heat runs to 4000 degrees Fahrenheit; No. 2 is a plastic clay, used with flint clay for making tile for various purposes, and said to be of excellent quality; No. 3 is a mixture of Nos. 1 and 2 as gathered up in the mines after the two grades have been assorted rather closely, and from this stock bricks of a second quality are made. These bricks are used in iron and steel works, glass furnaces, malleable-iron plants, or in any other place requiring a highly refractory brick.

Clarion fire clay.—This is a bed of plastic clay, 6 feet thick, in the vicinity of Templeton and Mahoning, where it is now being mined and shipped to Pittsburg, to be used in the manufacture of fire brick. It has not been developed elsewhere, though it is entirely possible that it may be found at other places in good thickness and quality.

Kittanning fire clay.—This is generally present in greater or less thickness but has not been developed or utilized in the quadrangle and nothing is known of its qualities.

IRON ORE.

Buhrstone ore.—This is a layer, generally of hematite or limonite, that immediately overlies the Vanport limestone, which, from this association, has been universally called the "Ferriferous limestone." The name Buhrstone is due to the fact that the ore is accompanied by chert nodules in some localities. The ore is a compact layer 1 foot thick or less. Locally it takes the form of carbonate nodules in the shale overlying the limestone. This seems to have been its character in the vicinity of Belknap, where it was once mined for use at McCrea Furnace. The ore is practically coextensive with the limestone and is present over the larger part of the northern two-thirds of the quadrangle except where it has been cut out in the valleys.

This ore was formerly the basis of an important industry throughout western Pennsylvania, to which the abandoned furnaces and extensive strippings in the Rural Valley quadrangle and elsewhere bear abundant testimony. With the introduction of the much better Lake Superior ores, however, the smelting of the Buhrstone ore became unprofitable and the business was abandoned. Pine Furnace, one of the last of these furnaces, was abandoned in 1879.

The ore was worked mainly by stripping the outcrop where it was under shallow cover and to a less extent by drifting, as at Mahoning Furnace. Most of the ore to be had by that method has been already taken out, and while there is an immense supply still remaining in the quadrangle, it can be procured only by expensive methods of mining.

The carbonate ores unroasted contain from 33 to 58 per cent of metallic iron, and the other ores often as much as 50 per cent. The most damaging impurities in the iron from these ores were phosphorus and silica, and their presence was due, it is believed, to imperfect methods of smelting and to the use of the Vanport limestone as flux, which communicated so much phosphorus to the metal that it was unsuited for making Bessemer steel but not for the ordinary uses of mill iron (W. G. Platt, H5, pp. lvii–lviii).

LIMESTONE.

Vanport (Ferriferous) limestone.—This limestone is present over most of the quadrangle, but it seems to be wanting in the extreme southeast corner. It is about 8 feet thick.

It is quarried in many places and burned into lime for agricultural use, a practice that is facilitated by an abundant and cheap supply of fuel. It is quarried near Mahoning for flux for use in the furnaces at Kittanning and is reported to be very satisfactory. The following analysis was furnished by the superintendent of the iron company:

	Per cent.
Carbonate of lime	94.51
Silica	2.60
Iron	1.05
Alumina	1.80
Sulphur	.028
Phosphorus	.076

Numerous analyses of this limestone show that it is of sufficient purity for the manufacture of cement, and abundant supplies are already available for that purpose. It could also be extensively used for road metal to the advantage of the roads of the quadrangle.

Freeport limestone.—This limestone is burned to some extent for use as a fertilizer in places where it is favorably exposed for quarrying. Its composition shows that it is generally suitable for making cement, but the supply is not sufficiently abundant and cheap to warrant the expectation that it will ever be used largely for that purpose. It might be used locally for road making, but it can not be regarded as an important economic factor in the quadrangle.

SANDSTONE.

The Pocono and Pottsville sandstones might yield an abundance of stone for coarse masonry along the Allegheny Valley and Mahoning and Redbank creeks, and the higher sandstones afford plenty of such material in other localities. So far as known to the writer, however, no quarrying on a commercial scale is done within the quadrangle.

May, 1904.

Coal analyses—Rural Valley quadrangle.

	Name of seam.	Locality.	Owner.	Analyst.	Fixed carbon.	Volatile hydrocarbons.	Moisture.	Ash.	Sulphur.	Phosphorus.	Total.	Color of ash.	Coke, per cent.	Character of coke.	Fuel ratio.
1	Lower Kittanning	Three-fourths mile east of Greendale	Rhea farm	A. S. McCreath (H5, p. 96)	52.032	38.205	.906	5.140	3.663		100.00	Reddish gray	60.835		1:1.36
2	Lower Kittanning	Mahoning	Mahoning Coal Company	A. S. McCreath (H5, p. 232)	49.686	42.550	1.180	4.585	1.999	.0061	100.0061	Pinkish gray	56.270		1:1.17
3	Upper Kittanning	Bostonia	Redbank Coal Company's mine	A. S. McCreath (H, p. 240)	46.194	30.490	.510	22.230	.576		100.00			Poor	1:1.51
4	Upper Kittanning	Bostonia	Cannel bench, analysis No. 1 (see sec. 23)	A. S. McCreath (H, p. 240)	49.815	31.680	.730	17.320	.435		100.980			Poor	1:1.54
5	Upper Kittanning	Bostonia	Cannel bench, analysis No. 2. Bituminous bench	A. S. McCreath (H, p. 240)	52.716	39.120	1.650	3.880	3.880			Brown	59.230		1:1.34
6	Upper Kittanning	Cathcart Run	Brooks bank, cannel shale at top (see sec. 24)	A. S. McCreath (H5, p. 180)	52.306	32.665	.640	13.345	1.044		100.000	Gray	66.695		1:1.60
7	Upper Kittanning	Little Mudlick Creek	Thompson's bank, upper bench, bituminous	A. S. McCreath (H5, p. 180)	52.575	37.930	1.120	6.705	1.388		100.00	Reddish gray	60.850		1:1.39
8	Upper Kittanning	Little Mudlick Creek	Middle bench, cannel	A. S. McCreath (H5, p. 180)	53.132	37.830	1.610	6.750	.678		100.00	Gray	60.560		1:1.40
9	Upper Kittanning	Little Mudlick Creek	Lower bench, bituminous	A. S. McCreath (H5, p. 180)	54.482	34.465	.810	9.655	.588		100.00	Gray	64.725		1:1.58
10	Upper Kittanning	Pine Furnace		A. S. McCreath (H5, p. 123)	58.301	34.185	1.820	4.705	.989		100.00	Cream	63.995		1:1.70
11	Upper Kittanning	Yatesboro	B. Schreckengost	A. S. McCreath (H5, p. 94)	53.224	34.270	.910	9.285	2.211		100.90	Gray			1:1.55
12	Lower Freeport	Mahoning Furnace		A. S. McCreath (H5, p. 161)	50.265	37.110	1.070	8.330	3.225	.0092	100.0092	Pinkish gray	61.820		1:1.35
13	Lower Freeport	Bostonia	Redbank Coal Company	A. S. McCreath (H5, p. 192)	53.960	35.940	1.690	5.040	3.380		100.00	Gray	62.370		1:1.50
14	Upper Freeport	Bostonia	Redbank Coal Company	A. S. McCreath (H5, p. 193)	53.661	35.940	1.840	6.820	1.739		100.00	Gray	62.220		1:1.49
15	Upper Freeport	Stewardson Furnace (Dee)		A. S. McCreath (H5, p. lxiv)	55.545	35.520	1.470	6.630	.835	.0684	100.0684	Yellowish gray	63.010		1:1.56
16	Upper Freeport	Mahoning Furnace	Colwell's mine	A. S. McCreath (H5, p. 160)	54.996	34.810	1.450	7.690	1.054		100.00	Gray	63.740	Tender	1:1.58
17	Upper Freeport	Mosgrove	Pittsburg Plate Glass Company		51.13	34.22	2.30	10.70	1.65		100.00				1:1.48
18	Upper Freeport	Yatesboro	Patterson's bank	A. S. McCreath (H5, p. 91)	53.569	36.995	1.020	5.775	2.461		99.820	Cream	61.985		1:1.45
19	Upper Freeport	Blanco	Beers bank	A. S. McCreath (H5, p. 92)	57.179	37.860	1.140	2.790	1.031		100.00	Cream	61.000		1:1.51

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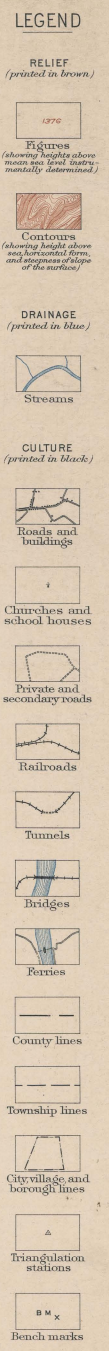
TOPOGRAPHY

PENNSYLVANIA
RURAL VALLEY QUADRANGLE



H.M. Wilson, Geographer in charge.
Triangulation by S.S. Gannett and E.L. McNair.
Topography by Frank Sutton, R.D. Cummin, and J.D. Forster.
Surveyed in 1901.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.

Edition of Dec. 1903, reprinted Feb. 1905.

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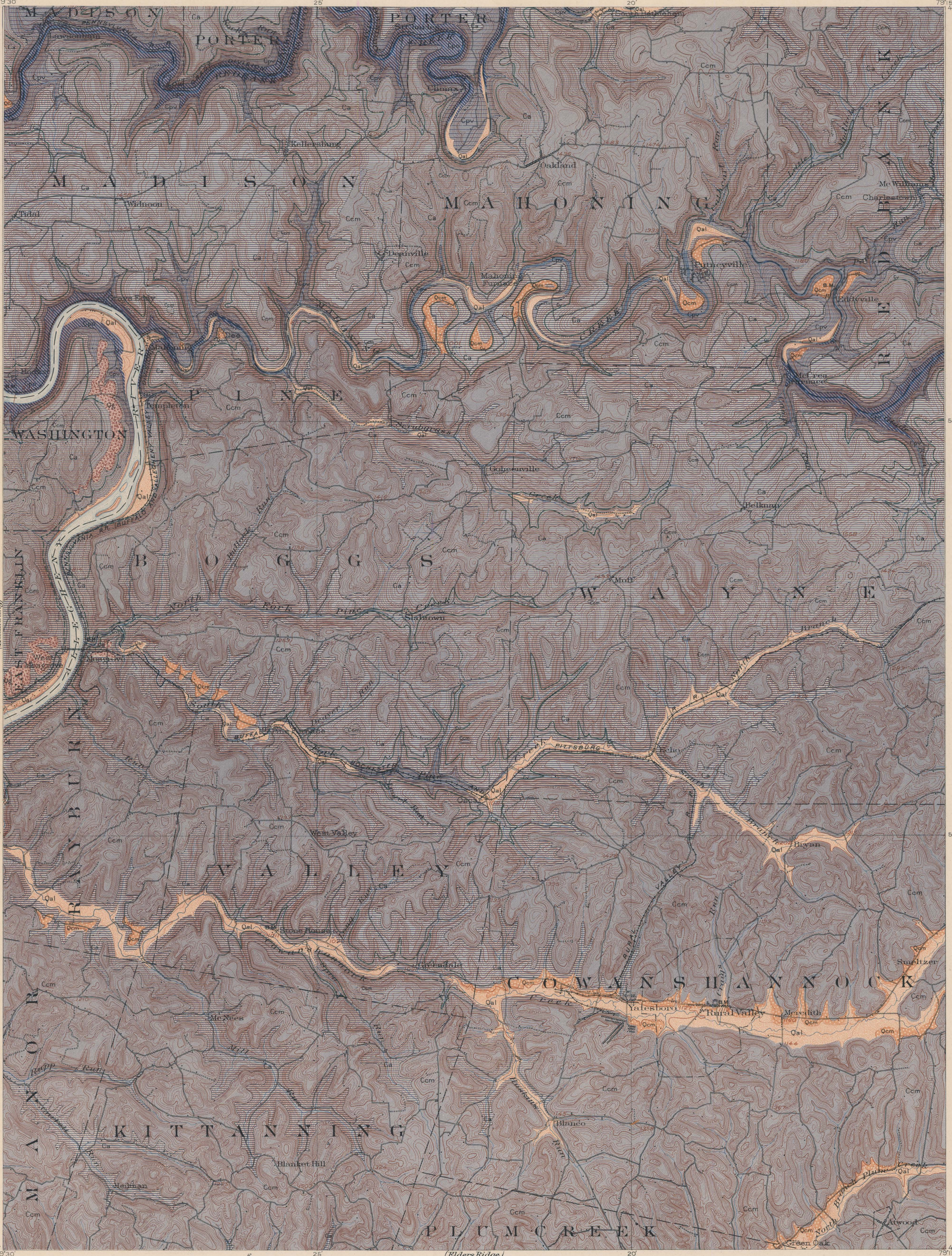
AREAL GEOLOGY

PENNSYLVANIA
RURAL VALLEY 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

Qg — Glacial gravel *(outwash gravel and silt of Kansan or pre-Kansan age)*

Qcm — Carmichaels formation *(gravel and silt of local derivation; Kansan or pre-Kansan age)*

CARBONIFEROUS

Pennsylvanian

Ccm — Conemaugh formation *(sandy shale and coarse sandstone with a few thin beds of limestone and coal, some red clay shale beds give color to the soil)*

Ca, Cv — Allegheny formation and Vanport limestone lentil *(shale with thin to massive sandstones and limestone lentil; several valuable beds of coal, fire clay, and iron ore; Upper Freeport coal at the top)*

Cpv — Pottsville formation *(coarse sandstone or conglomerate, sometimes massive, with shale and thin coal seams)*

Mississippian

Cpo — Pocono formation *(coarse massive sandstone with irregular beds of shale)*

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SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH. MAGNETIC NORTH. APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

Edition of May 1905

Geology by Charles Butts,
under the direction of Marius R. Campbell.
Surveyed in 1902.

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STRUCTURE AND ECONOMIC GEOLOGY

PENNSYLVANIA
RURAL VALLEY QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

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

Pleistocene

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Cpv — Pottsville formation *(coarse sandstone or conglomerate, sometimes massive, with shale and thin coal seams)*

Mississippian

Cpo — Pocono formation *(coarse massive sandstone with irregular beds of shale)*

Known productive formations

Coal outcrops *(continuous lines represent coal beds of workable or probably workable thickness; dashed lines, coals of possibly workable thickness)*

uf, *Upper Freeport coal*
lf, *Lower Freeport coal*
uk, *Upper Kittanning coal*
mk, *Middle Kittanning coal*
lk, *Lower Kittanning coal*
bv, *Brookville coal*

Structure contours drawn on the top of the Vanport limestone lentil *(contour interval is 50 feet, datum is mean sea level)*

Mines and quarries — *Coal mines, unless otherwise marked*

Oil wells
Gas wells
Dry wells, or product unknown

Sections of numbered wells are shown on well-section sheet

H.M. Wilson, Geographer in charge.
Triangulation by S.S. Gannett and E.L. McNair.
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SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH. MAGNETIC NORTH. APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

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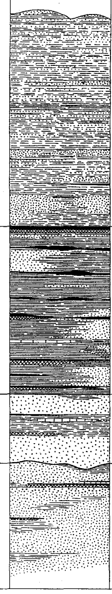
COLUMNAR SECTION

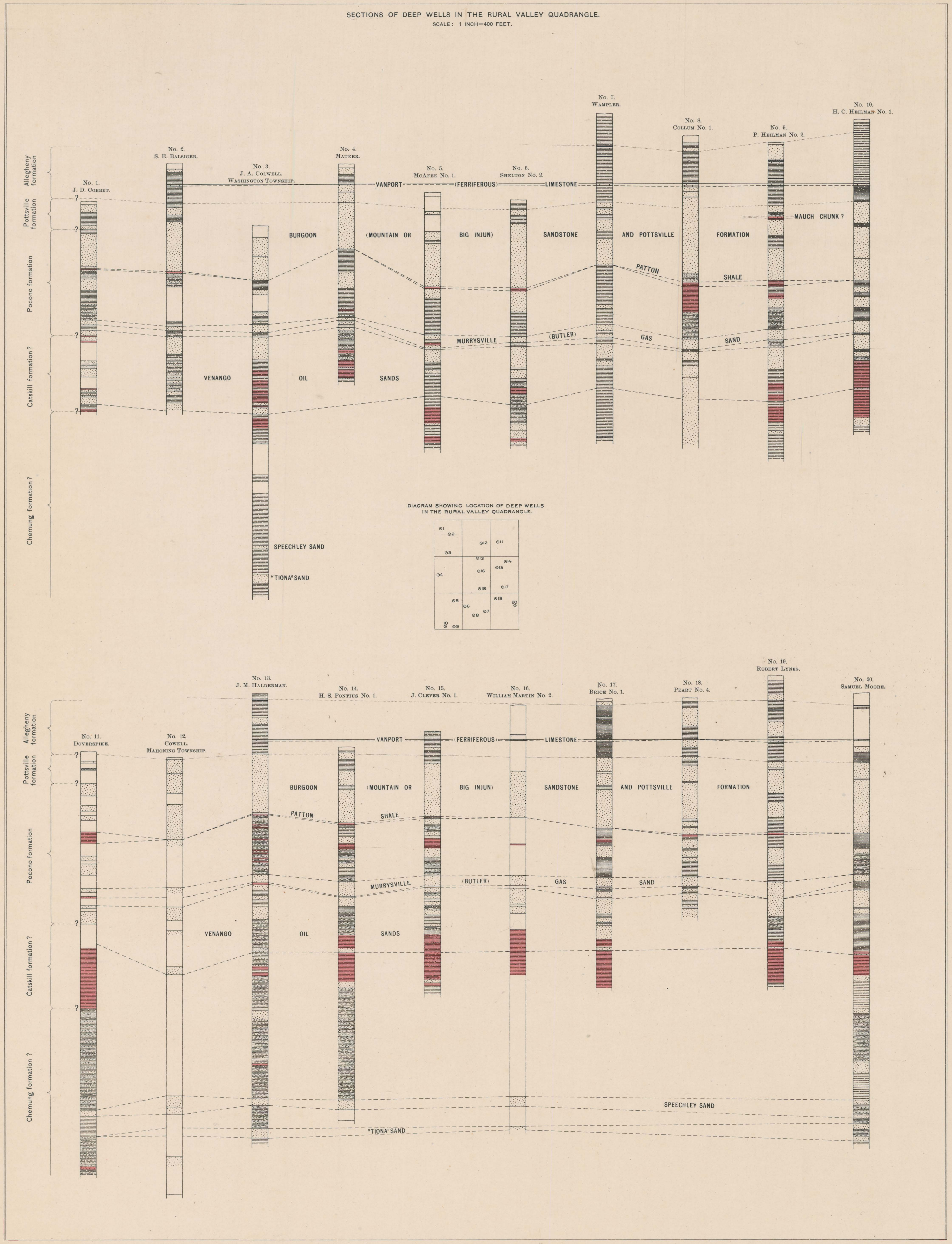
GENERALIZED SECTION FOR THE RURAL VALLEY QUADRANGLE.

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 Formation.
CARBONIFEROUS	PENNSYLVANIAN	Conemaugh formation.	Ccm		450	Morgantown ? sandstone.	Coarse; 10 to 20 feet thick. Southeast corner of quadrangle.	Shale and coarse sandstone with occasionally thin beds of limestone and coal. Most of the shale is sandy, but there are some prominent beds of green and red fine-grained clay shale which give a distinct color to the soil on their outcrop. The lower half of the formation is prevailingly sandy and carries several beds of coarse sandstone or conglomerate.
						Red shale.	0 to 20 feet thick. May consist of several thin beds locally in southern and eastern parts.	
						Saltsburg ? sandstone.	Soft, friable, and thin bedded; 0 to 20 feet thick.	
						Brush Creek coal.	Usually thin. Locally 2 feet 6 inches thick.	
						Mahoning sandstone.	Generally thin. Coarse and 40 feet thick in northeastern part.	
		Allegheny formation.	Ca		300-350	Upper Freeport coal.	Generally 3 to 4 feet thick	Shale, sandstone, fire clay, and coal beds. Shale predominates. Sandstone is generally thin bedded and shaly, but in places is coarse and massive. Several valuable coal beds. Fire clay is generally present and of great value. Iron ore and limestone valuable.
						Freeport limestone. Butler sandstone.	Limestone locally developed, 0 to 10 feet thick. Sandstone coarse and in lenses.	
						Lower Freeport coal.	Locally 2 feet 6 inches to 4 feet thick.	
						Freeport sandstone.	Coarse sandstone, locally developed, 0 to 30 feet thick.	
						Upper Kittanning coal.	Generally thin; thickens locally into pot-like deposits and known as "pot vein."	
						Middle Kittanning coal.	Generally thin. Locally 2 to 3 feet thick.	
						Lower Kittanning coal.	3 to 4 feet thick in western part. Generally thinner elsewhere.	
						Kittanning sandstone.	Lenses of coarse sandstone.	
						Vanport limestone.	Blue; 8 to 10 feet thick. Generally present and overlain by iron ore.	
						Clarion coal and clay.	Coal thin and worthless. Clay 0 to 6 feet thick and valuable.	
						Craigsville coal.	Thin and worthless.	
						Clarion sandstone.	Coarse and massive sandstone, locally developed, 0 to 25 feet thick.	
						Brookville coal.	Generally worthless. Locally workable.	
		Pottsville formation.	Cpv		140	Homewood sandstone.	Generally coarse; 20 to 30 feet thick.	Coarse, siliceous sandstone or conglomerate, sometimes massive, with intermediate shale carrying clay and coal.
						Mercer shale.	Shale with coal, limestone, and clay, 40 feet thick. Flint and plastic clay locally 8 to 13 feet thick and valuable.	
						Connoquenessing sandstone.	Coarse and heavy; 40 to 50 feet thick.	
		UNCONFORMITY						
	MISSISSIPPIAN	Pocono formation.	Cpo		225+	Burgoon (Mountain or Big Injun) sandstone.		Coarse, massive sandstone broken by shale. 300 to 400 feet thick. 225 feet exposed.

CHARLES BUTTS,
Geologist.

WELL SECTIONS



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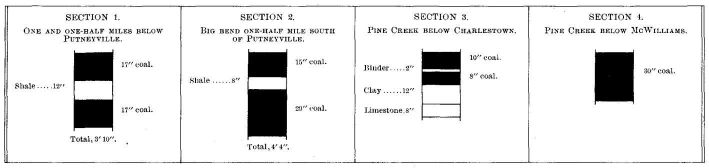
COAL SECTIONS

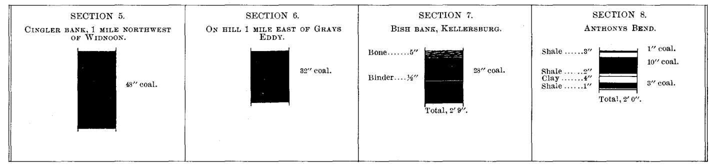
SECTIONS OF COAL SEAMS IN RURAL VALLEY QUADRANGLE.

SCALE: 1 INCH = 5 FEET.

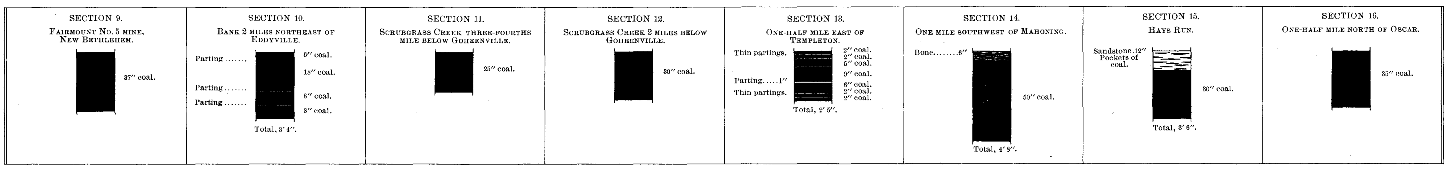
BROOKVILLE COAL.



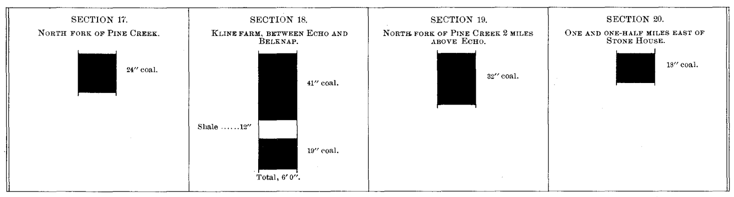
LOWER KITTANNING COAL.



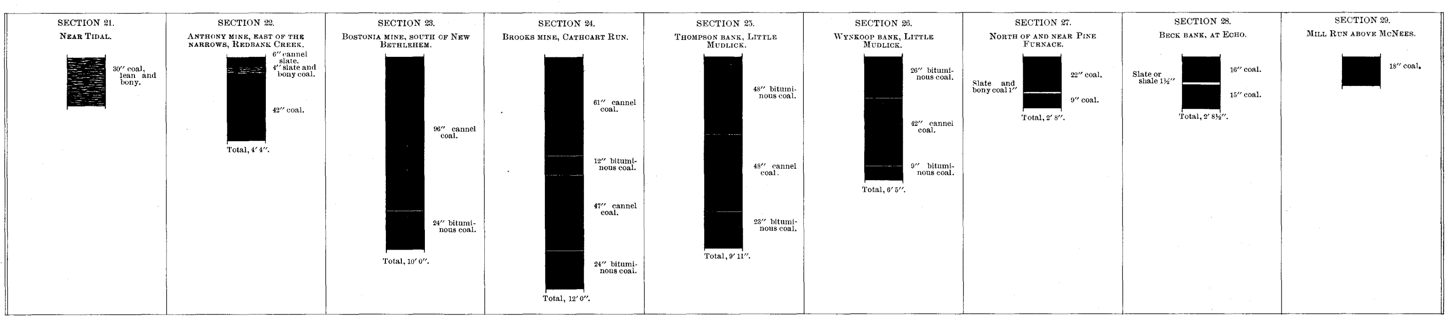
LOWER KITTANNING COAL.



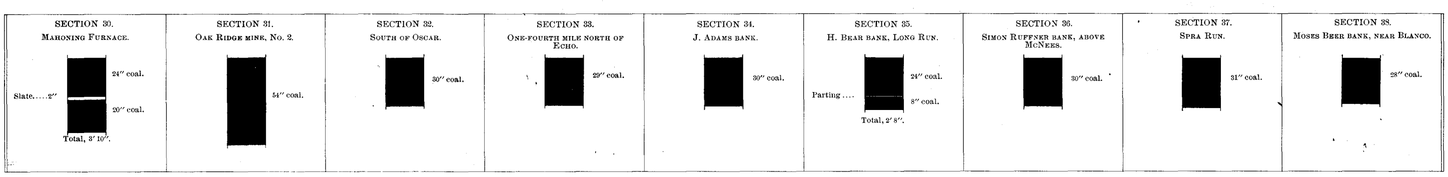
MIDDLE KITTANNING COAL.



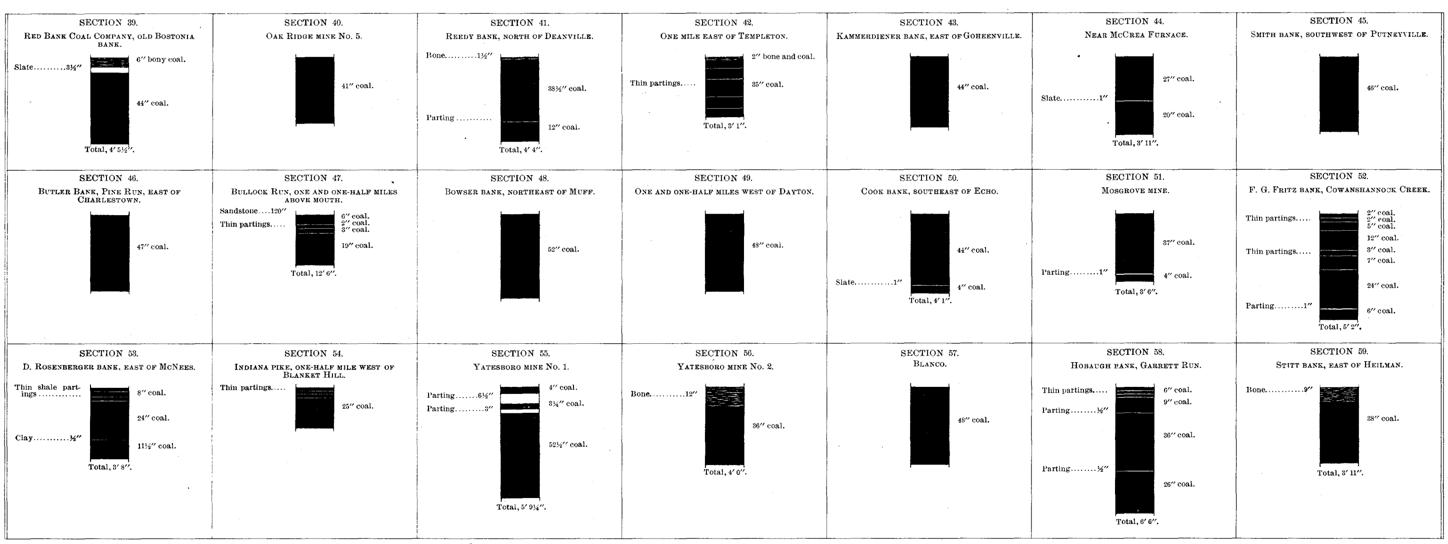
UPPER KITTANNING COAL.



LOWER FREEPORT COAL.



UPPER FREEPORT COAL.



CHARLES BUTTS,

Geologist.

ILLUSTRATIONS

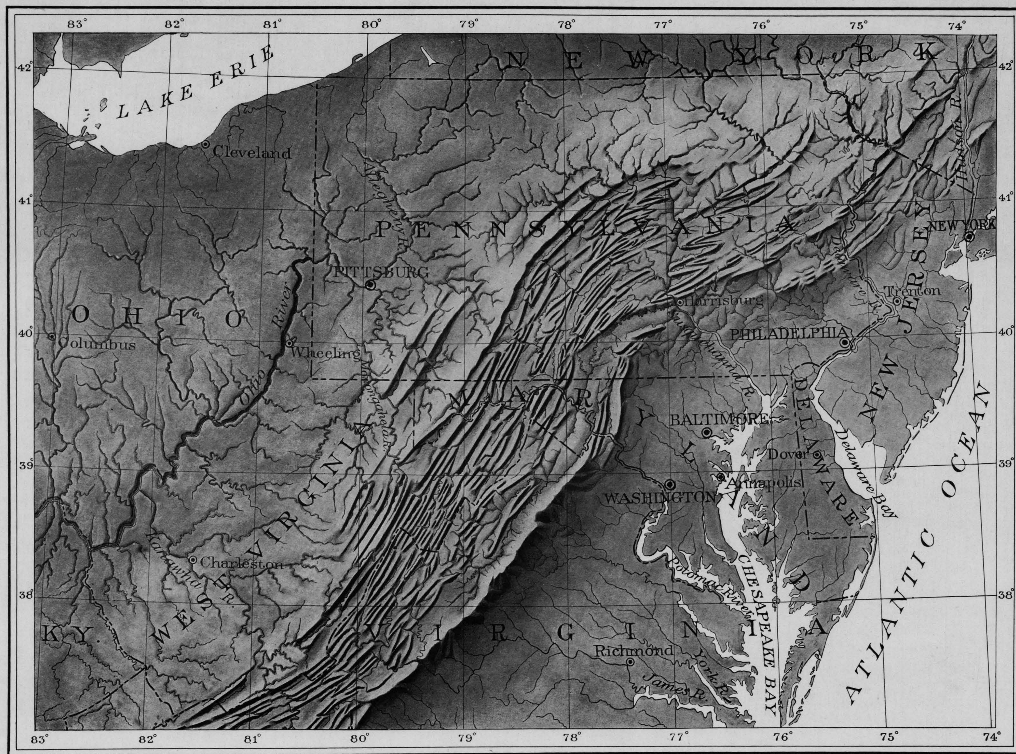


FIG. 6.—RELIEF MAP OF THE NORTHERN APPALACHIAN MOUNTAINS.

The Rural Valley quadrangle is situated on the plateau west of the belt of valley ridges, in the west-central part of Pennsylvania.

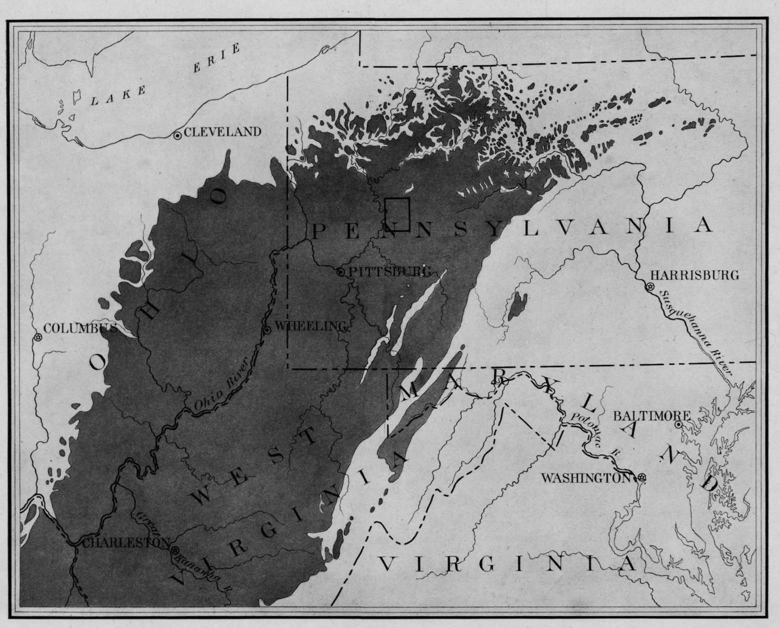


FIG. 7.—MAP SHOWING THE EXTENT OF THE NORTHERN PART OF THE APPALACHIAN COAL FIELD.

The position of the Rural Valley quadrangle within the field is shown by the rectangle.

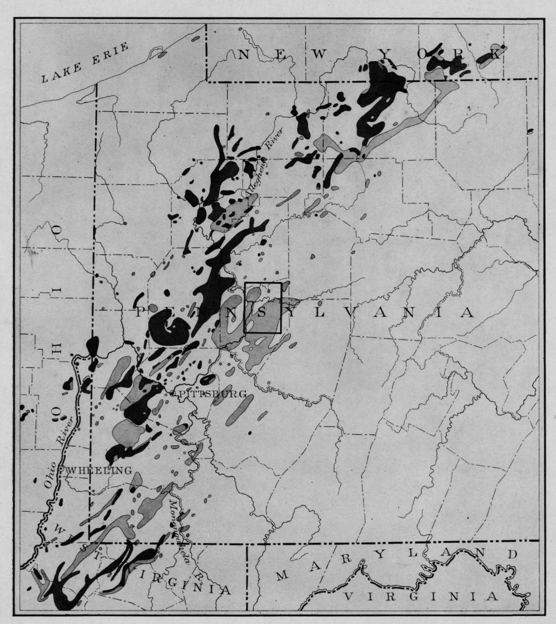


FIG. 8.—MAP SHOWING THE DISTRIBUTION OF THE GAS AND OIL POOLS IN WESTERN PENNSYLVANIA.

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

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34	Buckhannon	West Virginia	25
35	Gadsden	Alabama	25
36	Pueblo	Colorado	50
37	Downieville	California	25
38	Butte Special	Montana	50
39	Truckee	California	25
40	Wartburg	Tennessee	25
41	Sonora	California	25
42	Nueces	Texas	25
43	Bidwell Bar	California	25
44	Tazewell	Virginia-West Virginia	25
45	Boise	Idaho	25
46	Richmond	Kentucky	25
47	London	Kentucky	25
48	Tenmile District Special	Colorado	25
49	Roseburg	Oregon	25
50	Holyoke	Massachusetts-Connecticut	50
51	Big Trees	California	25
52	Absaroka	Wyoming	25
53	Standingstone	Tennessee	25
54	Tacoma	Washington	25
55	Fort Benton	Montana	25
56	Little Belt Mountains	Montana	25
57	Telluride	Colorado	25
58	Elmoro	Colorado	25
59	Bristol	Virginia-Tennessee	25
60	La Plata	Colorado	25
61	Monterey	Virginia-West Virginia	25
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70	Washington	D. C.-Va.-Md.	50
71	Spanish Peaks	Colorado	25
72	Charleston	West Virginia	25
73	Coos Bay	Oregon	25
74	Coalgate	Indian Territory	25
75	Maynardville	Tennessee	25
76	Austin	Texas	25
77	Raleigh	West Virginia	25
78	Rome	Georgia-Alabama	25
79	Atoka	Indian Territory	25
80	Norfolk	Virginia-North Carolina	25
81	Chicago	Illinois-Indiana	50
82	Masontown-Uniontown	Pennsylvania	25
83	New York City	New York-New Jersey	50
84	Ditney	Indiana	25
85	Oelrichs	South Dakota-Nebraska	25
86	Ellensburg	Washington	25
87	Camp Clark	Nebraska	25
88	Scotts Bluff	Nebraska	25
89	Port Orford	Oregon	25
90	Cranberry	North Carolina-Tennessee	25
91	Hartville	Wyoming	25
92	Gaines	Pennsylvania-New York	25
93	Elkland-Tioga	Pennsylvania	25
94	Brownsville-Connellsville	Pennsylvania	25
95	Columbia	Tennessee	25
96	Olivet	South Dakota	25
97	Parker	South Dakota	25
98	Tishomingo	Indian Territory	25
99	Mitchell	South Dakota	25
100	Alexandria	South Dakota	25
101	San Luis	California	25
102	Indiana	Pennsylvania	25
103	Nampa	Idaho-Oregon	25
104	Silver City	Idaho	25
105	Patoka	Indiana-Illinois	25
106	Mount Stuart	Washington	25
107	Newcastle	Wyoming-South-Dakota	25
108	Edgemont	South Dakota-Nebraska	25
109	Cottonwood Falls	Kansas	25
110	Latrobe	Pennsylvania	25
111	Globe	Arizona	25
112	Bisbee	Arizona	25
113	Huron	South Dakota	25
114	De Smet	South Dakota	25
115	Kittanning	Pennsylvania	25
116	Asheville	North Carolina-Tennessee	25
117	Casselton-Fargo	North Dakota-Minnesota	25
118	Greeneville	Tennessee-North Carolina	25
119	Fayetteville	Arkansas-Missouri	25
120	Silverton	Colorado	25
121	Waynesburg	Pennsylvania	25
122	Tahlequah	Indian Territory-Arkansas	25
123	Elders Ridge	Pennsylvania	25
124	Mount Mitchell	North Carolina-Tennessee	25
125	Rural Valley	Pennsylvania	25

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