DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

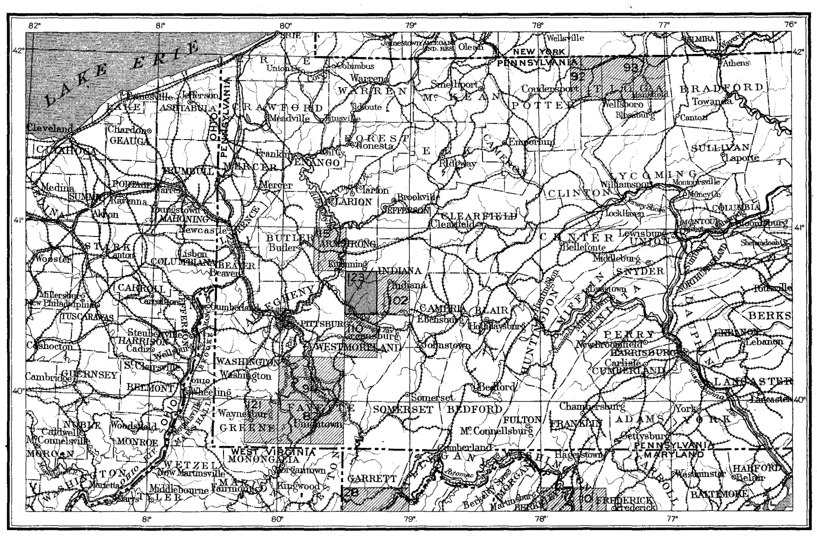
OF THE

UNITED STATES

ELDERS RIDGE FOLIO

PENNSYLVANIA

INDEX MAP



SCALE: 40 MILES=1 INCH

ELDERS RIDGE FOLIO

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ELDERS RIDGE FOLIO
NO. 123

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

1905

GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES.

The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

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

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

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map (fig. 1).

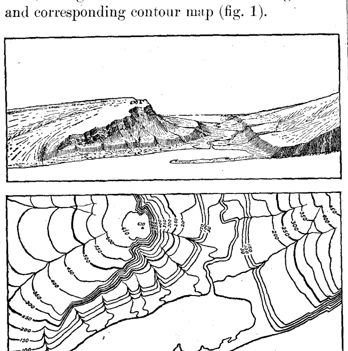


FIG. 1.—Ideal view and corresponding contour map.

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

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above sea; along the contour at 200 feet, all points that are 200 feet above sea; and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

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

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

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

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

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

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

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

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

The atlas sheets, being only parts of one map of the United States, disregard political boundary lines, such as those of States, counties, and townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic map.—On the topographic map are delineated the relief, drainage, and culture of the quadrangle represented. It should portray to the observer every characteristic feature of the landscape. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property; save the engineer preliminary surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

THE GEOLOGIC MAPS.

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

KINDS OF ROCKS.

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

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

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

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

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

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

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks, with reference to the sea, over wide expanses; and as it rises or subsides the shore lines of the ocean are changed. As a result of the rising of the surface, marine sedimentary rocks may become part of the land, and extensive land areas are in fact occupied by such rocks.

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

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

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

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

FORMATIONS.

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

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

AGES OF ROCKS.

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

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

(Continued on third page of cover.)

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

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

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

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

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

Symbols and colors assigned to the rock systems.

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

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

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

SURFACE FORMS.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

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

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

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

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

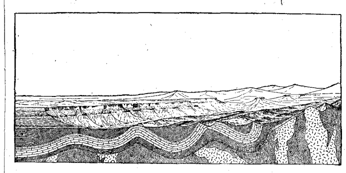


Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

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

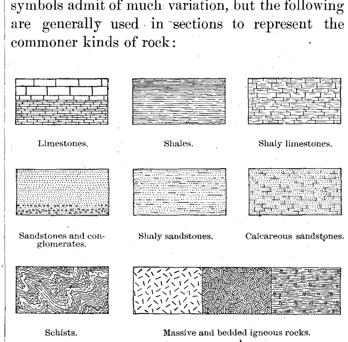


Fig. 3.—Symbols used in sections to represent different kinds of rocks.

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

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

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

On the right of the sketch, fig. 2, the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

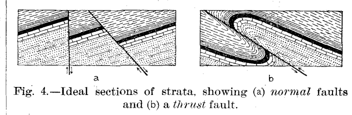


Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

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 ELDERS RIDGE QUADRANGLE.

By Ralph W. Stone.

INTRODUCTION.

LOCATION AND AREA.

The index map on the cover will show the reader that the Elders Ridge quadrangle is located in central-western Pennsylvania. Its limits are not determined by topographic features or political boundaries, but by geographic coordinates. It extends from latitude 40° 30′ on the south to 40° 45′ on the north, and from longitude 79° 15′ on the east to 79° 30′ on the west. It includes, therefore, one-sixteenth of a square degree of the earth's surface, and has an area of 227 square miles.

The quadrangle is about half in Armstrong and half in Indiana counties. The line bearing N. 36° E. which forms a portion of the boundary between the two counties extends from the northeast corner of the quadrangle to Kiskiminitas River in the southwest corner. The portion of the quadrangle that lies south of the river—about 5 square miles—is a part of Westmoreland County.

RELATION TO APPALACHIAN PROVINCE.

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

Appalachian province.—With respect to the topography and the attitude of the rocks, the Appalachian province may be divided into two nearly equal parts by an eastward-facing escarpment called the Allegheny Front (see fig. 1).

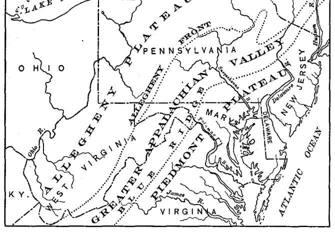


FIG. 1.—Diagram of northern portion of the Appalachian province, showing physiographic divisions.

From Pennsylvania to Alabama this separates the Allegheny Plateaus on the west from the Greater Appalachian Valley on the east. It is not a well-developed feature along the whole line, but is especially prominent in parts of Pennsylvania and Tennessee.

The general topographic features of the northern part of the province are well illustrated by fig. 3, on the illustration sheet. East of the Allegheny Front the topography consists of alternating ridges and valleys, designated the Greater Appalachian Valley, and of a slightly dissected upland like the Piedmont Plain of eastern North Carolina and Virginia. West of the Allegheny Front are more or less elevated plateaus, broken by a few ridges where minor folds have affected the rocks, and greatly dissected by streams. In contradistinction to the lowlands of the Mississippi Valley, still farther west, and the regularly alternating ridges and valleys of the Appalachian Valley, this part of the province has been called by Powell (Nat. Geog. Mon. No. 3, pp. 65–110) the Allegheny Plateaus. The Elders Ridge quadrangle is within the western portion of the Allegheny Plateaus.

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

ALLEGHENY PLATEAUS.

GEOGRAPHY.

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

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

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

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

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

The surface of the high Cumberland Plateau slopes to the west, but it is usually separated from the next lower or Highland Plateau by a generally westward-facing escarpment. This escarpment is most pronounced in Tennessee, where it has a height of 1000 feet. Toward the north the escarpment diminishes in height, having an altitude of 500 feet in central Kentucky, while north of Ohio River it is so indistinctly developed that it has not been recognized. In southern Pennsylvania it becomes more pronounced where the hard rocks of Chestnut Ridge rise abruptly above the plain formed on the soft rocks of the Monongahela Valley, but the surface of the uppermost plateau is so greatly dissected that it can be recognized only with difficulty. Toward the central part of the State the plateau surfaces that are usually separated by this escarpment seem to approach each other and the escarpment is lost in a maze of irregular hills which represent all that remains of the higher plateau.

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

The surface features of this plateau are variable, but there is not so much diversity as in the higher plateau. In Kentucky and Tennessee it is preserved in large areas as a nearly featureless plain, but in other States it was less perfectly developed, and has suffered greatly from dissection since it was elevated.

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

GEOLOGY OF THE PLATEAUS.

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

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

Structure of Appalachian coal field.—The geologic structure of the Appalachian coal field is very simple, consisting, in a general way, of a broad, flat, canoe-shaped trough. The deepest part of this trough lies along a line extending southwest from Pittsburg across West Virginia to Huntington on Ohio River. Toward this line the rocks dip from both sides of the trough. About the canoe-shaped northern end the rocks outcrop in a rudely semicircular line and at all points dip toward the lowest part of the trough.

In Pennsylvania the deepest part of the trough is situated in the southwest corner of the State, and the inclination of the rocks is generally toward that point.

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

STRATIGRAPHY.

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

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

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

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

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

Conemaugh formation.—The name Conemaugh, taken from the river along which the rocks outcrop, is applied to the formation which was formerly known as the Lower Barren measures on account of its stratigraphic position and the absence in it of workable coals. In some parts of Pennsylvania workable coals of limited extent do occur, however, and sometimes they are accompanied by thin limestone. The great mass of the formation is composed, however, of a succession of shale, mostly sandy, and sandstone strata. The sandstone strata are variable in thickness and occurrence. In some regions there may be scarcely any sandstone from the bottom to the top of the formation. In such cases the formation is composed almost wholly of shale, without any distinctive and traceable beds whatever. The total thickness of the Conemaugh varies from 550 to 700 feet.

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

Dunkard group.—This group of rocks was formerly known as the Upper Barren measures and later as the Dunkard formation. It lies above the Monongahela formation and includes the highest rocks of the Carboniferous system found in this area. It has a thickness in the southwest corner of Pennsylvania of about 1100 feet, and consists mainly of shale and sandstone, though it contains beds of coal and limestone. Some of the coals are locally workable, but they are generally worthless. In the Waynesburg folio these rocks were divided into two formations, the Washington and the Greene. In the Washington are included the rocks from the Waynesburg coal to and including the Upper Washington limestone, and in the Greene all higher rocks. It is doubtful whether the divisions into these two formations can be carried beyond the boundaries of the State, so that in Ohio and West Virginia these uppermost rocks of the Carboniferous system will be known simply as the Dunkard formation. They occupy an area in southwestern Pennsylvania and along Ohio River in West Virginia and Ohio similar in shape to the Monongahela formation, but of less extent. The Dunkard group is not represented in the Elders Ridge quadrangle.

TOPOGRAPHY OF THE QUADRANGLE.

GENERAL RELATIONS.

The Cretaceous (Schooley) peneplain of the Allegheny Plateaus, as described above, is not represented in the quadrangle. The degradation of the surface has gone so far that no traces of it remain. There is some evidence, however, of the Tertiary or Harrisburg peneplain. Careful study of the topographic map shows that many drainage divides and flat-topped ridges throughout the greater part of the quadrangle have a common altitude of about 1340 feet. This general level falls to about 1300 feet on the hills close to Crooked Creek. Traces of it occur at the same level near Kiskiminitas River, but on account of the broader erosion of the major stream they are not conspicuous features. The greater portion of this peneplain, apparent in this area, is along the Roaring Run and Jacksonville anticlines.

SURFACE RELIEF.

The highest point in this quadrangle is Watts Hill, in Armstrong Township, Indiana County. Its top is 1620 feet above sea level, or nearly 300 feet higher than the road corners at Parkwood. The point of least elevation is on Kiskiminitas River below Salina, where the stream passes beyond the limits of this quadrangle. The level of the water here is about 825 feet above tide. Crooked Creek has nearly the same elevation where it crosses the edge of the quadrangle a few miles to the north.

The Elders Ridge quadrangle is hilly. For this reason roads find better grades along the valleys than on the higher land, although some highways o the divides have easy grades for several miles. Because a large portion of the surface of the region is underlain by the rocks of one formation, and they vary but little from place to place, there is not much change in the character of the surface relief.

A close examination of the topographic map shows that throughout much of this quadrangle there are, at an elevation of a little over 1200 feet, numerous comparatively level areas and stream-divide saddles. Examples of these points are the flat top of a Y-shaped hill a mile northwest of Brick Church, the plateaus of Elderton, Nowrytown, and north of West Lebanon, and the flat tops of the ridges near Clarksburg. These points are supposed to be the remnants of a plain which was incompletely developed during a pause in crustal movements after the Tertiary peneplain mentioned in a preceding paragraph had been elevated about 100 feet. Although the development of a peneplain was far from complete, this stage in the evolution of the present topography has been called the Kittanning peneplain. The name is taken from a city on Allegheny River, near which the plain is broad and well defined. The plain naturally was most level along the main drainage lines and increased in elevation and unevenness toward the divides. There were many low hills still standing above the generally level, broad valley floors, however, when the region was again elevated and the dissection of this plain began. Among the unreduced areas are the comparatively level fields at Spring Church and south of Marshall Run between Conemaugh Church and Lewisville, which owe their undissected character, in part at least, to the heavy sandstone (Saltsburg) which underlies the surface at these places.

The present course of Crooked Creek presents a further argument for the presence of a broad plain in this region at some former time before the valley had been cut to its present depth. The creek meanders broadly in the manner of a sluggish stream flowing over a surface of very low grade. It is believed that this meandering course was developed on the Harrisburg or Kittanning peneplain, probably the former, and is therefore antecedent to the present topography. It seems doubtful that the Kittanning plain was broad enough for so sluggish a stream, and hence the age of this course is referred to the earlier and more completely developed Harrisburg peneplain.

The crustal movement which interrupted the Kittanning peneplain continued until the surface had been elevated more than 200 feet. The streams deepened their channels continuously until elevation ceased for a time and they began to broaden their valley floors. The results of this quiescence and widening of channels are seen in the rock-cut terraces which appear as level areas at an elevation of about 1000 feet and which are covered by terrace deposits, as shown on the areal geology map. This feature in the topography is conspicuous as a broad flat on Kiskiminitas River at Avonmore, and on Crooked Creek at a number of points near Cochran Mills, South Bend, and Idaho. Above Idaho, on Crooked and Plum creeks, the broad floor developed at this earlier period gradually merges with the flood plain of the present stream. In other words, the two streams above Idaho have cut but little below the flood plain of the former stage since its elevation. These terraces are correlated with the Parker "strath," or gradation plain, described in the Kittanning folio.

Since the elevation of the 1000-foot floor the creek, in deepening its channel, abandoned its course at a point just below Cochran Mills for a straighter one. This short, curved valley is not conspicuous on the topographic map, but is very apparent when viewed on the spot.

Another minor feature of interest is a terrace at an elevation of 1080 feet on the north side of Crooked Creek west of the "Loop." Well-rounded pebbles found on its surface indicate its origin by stream cutting. It is probable that this shelf represents a short stage of valley-floor broadening between the Kittanning and Parker episodes.

When the Parker strath had been elevated about 100 feet and the main streams had deepened their channels that much, movement of the earth's crust ceased for a time and the new valley floor was broadened. This process destroyed much of the floor of the Parker strath, leaving only occasional disconnected areas, but it formed a lower strath, which is named the Ford City strath from its development at that place on Allegheny River. More recent elevation has induced the streams again to cut their channels deeper, and the remnants of the Ford City strath are now found at an elevation of 900 to 920 feet above tide.

DRAINAGE.

The drainage system of this quadrangle is developed to such an extent that streams penetrate all parts of the area. The main streams are still cutting rapidly and not building extensive flood plains. As is the case throughout much of western Pennsylvania, they are liable to floods, due to occasional heavy precipitation and to stripping of the former forest.

All of the drainage is tributary to Allegheny River. The streams are so small that none is navigable, not even for rowboats, except on short stretches. The largest is Kiskiminitas River, which is formed by the junction of the Conemaugh and Loyalhanna at Saltsburg, about 3 miles south of the border of the quadrangle. The Kiskiminitas crosses the southwest corner of the quadrangle, flowing due north for 2 miles and then west past Avonmore and Salina, about $5\frac{1}{2}$ miles in all. It empties into the Allegheny near Freeport.

The main tributary of the Kiskiminitas in the region under discussion is Blacklegs Creek, which rises in the country about West Lebanon and Parkwood and flows in a direct course to its mouth $1\frac{3}{4}$ miles south of Edri, near the American Sheet Steel Company's plant. Marshall, Hooper, Whisky, and Harper runs are the principal branches of Blacklegs Creek.

Crooked Creek is the second largest stream in the quadrangle. It flows westward across the northern half of the quadrangle, in a course which its name describes. From Shelocta to South Bend, a village located almost in the center of the quadrangle, the stream flows through an open valley; but from South Bend to the western border it cuts a considerable gorge, making steep, rocky bluffs, in some places over 250 feet high.

The north and south branches of Plum Creek enter the quadrangle from the northeast and unite to form Plum Creek. This stream is increased by the waters of Dutch Run and joins Crooked Creek about a mile above Idaho. Cherry Run enters Crooked Creek at Cochran Mills, between banks which rise abruptly to a height of 300 to 400 feet, and brings its waters from Burrell, Kittanning, and Plumcreek townships.

The arrangement of the drainage in this quadrangle is an interesting feature. It will be noticed that the south-flowing streams in general are much longer than the north-flowing. The divide between the Kiskiminitas and Crooked Creek basins is so close to the latter stream that Long Run, flowing south, is about 6 miles long, while Lindsay Run, flowing north, is only 2 miles long. An adequate explanation of this unsymmetrical arrangement of basins, which has been noted in other quadrangles in western Pennsylvania, has not been found.

RELATION OF TOPOGRAPHY TO MAN'S ACTIVITIES.

Of the thirty or more hamlets in the Elders Ridge quadrangle, only a little more than half are on the banks of streams; the others are on the uplands. The reason for the location of some of these settlements is apparent. Cochran Mills, for instance, is at the confluence of two streams along which are main lines of travel and is also the site of excellent water power. It is in a deep gorge, however, where there is room for only a few houses. The location of West Lebanon, 1300 feet above sea level, on the top of a hill, may have been due to the opening of a 7-foot bed of coal (Pittsburg) in the ravines which head around the hill.

Crooked Creek carries a sufficient volume of water to furnish power for a number of mills. It falls 130 feet from Shelocta to Cochran Mills, a distance of nearly 18 miles as the stream flows; this furnishes enough head for water power at frequent intervals. Dams have been built at Cochran Mills, South Bend, and Idaho to run gristmills.

Roads for the most part are along the stream valleys, where the grade is easy. The longest stretches of stream-grade roads are along Blacklegs Creek, Crooked Creek above Girty, Plum Creek, and Cherry Run. Ridge roads are common and in some cases good. The road from West Lebanon to Spring Church is conspicuous on the topographic map for its directness and comparative levelness.

DESCRIPTIVE GEOLOGY.

STRUCTURE.

The rocks of the Elders Ridge quadrangle are bent into a number of nearly parallel wrinkles or folds which have a northeast-southwest trend. In describing these folds the upward-bending arch is called an anticline and the downward-bending trough is called a syncline. The axis of a fold is that line which at every point occupies the highest part of the anticline or the lowest part of the syncline, and from which the strata dip in an anticline and toward which they dip in a syncline.

METHOD OF REPRESENTING GEOLOGIC STRUCTURE.

The geologic structure is represented here, as in other folios in which the bituminous coal field of western Pennsylvania is described, by contour lines showing the position of some particular stratum which is known through its wide outcrop, its exploitation by mines, its relation to some other bed above it, or through the records of wells drilled for oil and gas. These contour lines show the form and size of the folds into which the deformed surface of the key stratum has been thrown and its altitude above sea level at practically all points.

In this quadrangle the Upper Freeport coal bed is a widely outcropping and well-known stratum, and is used by drillers in some fields as a key rock in determining the position of the oil- and gas-bearing sands. The floor of the coal has been selected as the surface by which to represent the geologic structure of the quadrangle.

Where the Upper Freeport coal shows in natural outcrop its altitude has been determined at many points. Where it occurs below the surface its existence and position are known through the records of the gas wells of the region. After its altitude has been determined at a great many places, points of equal altitude are connected by contour lines; as, for example, all points having an altitude of 900 feet above sea level are connected by a line, which then becomes the 900-foot contour. Similarly, all points having an altitude of 950 feet are connected by the 950-foot contour line, and, in like manner, contour lines are drawn representing vertical distances of 50 feet throughout the mapped area. These lines are printed on the structure and economic geology map, and show, first, the horizontal contours of the troughs and arches; second, the dip of the beds; and, third, the approximate height of the Upper Freeport coal above sea level.

The depth of the reference stratum below the surface at any point is obtained by subtracting its elevation, as shown by the structure contour lines, from the elevation of the surface at the same point. Suppose, for instance, the position of the Upper Freeport coal is desired at Parkwood. It will be seen by the map that the elevation of the surface at the road corners is 1325 feet, and that the 800-foot structure contour line passes through the place. The Upper Freeport coal, therefore, is here about 1325 minus 800 feet, or about 525 feet below the surface.

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

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

DETAILED GEOLOGIC STRUCTURE.

The general structural features of the Indiana, Rural Valley, Elders Ridge, and Latrobe quadrangles are shown in the accompanying figure. In the Elders Ridge quadrangle these have the same southwest-northeast strike that characterizes the whole Appalachian province. The folds in the rocks underlying this part of Indiana and Armstrong counties were recognized by Platt and described by him in Reports H4 and H5 of the Second Geological Survey of Pennsylvania. The strongest features are three anticlines and two synclines. These axes are named from localities where they are strongly developed or from places near which they pass. The first of these in this quadrangle, taking them in the order in which they occur from east to west, is the Jacksonville anticline, which passes near Lewisville and Jacksonville (Kent post-office). The next is the Elders Ridge syncline, which brings the Pittsburg coal down so that it lies in the hills under several square miles of this territory. The Roaring Run anticline parallels this syncline on the west for a short distance, but is broken up in the middle of the quadrangle. On the west of the Roaring Run anticline is a basin which is not strongly developed on Crooked Creek, but becomes more pronounced to the north and may be known as the Apollo syncline. The lower end of the strong anticline which has been mapped across the Rural Valley quadrangle and is known there as the Greendale anticline crosses the northwest corner of this quadrangle.

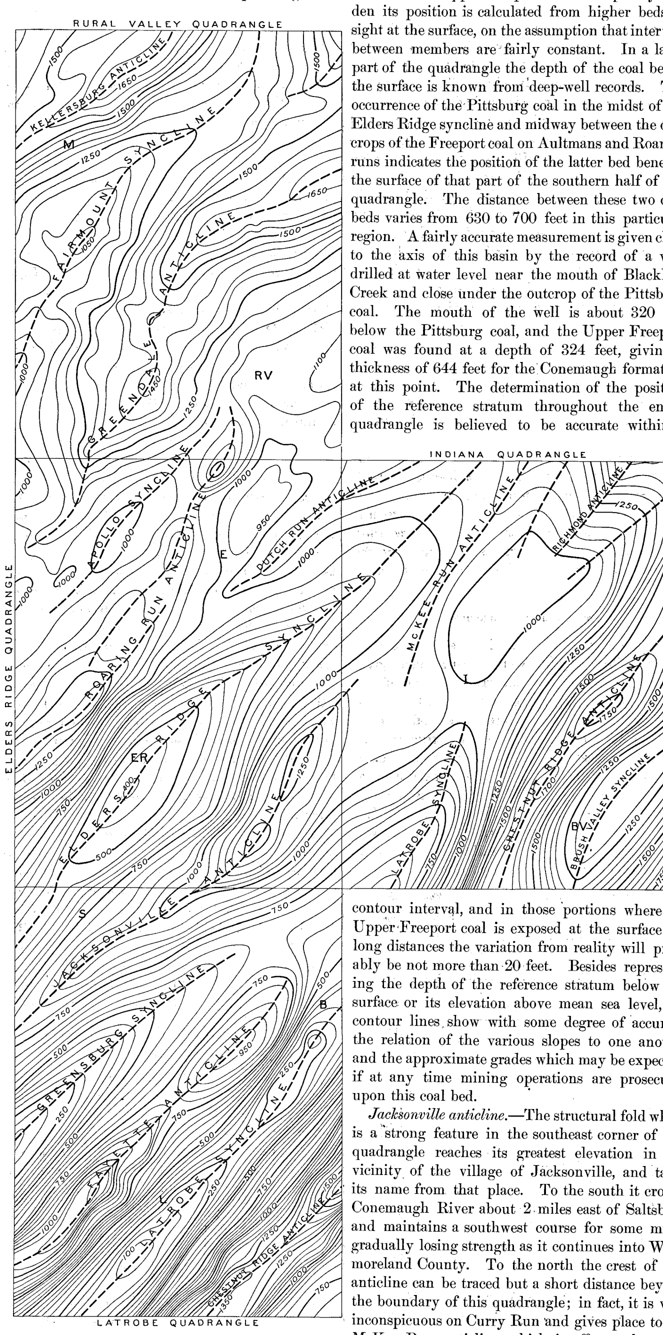


Fig. 2.—Sketch map showing geologic structure of Rural Valley, Elders Ridge, Indiana, and Latrobe quadrangles by means of contour lines drawn on Upper Freeport coal. Contour interval, 50 feet.

M, Mahoning; RV, Rural Valley; E, Elderton; ER, Elders Ridge; I, Indiana; BV, Brush Valley; S, Saltsburg; B, Blairsville; L, Latrobe.

These folds and basins in the rock structure are represented on the structure and economic geology map by contour lines drawn on the floor of the Upper Freeport coal, with a vertical interval of 50 feet. This coal, which is used as a reference horizon, outcrops for a number of miles on Aultmans Run and in the region north of Jacksonville, on Plum Creek, Dutch Run, Roaring Run, and on Crooked Creek, in disconnected stretches as the rolls in the structure bring it above or carry it below the water level. In the northwest quarter of the quadrangle the coal is so high above water level that it outcrops for many miles along most of the tributaries of Crooked Creek.

Where the Upper Freeport coal is completely hidden its position is calculated from higher beds in sight at the surface, on the assumption that intervals between members are fairly constant. In a large part of the quadrangle the depth of the coal below the surface is known from deep-well records. The occurrence of the Pittsburg coal in the midst of the Elders Ridge syncline and midway between the outcrops of the Freeport coal on Aultmans and Roaring runs indicates the position of the latter bed beneath the surface of that part of the southern half of the quadrangle. The distance between these two coal beds varies from 630 to 700 feet in this particular region. A fairly accurate measurement is given close to the axis of this basin by the record of a well drilled at water level near the mouth of Blacklegs Creek and close under the outcrop of the Pittsburg coal. The mouth of the well is about 320 feet below the Pittsburg coal, and the Upper Freeport coal was found at a depth of 324 feet, giving a thickness of 644 feet for the Conemaugh formation at this point. The determination of the position of the reference stratum throughout the entire quadrangle is believed to be accurate within a contour interval, and in those portions where the Upper Freeport coal is exposed at the surface for long distances the variation from reality will probably be not more than 20 feet. Besides representing the depth of the reference stratum below the surface or its elevation above mean sea level, the contour lines show with some degree of accuracy the relation of the various slopes to one another and the approximate grades which may be expected, if at any time mining operations are prosecuted upon this coal bed.

Jacksonville anticline.—The structural fold which is a strong feature in the southeast corner of this quadrangle reaches its greatest elevation in the vicinity of the village of Jacksonville, and takes its name from that place. To the south it crosses Conemaugh River about 2 miles east of Saltsburg and maintains a southwest course for some miles, gradually losing strength as it continues into Westmoreland County. To the north the crest of this anticline can be traced but a short distance beyond the boundary of this quadrangle; in fact, it is very inconspicuous on Curry Run and gives place to the McKee Run anticline, which is offset a short distance to the east. The Freeport coal on the crest of this anticline in the vicinity of Jacksonville is about 1280 feet above sea level. From here it falls rapidly to the west, so that the Pittsburg coal, which is stratigraphically from 630 to 700 feet above it, is found at the same elevation above tide on the west side of the valley of Blacklegs Creek.

Elders Ridge syncline.—The Elders Ridge syncline was described and accurately located by the Second Geological Survey of Pennsylvania under the name Lisbon-West Lebanon syncline. This name, however, has been abandoned for a shorter one taken from a small village in the center of this basin and located almost on the axis. The Elders Ridge syncline has been traced across Indiana County from Plum Creek; it dips gradually to the south. Where the axis enters the Elders Ridge quadrangle, 3 miles east of Shelocta, the reference stratum is 900 feet above sea level. From here it falls gradually to a point between Elders Ridge and Big Run where the Upper Freeport coal is not more than 400 feet above sea level. South of Big Run the axis rises fully 150 feet before it reaches the southern edge of the quadrangle. It crosses Kiskiminitas River near Edri and pursues a comparatively direct course northeast through Elders Ridge near the academy, passes one-half mile west of West Lebanon, and in the valley of Gobblers Run turns sharply to the east, so that it lies fully a mile south of Shelocta. It is by reason of this syncline that the small area of Pittsburg coal is caught on the hills. Westward from this axis the rocks rise more rapidly than to the east, and the Upper Freeport coal appears again on Roaring Run and Crooked Creek. From the description it will be seen that the Elders Ridge syncline is a canoe-shaped basin, and within the limits of this quadrangle is shallow at both ends and deepens toward the middle.

Roaring Run anticline.—In the report of the Second Geological Survey of Pennsylvania on Armstrong County, Mr. Platt describes an anticlinal axis which crosses Kiskiminitas River at the mouth of Roaring Run and follows the course of that stream northeastward to Shady Plain and Elderton. He maintained that it was the Waynesburg (Bellevernon) anticline of Greene County and described it as a continuation of the same, although he used the local term in his report. The present Survey does not feel justified in correlating these axes before the intervening territory is mapped. This axis, as traced by the writer, enters the quadrangle a little to the east of Roaring Run, but strikes into the stream toward its headwaters and passes directly through Shady Plain. On Crooked Creek in the vicinity of Girty there are two axes of about equal strength, and they seem to indicate that the Roaring Run anticline has a slight wrinkle on its crest for a short distance north of Shady Plain. The anticline decreases somewhat in height toward the north. The easternmost axis brings the Vanport limestone above water level about three-quarters of a mile east of Girty, and the westernmost crosses Crooked Creek near the neck of the "Loop," and also brings the limestone to daylight. Since the depth of the wrinkle between these two axes probably is less than 50 feet and the Roaring Run anticline as a whole continues northward beyond the boundary of the quadrangle, it is not deemed necessary to apply a new name in Plum Creek Township, although Platt did so, calling the western axis the Fagley Run anticline. The numerous openings on the Upper Freeport coal in this vicinity give frequent elevations on the reference stratum, and also the dip of the rocks, and from this it has been determined that the western axis is the stronger in the highlands between Elderton and Cherry Run. At this point the crest of the anticline rises again slightly, but falls off to the north and reaches its lowest point in the vicinity of the Say farm, 3 miles northwest of Elderton. The Roaring Run anticline continues a northeast course, and on the northern boundary of this quadrangle changes abruptly to a marked dome, the southern half of which is shown on the structure and economic geology map. This dome marks the extreme northern development of this anticline and terminates 2 miles north of the boundary line of this quadrangle and about 2 miles east of Blanco, in Cowanshannock Township. The position of the Upper Freeport coal in the northern part of the quadrangle, where the seam is below the surface, is determined by a number of deep-well records, and is probably accurate within a contour interval.

Dutch Run anticline.—North of the Elders Ridge syncline and east of the Roaring Run anticline in Indiana County there is a low structural fold which has enough strength to raise the

Upper Freeport coal just above water level along the lower courses of Dutch Run and Plum Creek. The axis of this fold crosses the South Branch of Plum Creek, three-quarters of a mile east of the Armstrong–Indiana county line and crosses Dutch Run about the same distance west of Advance. It pursues a direct course to Plum Creek, paralleling Dutch Run for 3 miles, and crosses the former stream a mile above its mouth.

This axis was called the Roaring Run anticline in the Indiana folio under the misapprehension, on the part of the present writer, that the fold extended from Plum Creek to Crooked Creek and was a part of the axis seen on Roaring Run. The records of a number of wells obtained in this territory after the Indiana folio had been completed showed that the axis terminates 2 miles north of Idaho.

Although this fold is nearly parallel with the northeast portion of the Elders Ridge syncline and falls in line with that part of the Roaring Run anticline which lies south of Crooked Creek, it can not be considered as a part or a spur of the latter fold, for the reason that the axis of the Dutch Run anticline plunges toward the much higher flank of the Roaring Run anticline. The name Dutch Run is taken from the stream which the anticline mostly follows.

There is a synclinal basin north of Elderton and Gastown which is not considered to be a sufficiently important feature to receive a name. It assumes a a very irregular shape in the Rural Valley quadrangle and is nameless there.

Apollo syncline.—This name is applied to a basin which is described by Mr. Platt as crossing Kiskiminitas River under the village of Apollo, and extending northeastward across Crooked Creek at Cochran Mills. Although the structural feature has not been traced southward to prove the connection with the basin which is seen on Kiskiminitas River, it is assumed that the correlation is correct and the name is here used. The basin, as it appears in this quadrangle, crosses Crooked Creek and Cherry Run a short distance east of Cochran Mills, deepening to the north so that on the north branch of Cherry Run the Upper Freeport coal is carried a few feet below the surface for more than half a mile. The Apollo syncline passes east of Whitesburg and pursues a direct course toward Rural Valley. In Cowanshannock Township, however, this basin is very irregular, and its exact shape is determined with difficulty. A minor fold which raises the rocks probably 30 feet crosses Crooked Creek in the first bend below Cochran Mills, but apparently does not extend more than a short distance in either direction along the strike. This was described by Mr. Platt as the Apollo anticline.

Greendale anticline.—The anticline which enters this quadrangle north of Shay with a southward plunge but appears to terminate before reaching Crooked Creek is known as the Greendale anticline. It takes its name from the village of Greendale, which is situated near the point where the axis crosses Cowanshannock Creek. This axis as mapped in the Rural Valley quadrangle pursues a northerly course through Blanket Hill and Greendale, where its shape is irregular, particularly along the crest. After crossing Cowanshannock Creek it swings eastward to Belknap. In the Elders Ridge quadrangle this axis has the effect of keeping the Upper Freeport coal above water level for a number of miles on the north branch of Cherry Run in Kittanning Township and also on Elbow Run and other tributaries of Crooked Creek. This anticline is described by Mr. Platt as continuing southward, but that it continues much beyond Crooked Creek has not been established by the present work.

STRATIGRAPHY.

The rocks discussed here are readily divided into those which outcrop and those which are hidden. The former are known by direct observation and the latter from the records of deep wells. The hidden rocks are the older and will be discussed first.

ROCKS NOT EXPOSED.

INTRODUCTION.

The stratigraphic section described under this head extends from the Vanport limestone in the Allegheny formation to the lowest rocks reached by the drill. The information is derived from well records which have been kindly furnished by gas companies operating in the territory. Such information is likely to be more or less imperfect for a number of reasons. Although the depth of producing sands below the well mouth is measured with a steel line, most of the other measurements are made by counting the number of turns of the cable on the bull-wheel shaft, and errors may easily occur. Furthermore, it is probable that in very deep wells the cable stretches enough to cause considerable error. Drillers are not trained scientific observers and many features shown by the sand pumpings escape their attention. In many cases record is made only of the oil- and gas-bearing beds, while other beds, geologically important, such as red rock and limestone, are overlooked or not recorded. Thus it may happen that the records of two wells drilled on the same location by different men may differ greatly.

It is well known that rocks exposed change in character and thickness from place to place, and the same thing may be expected in the hidden formations. Although the vertical interval between two easily recognized beds may be approximately constant the details in the sequence of rocks filling the interval often change materially both in exposed sections and in well sections. For this reason, and for those given above, it is often difficult to correlate beds in the records of wells drilled in close proximity to one another, and the author, upon plotting well records to scale, has not always been able to agree with the drillers in their identifications.

The records of a number of deep wells in this quadrangle are shown on the well-section sheet. It must be borne in mind that the holes were churn drilled and that the value of such records varies with the care exercised by the recorder. The correlation lines on the section sheet are the author's interpretation of the records and are more or less tentative.

STANDARD WELL SECTION.

The record of the W. G. King well (No. 15), on Crooked Creek 2 miles west of South Bend, gives a good section of the underlying rocks of the Elders Ridge quadrangle down nearly to the Fifth sand. Figures in parentheses referring to wells indicate their location on the structure and economic geology map. The author has taken the liberty to use the word shale instead of slate, as in the original record, and has named the members according to his interpretation. The well mouth is near the horizon of the Lower Kittanning coal. It was drilled by the Ford City Gas Company in February, 1892.

Record of W. G. King well, South Bend Township.

		Thickness in feet.	Depth in feet.
Conductor		5	0
Sand		15	5
Shale		35	20
Limestone (Vanport)		15	55
Shale		130	70
Sand		40	200
Shale		70	240
Sand (Big Injun)		300	310
Shale		150	610
Sand		105	760
Shale		77	865
Sand		40	942
Shale and shell		23	982
Sand (Murrysville)		35	1005
Shale		30	1040
Sand		15	1070
Shale		20	1085
Sand (Hundred-foot)		50	1105
Shale and shell		140	1155
Red rock	Sub-Blairsville red beds	255	1295
Shale	Sub-Blairsville red beds	5	1550
Red rock	Sub-Blairsville red beds	25	1555
Pebbly sand	Sub-Blairsville red beds	7	1580
Red rock	Sub-Blairsville red beds	33	1587
Shale		73	1620
Depth			1693

ALLEGHENY AND POTTSVILLE FORMATIONS.

The lower portion of the Allegheny formation is not exposed in the quadrangle. In the record of the King well it is given as shale. The interval between the Vanport limestone, the lowest rock exposed, and the top of the Pocono sandstone, or Big Injun sand, is 200 to 250 feet. According to the records of a number of wells this interval is occupied by shale and sandstone in varying proportions. Usually the lower portion is shale, and much of the sandstone probably is Pottsville.

MAUCH CHUNK FORMATION.

At the base of the Pottsville, in the George W. Stahl well, Conemaugh Township, is 8 feet of red rock. The color suggests that this rock is possibly Mauch Chunk formation. It may be that some of the shale shown in other well records as occurring between the Pottsville and Pocono formations is of Mauch Chunk age, although no mention of the color is made. What little Mauch Chunk may underlie this quadrangle probably is very thin. This scanty representation is interesting because of the well-known westward thinning of the formation and of the erosional unconformity which separates the Pottsville from the underlying rocks. Farther westward, in the vicinity of Kittanning, M. R. Campbell and David White have shown that the Pottsville rests directly on the Pocono, with no intervening Mauch Chunk.

POCONO FORMATION.

Practically all well drillers in western Pennsylvania know the Big Injun sand, which, to the geologist, is the upper part of the Pocono formation. It is difficult to draw definite boundary lines between formations which are known only by well records, and it may be that the Big Injun sandstone as recorded in some wells includes part of the Pottsville. The Big Injun is found from 450 to 500 feet below the Upper Freeport coal and is often from 300 to 500 feet thick. Records show considerable variation in this part of the formation. While in one well there may be 300 feet of unbroken sandstone, other wells show large admixture of shale and shaly sandstone. In some wells shale appears less than a hundred feet below the top of the formation and the upper sand is called the Seventy-foot. It is the practice of some drillers to call the main sandy portion of the formation, which is separated from the Seventy-foot sand by a varying amount of shale, the Mountain sand. In fact, the term Big Injun is not always used. The variations in this formation can best be understood by examining the well-section sheet.

Patton shale member.—At the bottom of the Big Injun sand there is found in some wells, particularly in the southern part of the quadrangle, a few feet of red rock, which may be either sandstone or shale, or both. This band of red rock is between 800 and 900 feet below the Upper Freeport coal, and is from 10 to 90 feet thick. It outcrops at Patton, on Redbank Creek, Jefferson County, from which occurrence Campbell has called it the Patton shale. David White has found fossils in the Patton shale which show that it is a member of the Pocono formation.

The lower limit of the Pocono formation is uncertain. It is probable that the Sub-Blairsville red beds described below are Devonian, but whether the three sands next described are Carboniferous is not proved. They may be either Pocono or Chemung. The interval from the Big Injun or the Patton shale member, when the latter is present, to the next sand below is filled in some wells entirely with sandstone, in others with shale or sandy shale, and in others with all three types of rocks.

Murrysville sand.—Throughout this quadrangle at an approximate depth of 1100 feet below the Upper Freeport coal is found a sand rock which often carries gas. This is the Murrysville sand, which takes its name from a village in Westmoreland County, where a strong gas pool was discovered at this horizon. Other names used in Armstrong County for the same bed are Butler gas sand and Salt sand. The thickness of the Murrysville, based on drillers' recognition, varies from 20 to 105 feet, and sixty-nine records gave an average thickness of 64 feet. The top of the Murrysville sand is usually about 700 feet below the top of the Big Injun.

Hundred-foot sand.—From 100 to 125 feet below the top of the Murrysville sand, and separated from it by a varying amount of shale and sandstone, is the Hundred-foot sand. The name is derived from its thickness, which, although it varies from 35 to 150 feet, in the records of fifty-one wells averages 94 feet. This sand also is a gas producer. Immediately below the Hundred-foot and separated from it by a few feet of shale the drillers sometimes recognize a sand known as the Thirty-foot. The term is used but little in the Elders Ridge quadrangle, but is common in the records of wells in the Rural Valley quadrangle on the north. This sand in a few wells appears to be merged with the Hundred-foot, the intervening shale being absent. Sometimes it carries gas.

Pine Run sand.—In wells drilled at Mateer a gas-bearing sand was found 275 feet below the top of the Murrysville. A sand at this horizon and about 20 feet thick is shown in the records of wells in other parts of the quadrangle, but only at this point is it given a name. It is separated from the Hundred-foot sand by shale, sandstone, or sandy shale, and lies only a few feet above a considerable thickness of red beds.

DEVONIAN ROCKS.

Sub-Blairsville red beds.—A conspicuous mass of red shale is shown in all the wells which go more than 1300 feet below the Vanport limestone. The top of this red rock is usually from 300 to 350 feet below the top of the Murrysville sand, and the color extends through an average thickness of 300 feet in this region. The rocks probably constitute a part of what is known as the Catskill formation and may be of Devonian age. They are not known in outcrop, and because of their considerable development in wells drilled in the vicinity of Blairsville have been called by Campbell (Latrobe folio, No. 110) the Sub-Blairsville beds. Richardson noted this mass of red rocks as occurring in wells in the Indiana quadrangle at a depth of 1400 to 1500 feet below the Upper Freeport coal and correlated them in a number of well records on columnar section sheet 2 in the Indiana folio, No. 102.

It will be seen by reference to the sheet of well sections in the back of this folio that the correlation lines drawn at the top and bottom of the Sub-Blairsville red beds include in a number of cases more shales and sandstones than those which the drillers noted as being red. These lines limit the zone in which red beds occur rather than mark the occurrence as actually noted, and are the author's interpretation of the probable correlation between the sections. In the Crownover (No. 1), Kerr (No. 2), King (No. 15), Stahl (No. 20), and other wells red beds occupy the entire interval; in the Sturgeon well (No. 8) they are in the upper portion; and in the Robinson (No. 4) and Smith Bros. (No. 17) wells they are in the lower portion of the zone. It is assumed that if particular attention had been paid to the subject when the wells were being drilled, the drillers' records of a number of the wells would have shown more red beds. A sand known as the Fourth sand, which occurs in the midst of the Sub-Blairsville red beds in the Rural Valley quadrangle, is not recognized by drillers in this field.

The age of the Patton shale member is known to be Pocono, and these Sub-Blairsville red beds probably are Devonian, but the exact position of the boundary between Carboniferous and Devonian rocks beneath this quadrangle is not known and can not be determined by well records alone. It is probable that there is a zone of transition in which Chemung and Pocono faunas merge.

Fifth sand.—The Fifth sand is at the base of the red beds, from 600 to 700 feet below the top of the Murrysville sand, and from 1700 to 1900 feet below the Upper Freeport coal. According to well records it ranges in thickness from 5 to 49 feet, the average of twenty-one records being 21 feet. The position and correlation of the Fifth sand is shown on the well-section sheet. Three wells figured on this sheet, which go below the Fifth sand, show another sand of about the same thickness 150 feet below the bottom of the red beds. In Moore well (No. 12) it is 225 feet below. This was called the Fifth sand in the Graff (No. 9) and Henry Reefer (No. 11) wells.

Speechley sand.—At least three wells in the Elders Ridge quadrangle have a depth of more than 2900 feet. These are the Nicholas Reefer (No. 10) and Samuel Graff (No. 9) wells in Plum Creek Township, and the Samuel Bracken well east of Russell Hill in Washington Township. At depths of 2460, 2495, and 2540 feet, respectively, below the Upper Freeport coal these wells encounter a sand which is in the midst of "slate and shells." In two wells it is 40 feet thick and in the third 20. This sand produces gas in some fields and is called the Speechley.

Tiona sand.—The three wells mentioned in the preceding paragraph encountered a lower sand which drillers call the Tiona. In the Graff and Reefer wells the top of the Tiona is 150 feet below the top of the Speechley sand, and in the Bracken well 100 feet below it. On the other hand, the distance from the Upper Freeport coal to the Tiona sand in the Bracken and Graff wells is 2640 and 2646 feet, respectively—a remarkably close accordance—while the same interval in the Nicholas Reefer well is 2610 feet.

The well on the Samuel Bracken farm, near Russell Hill, 3 miles north of Shelocta, so far as is known to the writer, is the deepest well in the Elders Ridge quadrangle. Its total depth is 3025 feet.

SURFACE ROCKS.

Carboniferous System.

The surface rocks belong to three Carboniferous formations, the Allegheny, Conemaugh, and Monongahela. These are, respectively, the Lower Productive, Lower Barren, and Upper Productive measures. The Allegheny formation is exposed along Roaring Run, Crooked Creek, Plum Creek, Dutch Run, and Aultmans Run, a small portion of the whole surface. The Monongahela formation underlies a belt of country about 11 miles long and 3½ miles wide between Kiskiminitas River and West Lebanon. The rocks underlying the remainder and by far the largest portion of the surface belong to the Conemaugh formation. More than 1100 feet of stratified rocks are exposed. They are divided among the formations as follows: Allegheny 240, Conemaugh 650, Monongahela 216. A generalized section for the quadrangle is presented on the columnar section sheet.

ALLEGHENY FORMATION.

The Allegheny formation extends from the base of the Brookville coal to the top of the Upper Freeport coal and is 300 feet thick.

The whole formation does not reach the surface in this quadrangle, the lowest stratum seen being the Vanport limestone. From the top of the formation, which is the Upper Freeport coal bed, to the bottom of this limestone is 250 feet, measured near Girty on Crooked Creek, where the limestone outcrops at water level and the coal is opened in the hills north of the creek. It is impossible to obtain a detailed section of this formation at any one place. Measurements of different local exposures accurately joined together in their regular order of superposition give the section which follows. It represents the average condition of the upper part of the Allegheny formation as exposed in this quadrangle.

Partial section of Allegheny formation.

	Feet.
Upper Freeport coal	4
Shale	8
Limestone	3
Sandstone	4
Shale	5
Fire clay	8
Sandstone and shale	30
Lower Freeport coal	2
Shale and sandstone	18
Freeport sandstone	25
Upper Kittanning coal	1
Sandstone and shale	70
Sandstone	25
Lower Kittanning coal	3
Fire clay	8
Shale, iron nodules, and sandstone	22
Vanport limestone	10
Total	246

Vanport limestone lentil.—A widely known limestone occurring in the lower portion of the Allegheny formation is the lowest member which outcrops in this quadrangle. It is commonly called the "Ferriferous" limestone, but the name Vanport limestone has been recently revived for it and will be used here. Vanport is a village on Ohio River 3 miles below Beaver, where the limestone is well exposed. At water level on Crooked Creek east of Girty and around the "Loop" 2 miles west of the hamlet, the Vanport limestone is exposed. It shows 8 to 10 feet of solid limestone; it is dark bluish gray on the freshly broken surface, but reveals a large number of white fossils (mostly crinoid stems) on the weathered surface. It is compact, rather coarse, and very brittle. The richly fossiliferous weathered surface is a distinguishing feature. The exposed edge often has a pitted appearance, due to irregular weathering along bedding planes. Above the limestone are 22 feet of sandstone and shales, the upper layers containing iron-ore nodules. This horizon is overlain by 8 feet of fire clay, often of poor quality, which underlies the Lower Kittanning coal bed.

Lower Kittanning coal.—This coal occurs at varying intervals above the Vanport limestone. In western Pennsylvania the interval may vary from 5 to 45 feet, but the coal occurs everywhere. The outcrop line of the coal in this quadrangle should vary but little from that of the Vanport limestone which is shown on the map, because the coal is only 30 feet above it. The coal is at the surface for only short distances on Crooked Creek. The thickness of the bed in Armstrong County is about 3 feet 6 inches, but it varies in different localities. At the "Loop" it is overlain by 25 feet of sandstone. Above this sandstone, whose massive character is not persistent, occur sandstone and shale for 70 feet or more. The Middle Kittanning coal has not been recognized in this region. Its place is in the midst of these shales and about 60 feet above the Lower Kittanning coal. Some of the sandstone a few feet above the Lower Kittanning coal is so fine grained, even, and thin bedded that it has been quarried for paving stones and tombstones.

Upper Kittanning coal.—This bed caps the series of soft rocks and is usually present at its proper horizon. It has a thickness of scarcely more than a toot and is therefore of little value. A few inches or feet of shales separate it from the Freeport sandstone, which in this region has a thickness of 25 feet. This sandstone is often massive, coarse grained, and mottled with iron stains, but in places becomes shaly. A typical section of it in its massive condition and of the underlying Upper Kittanning coal with the Johnstown limestone is seen at Cochran Mills in the bluff opposite the mill, and also at the road corner three-fourths of a mile southeast of Girty.

A series of soft clay shales and sandstones overlies the Freeport sandstone. They are thin and interstratified, so that the outcrop weathers rapidly and conceals itself with débris. This series is about 18 feet thick.

Lower Freeport coal.—The outcrop of this coal is usually hidden by wash from above, so that the extent of the coal bed is uncertain. It may be persistent, but this is not known. Its blossom and a few exposures seen in this quadrangle indicate that the bed is from 15 inches to 2 feet thick. There is, however, an unusual development of the seam on Aultmans Run north of Jacksonville (Kent post-office). Here the Lower Freeport reaches a thickness of 5 feet, while the Upper Freeport coal, 60 feet above, retains its customary dimensions. This occurrence will be described later. A layer of black "slate" forms the roof of the Lower Freeport coal and is usually about a foot thick. The interval between this bed and the Upper Freeport coal is from 30 to 60 feet and is occupied largely by shales with thin layers of sandstone. In the valley of Crooked Creek below South Bend the Butler sandstone, which lies between the Upper and Lower Freeport coals, is massive and conspicuous. It is coarse grained, gray, and forms the upper part of the bold cliff at Cochran Mills. A fire clay of varying thickness and quality overlies the shales, and forms the floor of the Upper Freeport coal seam. That which lies immediately below the coal is impure and calcareous, but that found 12 or more feet below the coal is often good and is worked at Salina by the Kier Fire Brick Company.

Upper Freeport coal.—A coal bed of workable thickness which outcrops in many places in this quadrangle is known as the Upper Freeport. Its outcrop in the hills and valleys on three sides of the territory is long and irregular as it is brought to light in many side valleys which branch off from the main streams. This coal bed persists throughout a large area in western Pennsylvania and maintains a fairly constant thickness of 4 feet.

Sections measuring little more than 3 feet are common; and where a thickness of 5 feet or more is found the seam is much broken by partings, or the lower benches are so small and separated from the upper bench by so much shale that it does not pay to remove the burden in order to get the coal.

In the valley of Crooked Creek the Upper Freeport coal is found always in the hills from South Bend westward to the Allegheny River. It is commonly about 3½ feet thick, contains one or more shale partings, and is never free from iron pyrites.

CONEMAUGH FORMATION.

The Conemaugh formation includes the strata from the roof of the Upper Freeport coal to the floor of the Pittsburg coal. The Mahoning, Saltsburg, Morgantown, and Connellsville sandstones are the prominent members of the formation, and their presence is often shown by the number of large blocks of sandstone scattered over the surface. All of these sandstones when well developed and massive have much the same appearance. They weather grayish white, are sometimes iron stained, vary from coarse to fine grained, and are best recognized by their position in the geologic section.

The entire Conemaugh formation is present only in the region of the Pittsburg coal, between Long Run and Blacklegs Creek; it forms the upland of the quadrangle, except in the above-mentioned belt, where the Monongahela formation is present. It is over 600 feet thick, and yet there is nothing in it of particular economic interest.

The frequent changes and modifications which these strata undergo are shown by exposures, natural and artificial, found on the highways and along stream courses. Beds often change so completely in thickness and character that sections measured a few hundred feet apart may have little resemblance. The formation is composed largely of shales. These are variegated, and show green, gray, and red tints. There are several insignificant beds of limestone, none of which are valuable as key rocks in this quadrangle. A generalized section is as follows:

Generalized section of Conemaugh formation.

	Feet.
Shale	8
Pittsburg limestone	5
Fire clay	3
Shale	24
Connellsville sandstone	30
Sandstone, shale, and thin limestone	100
Morgantown sandstone	20
Shale, sandstone, and thin limestone	320
Saltsburg sandstone	45
Sandy shale	40
Mahoning sandstone	50
Shale	5
Total	650

Mahoning sandstone.—The roof of the Upper Freeport coal, which is the bottom of the Conemaugh formation, is usually a bed of shale varying in thickness from a mere streak to 10 feet. Over this is a heavy bed of massive sandstone which rests on the shale or in places cuts it out and rests directly on the coal. This sandstone, commonly called Mahoning, has a thickness of 50 feet or more and often stands out in bluffs, or strews the surface with large blocks. The blocks are particularly conspicuous about Jacksonville, and the massive sandstone is well exposed on Roaring Run and about Salina. In the northern part of the quadrangle, beyond Crooked Creek, this member loses something of its massive character and is less conspicuous for that reason, although it is seen frequently between Elderton and Cherry Run. It is recognized largely by its thickness and its position immediately above the Upper Freeport coal, for its grayish-white color, its hardness, and its grain are equally characteristic of other sandstones in the formation. In the northeast corner of the quadrangle the Mahoning sandstone horizon is occupied by shales.

Saltsburg sandstone.—The succeeding 40 feet comprise a mass of sandy shales which in the Conemaugh region are overlain by a heavy sandstone. This rock is traceable along the southern line of the quadrangle by an abundance of sandstone débris and some outcrops. It is known as the Saltsburg sandstone and can be seen to the best advantage in the bluff opposite the village of that name. The top of this member is generally about 150 feet above the Upper Freeport coal. In the hills on both sides of Kiskiminitas River at Salina this member has a massive character and outcrops conspicuously in the roads and ravines. It is also well exposed at the road forks known as "Flat Rocks" on the ridge west of Long Run. The Saltsburg sandstone is thin bedded and shaly in the northern part of the quadrangle and could not be traced continuously. In the Plum Creek Valley the Mahoning sandstone seems to be but a few feet thick and the Saltsburg horizon is occupied by shales.

Two thin coal seams are found occasionally at intervals of about 50 and 100 feet above the base of this formation. The lower one has been seen 18 inches thick, but the upper one is usually 3 to 5 inches.

Limestone.—Above the Saltsburg sandstone are 320 feet of thin sandstones, shaly sandstones, and shales which present no conspicuous or traceable members. The interval contains several very thin layers of limestone. One of these, which is probably not far above the top of the Saltsburg, is 8 inches thick, black, and contains many fossils. The black shale immediately underlying the limestone contains even more animal remains, the most numerous being an elongated spiral gasteropod of the genus *Bulimorpha*. Bellerophons are also numerous. There is a good exposure of this black fossiliferous limestone in the creek bank beside the road three-quarters of a mile west of Shelocta. A green limestone about 1 foot thick is sometimes found near the middle of the formation, about 340 feet above the Upper Freeport coal. It carries abundant brachiopods and crinoid stems, and can be seen on Walford Run 1½ miles southwest of Avonmore. According to I. C. White, this would be the Ames limestone, which he describes (Bulletin No. 65) as occurring throughout Pennsylvania about 275 to 300 feet below the Pittsburg coal, and the same distance above the Upper Freeport coal, increasing in places to 350 feet. The position of this limestone also agrees with White's section (Rept. K, p. 334) in Beaver County, south of Ohio River. In his section of the Lower Barren measures in Armstrong County (Rept. H 5) Platt places the green fossiliferous limestone, which is another name for the Ames limestone, 220 feet below the Pittsburg coal. Some thin limestone was noted at this horizon by the writer but not recognized as described. Furthermore, Platt's section is 100 feet shorter than the section of the formation determined in this quadrangle. Whether either of these limestones can be correlated with the type is an open question.

Morgantown sandstone.—It is difficult to recognize the Morgantown sandstone in this quadrangle because of its thin-bedded, shaly character. Its position seems to be a little less than 200 feet below the Pittsburg coal. The bed was named from the city of Morgantown, W. Va., where it is well exposed and extensively quarried. The Morgantown sandstone is often underlain by red shales, and is overlain by 50 feet of variegated shales which sometimes contain three thin beds of limestone. The horizon of these limestones is approximately 150 feet below the Pittsburg coal, and this part of the section is well exposed and can be measured in the west bluff of Kiskiminitas River halfway between Edri and the mouth of Blacklegs Creek.

Connellsville sandstone. — There is generally present in this quadrangle at a distance of 40 feet below the Pittsburg coal a coarse sandstone which has received its name from the city of Connellsville, where it outcrops. The bed is usually 30 feet thick. It is massive or slightly shaly, and is underlain by red shales and shaly sandstone. The Connellsville in its massive condition is a grayish quartzose sandstone, sometimes iron stained, and in no way different from other sandstone in the formation. It is recognized solely by its geologic position. It lies so near the Pittsburg coal that its importance as a key rock is overshadowed by the coal, which is better known in its outcrop and in its underground extension.

Pittsburg limestone. — A limestone, which is separated from the Pittsburg coal by a few feet of shale, outcrops at a number of places in the southern half of this quadrangle. It can be seen on several roads within a mile or two of Olivet. The limestone is about 5 feet thick and fairly pure. It is generally compact, moderately heavy bedded, and brittle. The weathered surface is light colored, but a fresh fracture shows bluish-gray seamed with bluish-black.

MONONGAHELA FORMATION.

The Monongahela formation consists for the most part of shale, sandstone, and limestone. The formation is usually about 375 feet thick, and extends from the Pittsburg coal at the base to the Waynesburg coal at the top. About 216 feet of the formation are present in this quadrangle, the upper portion having been removed by the general degradation of the land surface. The thickness of the rocks above the Pittsburg coal averages about 100 feet in this region; it is rarely 200 feet. Geographically the area of the Monongahela formation is clearly defined—on the north by Gobblers Run, on the east by Blacklegs Creek, on the south by Kiskiminitas River, and on the west by Long Run.

The highest rocks in this quadrangle, in a stratigraphic sense, are found in the vicinity of Elders Ridge and West Lebanon. Here the Benwood (Great) limestone caps several hills in the basin of the Elders Ridge syncline.

A section made here must be generalized and the result of compilation of measurements from several localities. The following gives an idea of the sequence of rocks exposed in the basin, but does not indicate the frequent variations which occur:

Partial section of Monongahela formation.

	Feet.
Benwood limestone	25
Sandstone	7
Sandy shale, sandstone, and limestone	76
Sewickley coal	2
Shale	12
Limestone	6
Shale	15
Sandstone	5
Shale	25
Redstone coal	1
Sandstone	30
Shale	5
Pittsburg coal	7
Total	216

Pittsburg coal.—The basal member of the Monongahela formation is the Pittsburg coal. The bed has hundreds of miles of outcrop in western Pennsylvania (see fig. 5, illustration sheet), and is well and favorably known for its coking and steaming qualities. It is usually from 6 to 10 feet thick, with thin shale partings, and can be traced easily by the numerous springs, coal blooms, and openings on the outcrops, and by the broad bench on the slopes over which it runs.

The Pittsburg seam reaches its most northern development in this quadrangle. It exists in three irregular areas of nearly equal size which lie along the Armstrong–Indiana county line. The boundaries of the coal area are the same as those of the Monongahela formation. It does not extend east of Blacklegs Creek or west of Long Run, and the most northern occurrence is in the hills just north of West Lebanon. On the south side of Kiskiminitas River, in Westmoreland County, the coal has a more extensive development, only a small area of which is included in this quadrangle.

The deep ravines which cut entirely through the coal seam and divide the belt into separate areas, together with notches made on all sides by small streams, furnish long and irregular lines of outcrop and ready access to the coal in the basin. The bed dips gently from all directions toward the lowest point on the synclinal axis, which is between Elders Ridge and Big Run.

The coal is about 300 feet above Kiskiminitas River at Hicksville and 200 feet above Blacklegs Creek at Clarksburg. It lies beneath the villages of Elders Ridge and West Lebanon. The dip of the bed and its elevation above the river are all favorable to mining and transportation. The shales forming the roof of the Pittsburg coal vary in thickness from 1 to 8 feet, and are overlain by sandstone.

Pittsburg sandstone.—The sandstone which begins a few feet above the Pittsburg coal is known by the same name. It is 30 to 40 feet thick near the river, and forms cliffs in the hilltops overlooking Avonmore. Its character is generally massive, and the blocks that break off from the outcrop are large. Toward the northeast this massiveness becomes less pronounced, and the thickness decreases. South of Olivet it is current bedded, making it suitable for flagging. The sandstone, which is directly above the Pittsburg coal near West Lebanon, is only 25 feet thick and so thin bedded that it weathers off into thin, soft fragments. This extreme variation from massive and compact to loose and shaly carries with it a change from quartzose to clayey, and from gray to dark color.

Redstone coal.—There is a small seam of coal above the Pittsburg sandstone, separated from it by a bed of clay, but it is not thick enough to be worked; in fact, the bed scarcely more than shows itself in the most favorable exposures. It is reported as being present and nearly 3 feet thick in the vicinity of Elders Ridge. This thickness probably is made up largely of shale partings. In the southern part of the field, near Kiskiminitas River, it seems to be absent.

Above the Redstone coal for 45 feet the rocks are shale with some thin sandstones and arenaceous shales which are so soft that they weather deeply. A limestone which averages 6 feet thick occurs at the top of this interval. It is fossiliferous, fairly pure, sometimes has a brownish cast, and is easily calcined. It is exposed in the bluff on the river and has been opened in a ravine at Olivet. So far as known it has not been explored elsewhere and its exposures are few. The name commonly given to this member of the formation is Sewickley limestone.

Sewickley coal.—This coal throughout the basin occurs much less extensively than the Pittsburg, for it is 100 feet higher in the hills. It has a thickness of 2 to 5 feet, and is found frequently with strong bloom, showing a persistence in its occurrence. So long as the Pittsburg coal bed is near by, this coal seam can not be worked with profit, and it is not mined at present within the boundaries of the quadrangle. This coal shows at the extreme hilltops in the northern bluffs below Hicksville, and is seen frequently in the roadside ditches near Elders Ridge.

Above the Sewickley coal is an interval of about 80 feet which is occupied mainly by argillaceous shale. These rocks weather easily and produce good soil.

Benwood limestone.—This bed is found only on Elders Ridge and only the lower part of the member is here present. It consists of several layers of limestone separated by variable thicknesses of shales, in all about 25 feet. The limestone is grayish in color, smooth and compact, and nonfossiliferous. It has been burned for making fertilizer and found excellent for that use, as it makes a strong lime and is easy of access. No stripping is required in order to quarry it, because all the limestone lies in the very crown of the highest knolls in the middle of the basin. Where the bed is present abundant fragments of gray limestone usually are found on the ground.

Quaternary System.

PLEISTOCENE DEPOSITS.

CARMICHAELS FORMATION.

Deposits of gravel, sand, and clay are found at a number of places high above the present flood plains of Kiskiminitas River and Crooked Creek within the boundaries of this quadrangle. The presence of water-laid deposits, rounded pebbles and stratified sands, at an elevation of 100 or more feet above the streams is a feature of the geology in many valleys in this part of the State. These sands and clays were laid down as alluvial deposits on valley floors which have subsequently been dissected.

The occurrence of these terrace deposits and their elevations above the present streams are shown on the areal geology map. In the vicinity of Shelocta the terrace deposits are only a few feet above the reach of the highest floods on Crooked Creek, and the slopes away from the stream are so gentle that it is difficult to determine where the recent alluvium stops and the terrace deposits begin; in fact it is quite probable that the gravels and sands of the old river stages have washed down upon and merged with the present flood-plain deposits. On the same stream, below Girty, well-rounded pebbles and river silts have been found in a number of places at an elevation of 100 feet or more above the creek. Well-developed terrace deposits occur back of the village of Avonmore, on Kiskiminitas River, at an elevation of 80 feet above the river, and also on the broad upland above the village 100 feet higher, at an elevation of about 1000 feet above tide. The deposits, as shown in ditches in the village and in tilled land on the flat above the village, consist of interstratified gravel, sand, and clay. These were laid down during the periods of no crustal movement, in which valley floors were broadened. The river deposits found at an elevation of about 1000 feet are supposed to be contemporaneous with the Parker strath, and those at 900 to 920 feet with the Ford City strath, described in the Kittanning folio.

The name Carmichaels clay was first applied to these river deposits in the Masontown-Uniontown folio, No. 82. Carmichaels is a village in Greene County, Pa., where an abandoned channel of Monongahela River contains a considerable thickness of clays, sand, and gravel.

RECENT DEPOSITS.

ALLUVIUM.

The activity with which the streams are deepening their channels prevents the development of broad flood plains. Where these recent river deposits have accumulated to some extent they are represented on the geologic map. Alluvium consists of sand, clay, and silt—the disintegrated rock particles which have been washed down from the hillsides and deposited in their present position in time of high water. Kiskiminitas River, where it crosses the southwest corner of this quadrangle, has a flood plain above Edri, but below that point is confined within steep banks on one or both sides. Opposite Avonmore and below Salina the side walls are precipitous and rocky and no alluvium is deposited.

Blacklegs Creek has built a narrow flood plain along several miles of its course. It is nowhere more than a few hundred yards wide and is only a minor feature of the geology.

Cherry Run has no alluvium broad enough to be represented on the map, and Aultmans Run shows only a small amount.

Crooked Creek flows in a narrow gorge below Girty, but has some wide flood plains along its course east of that village and on its tributaries. Plum Creek in particular has a broad, flat valley bottom and is conspicuous on the maps for its wide floor. Dutch Run, which empties into Plum Creek, also has a flood plain broad enough to be represented on the map along several miles of its course.

These alluvial deposits often afford good soil and are extensively cultivated in those places where danger from floods is not too great. The fine character of the material and the levelness of the surface make them easy to till, and where this is not done the flood plains make good pastures.

GEOLOGIC HISTORY.[1]

Paleozoic Era.

Doubtless the geologic history of the quadrangle extends back through the entire Paleozoic era, but the sequence of events during Cambrian, Ordovician and Silurian periods can be inferred only from the character of the rocks in other parts of the country. Such inferences possess little value and will not be undertaken. The underlying Devonian system is fairly well known from the records of deep wells drilled for oil and gas.

DEVONIAN PERIOD.

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

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

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

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

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

CARBONIFEROUS PERIOD.

POCONO EPOCH.

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

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

MAUCH CHUNK EPOCH.

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

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

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

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

POTTSVILLE EPOCH.

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

Deep wells in the Elders Ridge quadrangle show that the Pottsville beneath that area is about 150 feet thick and is composed of two sandstones separated by shale. In the southern anthracite region the formation is 1200 feet thick and is composed of sandstone and conglomerate with a number of coal beds, while in Tennessee and Alabama it is more than 5000 feet thick. (David White, Notes on the deposition of the Appalachian Pottsville: Bull. Geol. Soc. America, vol. 15, pp. 267–282.)

Formerly it was supposed that the great difference in thickness of the Pottsville formation in the southern anthracite basin and in the bituminous field of the western part of the State is due to different amounts of material having been supplied to the two areas. In other words, that the thin sections of the western part of the State represent the same epoch of geologic time as the thick sections of the southern anthracite basin. From the work of Mr. David White on the fossil plants (Fossil floras of the Pottsville formation in the southern anthracite field, Pennsylvania: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 751–930), it is now known that in the southern anthracite basin sedimentation was carried on continuously from the close of Mauch Chunk to the beginning of Allegheny time, whereas in the western part of the State the close of the Mauch Chunk epoch was marked by an uplift which raised the main part of the bituminous field above sea level, and hence no rocks of corresponding age were deposited. While the field was a land area it must have been subjected to erosion, and probably much of the rock previously laid down was carried away.

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

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

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

ALLEGHENY EPOCH.

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

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

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

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

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

CONEMAUGH EPOCH.

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

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

MONONGAHELA EPOCH.

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

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

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

DUNKARD EPOCH.

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

The formation of the Waynesburg "A" coal was interrupted by a gentle submergence which made the waters muddy and deposited a few feet of shale. When the waters became clear limestone formed, but frequent tilting and elevation or depression of the surface characterize this period and conditions did not remain the same for any great length of time. Small coal beds were formed, thin, and local in extent, only to be submerged and buried after a short period.

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

APPALACHIAN REVOLUTION.

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

Mesozoic Era.

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

After its formation, which occurred near sea level, this gently undulating surface was elevated and the streams at once proceeded to dissect its surface. It is not certain that any of the original surface remains, but it is probable from the fairly constant altitude of the ridges either that their summits were once at the surface of this plain or that they have been reduced only slightly below it. There are no traces of the Schooley peneplain in the topography of the Elders Ridge quadrangle.

Cenozoic Era.

TERTIARY PERIOD.

Following the period of long-continued erosion during which the Schooley peneplain was produced, this region was uplifted not less than 800 feet, and again the crust remained stationary long enough for the somewhat softer rocks west of Chestnut Ridge to be reduced to a common level. This surface is now represented by a general level of hilltops and is called the Harrisburg peneplain, from its development about the capital of the State. (M. R. Campbell, The geographic development of northern Pennsylvania and southern New York: Bull. Geol. Soc. America, vol. 14, pp. 277-296.) Remnants of this peneplain are seen in the Elders Ridge quadrangle at altitudes varying from 1340 feet above tide in the northern part to about 1300 feet in the southern part. Subsequent elevation caused the dissection of this partial peneplain, and later movements have produced other substages of erosion.

MINERAL RESOURCES.

The mineral resources of the quadrangle are briefly described in this folio. For a fuller discussion reference should be made to Bulletin No. 256, entitled "Mineral Resources of the Elders Ridge quadrangle," by the same author.

COAL.

The aim of the present workers in making a geologic map of the coal fields in western Pennsylvania has been to determine as accurately as possible the geologic structure of the region and to delineate the outcrop of formations to as great a refinement as the scale of the base map will permit. In the Elders Ridge region the boundaries of the formations are workable coal beds, and hence the line which represents the upper and lower limits of the Conemaugh formation is really the outcrop line of the Pittsburg and Upper Freeport coals.

Coal is by far the most important mineral resource of the Elders Ridge quadrangle. Besides the two beds mentioned, a portion of the Lower Freeport coal, which is workable for a short distance, has also been mapped. There are two or three other coal beds which are too thin to be of economic importance, but what little is known of them will be described in the order in which they occur in the geologic column.

The most important coal in this territory is the great Pittsburg bed, which underlies about 14 square miles in the southern half of the quadrangle, and this is the only bed which is at present mined on a commercial scale, though the Upper Freeport has considerable prospective value.

LOWER KITTANNING COAL.

On Crooked Creek below South Bend there are two stretches in which the Lower Kittanning coal is above water level. Its outcrop is practically the same as that of the Vanport limestone, which is shown on the map, since the coal is confined to the deep gorge and is not more than 30 or 40 feet above the limestone. This bed is not worked at any point on the creek at present, but had been opened previous to the work of the Second Geological Survey of Pennsylvania, and the reports of that survey state that the thickness of the coal averaged about 3 feet where it was seen at the old salt works below the "Loop." The bed is 2 feet 7 inches thick in a ravine two-thirds of a mile below the "Loop." It was also mined at one time just above water level near Girty, but there, as elsewhere along the creek, the seam is so broken with partings that it is nearly worthless. Moreover, the coal is highly pyritous. The section of the bed published by Platt gives the subdivisions shown in the section below. This and the following coal sections are also illustrated on the columnar section sheet.

Lower Kittanning coal near Girty (section 1, columnar section sheet).

	Feet.	Inches.
Coal		6½
Slate		1
Coal	1	6
Slate		½
Coal		3
Total	2	5

UPPER KITTANNING COAL.

This coal bed also is seen only in the valley of Crooked Creek below South Bend. It is nowhere of practical importance, although it was at one time mined to a small extent at the mouth of Cherry Run for household use. At this point the Upper Kittanning is more favorably located than the Upper Freeport coal and can be more conveniently worked. It is not over 2 feet thick where its complete section is seen on Cherry Run and on Crooked Creek in the bluff opposite the mill at Cochran Mills. Farther down the creek the thickness of this seam diminishes to a mere streak. Since the development of the gas field at Cochran Mills the mining of this coal has completely ceased. This coal shows in the highway at the mouth of Sugar Run, and has been stripped farther up the stream.

LOWER FREEPORT COAL.

Whether this seam is present throughout the Elders Ridge quadrangle is questionable. In the course of the survey it was recognized at only two points in the valley of Crooked Creek, and probably is not present at Cochran Mills; at least no trace of it was discovered there. A small blossom was seen at the road corners a mile east of Girty, and another in a ravine south of the "Loop" on Crooked Creek. It is commonly reported that at Rockville there is a coal bed a few feet below the surface of the run; if a coal occurs here, it is the Lower Freeport. The horizon of the Lower Freeport coal is below water level on Plum Creek and Dutch Run. Near Jacksonville, Conemaugh Township, the Jacksonville anticline raises the Allegheny formation high above water level, so that the Lower Freeport coal is exposed for a number of miles. On Neal Run, a tributary of Aultmans Run, the Lower Freeport has an unusual development. It is mined near the school house 2 miles north of Jacksonville by Mr. Clark Neal and by Mr. William H. Martin. In both of these banks, which are nearly opposite each other on the same run, the Lower Freeport coal measures 5 feet 2 inches (section 2). The bed is very even and fairly free from sulphur, but is considerably intermixed with thin bands of earthy material, which give it a large percentage of ash. It is the presence of this impurity that gives to the coal its great firmness, causing it to come from the mine in large blocks. The coal has a dull luster generally, but shows numerous bands of bright pitchy coal. The lower bench, which is 20 inches thick, is harder than the rest. It is overlain by 8 inches of a softer coal which is particularly desired for blacksmithing. Mr. Neal produces from 20,000 to 30,000 bushels annually and Mr. Martin puts out from 10,000 to 15,000 bushels. Coal has been mined here continuously for nearly sixty years. In the first hollow south of Neal Run the Lower Freeport coal has been mined on the F. P. Marshall farm, where the seam is 4 feet 6 inches thick. It is believed by some that this seam maintains the same thickness throughout a considerable area in this part of Indiana County, but it is probable that the coal will not measure 5 feet thick for more than a very short distance in any direction from these two banks. It is known to be not more than 20 inches thick on Reeds Run (section 3), and is probably less than 2 feet thick at a point not more than a mile north of these banks on Neal Run. This coal has been opened on the east hillside three-fourths of a mile northwest of Jacksonville, and found to be only 2 feet thick.

A sample of this coal was collected by the writer at the Clark Neal bank, and an analysis of it by Mr. W. T. Schaller, of the United States Geological Survey, resulted as follows:

Analysis of Lower Freeport coal from Neal Run.

	Per cent.
Fixed carbon	60.50
Volatile matter	29.17
Moisture	1.52
Ash	8.81
Sulphur	1.69

Color of ash, white. It is a good coking coal.

UPPER FREEPORT COAL.

The "Four-foot coal," as it is called, appears in all four quarters of the Elders Ridge quadrangle. By far the longest line of outcrop is in the northwest quarter, where this coal is above water level on every tributary of Crooked Creek. The average thickness of the bed throughout the quadrangle is probably a little under 4 feet, the extremes being 27 and 55 inches. The coal is everywhere slaty and sulphurous. The areas in which the coal outcrops are so detached that they may well be described separately.

In the southeast quarter of the quadrangle the Jacksonville anticline raises the Allegheny formation to the surface. The Upper Freeport coal is exposed along the whole length of Coal Run, and on Aultmans Run northward from the mouth of Coal Run nearly to the headwaters of Neal and Reeds runs. Openings has been made at short intervals both north and south of Jacksonville, and coal is mined in a number of places. In this valley the thickness of the bed ranges from 3 feet 6 inches to 4 feet 7 inches, averaging about 4 feet. The Upper Freeport coal, with its underlying limestone, is also exposed for more than a mile at the upper end of Marshall Run, in which distance it rises 170 feet on the flank of the Jacksonville anticline.

A typical section of the bed in this part of the quadrangle, as measured by the Second Geological Survey of Pennsylvania on Coal Run, is as follows:

Upper Freeport coal at Kennedy's mine on Coal Run (section 4).

	Feet.	Inches.
Coal	3	2
Bony coal and slate	0	3
Coal	0	6
Total	3	11

In the southwest quarter of the quadrangle the Roaring Run anticline brings the Allegheny formation to the surface again. The Upper Freeport coal appears in the Kiskiminitas at Salina with a thickness of 3 feet 10 inches, but at a point less than a mile downstream it is seen 130 feet above the water, and is 4 feet 5 inches thick.

In the valley of Roaring Run the bed has a thickness of 4 feet, which it maintains with great persistency. It carries a small parting, which usually is not more than an inch thick. The outcrop extends to the head of the run near Shady Plain.

There is a very limited outcrop of the Upper Freeport coal in a small ravine on the Grey farm a mile northwest of Long Run. The stream has cut into the flank of the Roaring Run anticline, just deep enough to reveal the coal for a few rods. The dip here is to the southeast at an angle of 6° for a short distance, and the section, as measured at the lowest opening, is as follows:

Upper Freeport coal on Grey farm near Long Run (section 5).

	Feet.	Inches.
Coal	1	3
Parting	0	2
Coal	0	10
Parting	1	3
Coal	3	8
Total	7	2

This is the same thickness of bed and of coal, but not the same structure as published by the Second Geological Survey of Pennsylvania.

In the northeast quarter of the quadrangle, on the South Branch of Plum Creek the Upper Freeport coal is exposed just above water level for 3 miles, where the Dutch Run anticline is cut by the creek. One mile of this outcrop is in the Elders Ridge quadrangle, and the other two extend up to Willet, in the Indiana quadrangle. The coal in the banks on this stream measures from 2 feet 10 inches to 3 feet 6 inches thick. The following section, published by the Second Geological Survey of Pennsylvania, is typical:

Upper Freeport coal on South Branch of Plum Creek (section 6).

	Feet.	Inches.
Coal	3	0
Slate	0	1
Coal	0	3
Total	3	4

The Upper Freeport coal is also exposed for 2 miles on Dutch Run, and on Plum Creek to its mouth, with an average thickness of little more than 3 feet.

In the northwest quarter of the quadrangle the Upper Freeport coal is widely exposed. It is raised above water level a half mile below South Bend by the Roaring Run anticline and continues in sight to Allegheny River. The elevation of the formation is sufficient to carry the outcrop of the coal up the tributaries of the creek for long distances.

In the vicinity of Girty on the north side of the creek the bed is from 40 to 46 inches thick, averaging about 3½ feet. On the south side of the creek, however, the coal has been opened 1½ miles south of Girty and found to have a thickness of 27 to 30 inches. This is probably a local thinning, for the same bed measures from 3½ to 4 feet on Cherry Run, 3½ to 4½ feet at Mateer, 40 to 45 inches at Cochran Mills, and nearly 4½ feet at the mouth of Elbow Run.

It will be seen by the accompanying maps that the Upper Freeport coal is above water level on the north branch of Cherry Run in the vicinity of Rockville. Mr. Platt stated in his report on Armstrong County (Rept. H5) that the coal goes under the run at Heilman schoolhouse (Rockville) and that the Gallitzin seam is opened at Remaley's mill, between Rockville and Shay. He describes the Gallitzin seam as being 2 feet 7 inches thick, 50 feet above the Upper Freeport coal, and resting on massive Mahoning sandstone. In the course of the present survey the conclusion was reached that the Upper Freeport coal continues above water level at Rockville and decreases in thickness from 42 inches near Pyrra to 22 inches or less at Remaley's mill. The heavy sandstone which outcrops at Rockville is believed to be the Butler sandstone.

Elevation of Upper Freeport coal.

	Feet above tide.
Abandoned coal bank near Pyrra	1045
Van Schall coal bank (coal 42 inches)	1050
Coal blossom reported plowed up on hillside	1070
Wet spring spots opposite Reuben Schall's	1085
Old opening below Crim's house	1110
Old opening below Crim gas well	1120
New opening below Remaley's mill (coal 22 inches)	1130
Old opening above Remaley's mill (coal 18 inches to 3 feet)	1150

It is generally admitted that the coal which outcrops just above water level at Pyrra is the Upper Freeport. The rocks rise to the northwest on the Greendale anticline, and that the coal keeps above the stream to Remaley's mill is shown by the observations, with approximate elevations, given in the preceding table.

North of Rockville the Upper Freeport coal has been mined in several places and measures from 28 to 34 inches of clear coal.

It is generally believed by the people at Rockville that there is a 4-foot bed of coal about 15 or 20 feet below the run. Coal has been reported at that depth in two or three gas wells which have been drilled at water level. The writer believes that the horizon of the Lower Freeport coal is only a short distance below the run in the vicinity of Rockville, but that the coal is 4 feet thick is not proved. The Upper Freeport coal is, however, 4 feet thick on the run northwest of Shay.

The composition of the Upper Freeport coal is shown by the following analyses. One was made by W. T. Schaller, of the United States Geological Survey, from a sample of the marketable coal taken in the Robinson bank at the head of Reeds Run north of Jacksonville. The other analysis was made by E. C. Sullivan, of the United States Geological Survey, from a sample of marketable coal in the Walker mine on Crooked Creek near the mouth of Elbow Run:

Analyses of Upper Freeport coal.

	Robinson.	Walker.
Fixed carbon	58.94	51.23
Volatile hydrocarbons	29.26	37.76
Moisture	1.47	1.23
Ash	9.63	9.78
Sulphur	2.25	3.94

PITTSBURG COAL.

The most northern area of the great Pittsburg coal bed, which underlies nearly 2000 square miles in southwestern Pennsylvania, is in the Elders Ridge quadrangle. This portion of the Pittsburg coal basin is known as the Elders Ridge field. It is bounded on the north by Gobblers Run, on the east by Blacklegs Creek, on the south by Kiskiminitas River, and on the west by Long Run. The field is 9 miles long and 3½ miles wide, with the long axis in a northeast-southwest direction, and contains about 14 square miles of coal, which will average 7 feet thick. The area is divided into three main blocks by Whisky Run and Big Run, which cut below the horizon of the coal.

This coal area lies in the Elders Ridge syncline. All of the coal on the east side of the axis rises toward Blacklegs Creek, and all on the west side toward Long Run. The basin is deeper near Elders Ridge than at Edri or Long Run, so that the structural shape of the field is a broad canoe-like fold with the rocks dipping from all sides toward the center.

The Pittsburg coal bed in the Elders Ridge field is slaty in some places and has many partings; in others it is clean and almost unbroken. It varies in thickness, including its partings and roof coal, from 6 to 10 feet. Generally the roof coal is not taken, as it contains so many thin bands of hard shale that it has little value. Another reason for not mining it is that the shales over the roof coal are so soft and friable that the coal has to be left to support them. The bed has been opened at a great many places. A few sections of the coal as seen in different parts of the field are given to show its character.

In a coal bank at the northern edge of the field about two-thirds of a mile north of West Lebanon, owned by Holsten Brothers, the bed is practically free from partings and horsebacks. The section is as follows:

Pittsburg coal near West Lebanon (section 7).

	Feet.	Inches.
Coal	2	2
Bony coal	0	4
Coal	2	5
Shale	0	½
Coal	2	2
Total	7	1½

On Harper Run north of Clarksburg the coal is mined by John Hart. A section obtained there shows all of the bed except perhaps a thin layer in the roof shales.

Pittsburg coal at Hart Bank on Harper Run (section 8).

	Feet.	Inches.
Coal	0	10
Shale	1	0
Coal	4	0
Shale	0	1
Coal	1	2
Shale	0	6
Coal	1	8
Total	9	3

At the new mine of the Pittsburg Gas Coal Company, across the run from the bank mentioned above, the bed has about the same thickness, but shows fewer partings. A measurement made in No. 2 heading is as follows:

Pittsburg coal at Iselin, on Harper Run (section 9).

	Feet.	Inches.
Coal	6	6
Shale	0	6
Coal	2	0
Total	9	0

The bottom bench, which runs from 20 inches to 2 feet, is not being taken out at present.

On Big Run an opening on the James Crawford heirs' farm shows the bed with one heavy parting in the upper half.

Pittsburg coal on Big Run (section 10).

	Feet.	Inches.
Coal	1	8
Shale	1	0
Coal	5	4
Total	8	0

On Long Run due west from Elders Ridge the bed loses much of its value on account of the number and thickness of the partings. In a bank on the C. J. Palmer farm the following section was measured:

Pittsburg coal on Long Run (section 11).

	Feet.	Inches.
Coal	1	3
Shale	0	5
Coal	1	5
Shale	0	8
Coal	1	9
Shale	0	5
Coal	1	11
Total	7	10

In the southern portion of the field, on Kiskiminitas River, the thickness of merchantable coal averages fully 6 feet. The character of the bed is well shown by a section measured at the Bowman mine south of Edri.

Pittsburg coal on Kiskiminitas River (section 12).

	Feet.	Inches.
Coal	4	2
Shale	0	1½
Coal	2	5
Total	6	8½

Five or six mines in the southern part of the field are shipping 150 to 750 tons of coal daily by rail. There are twelve or more small banks which supply local demand.

The following table gives three analyses of the Pittsburg coal in this quadrangle. Samples were taken from the Holsten Brothers' bank at West Lebanon and from the Pittsburg Gas Coal Company mine on Harper Run, and analyzed in the chemical laboratory of the United States Geological Survey. The third analysis was furnished by the Avonmore Coal and Coke Company, which owns a mine at Hicksville.

Analyses of Pittsburg coal in the Elders Ridge field.

Location.	Fixed carbon.	Volatile hydrocarbons.	Moisture.	Ash.	Sulphur.	Analyst.
West Lebanon	56.25	33.41	1.61	8.73	1.87	Eugene C. Sullivan
Harper Run	56.34	31.48	1.76	10.42	1.25	George Steiger
Hicksville	56.432	35.04	.72	6.81	.988	

SEWICKLEY COAL.

The horizon of the Sewickley coal is about 120 feet above the Pittsburg, and its occurrence is limited in this quadrangle to the center of the Elders Ridge syncline. The coal is nowhere worked in this region, but the blossom is seen frequently in ditches along the roadside. It is conspicuous at the road corner above the Thomas Hart bank 1½ miles northwest of Clarksburg, and also a few rods north of the church at Elders Ridge. An opening on the Smith farm near Elders Ridge, made many years ago, is claimed to have revealed a much-parted seam measuring 5 feet 3 inches. The coal is said to be 3 feet thick in the cliff above Hicksville, but occurrences noted do not indicate more than 2 feet.

NATURAL GAS.

GENERAL STATEMENT.

About 260 wells have been drilled for gas and oil in the Elders Ridge quadrangle during the last ten years, drilling having been begun about 1894. Many of the wells have produced gas, some have been unproductive, and not one found a pool of oil. The wells may be grouped in seven more or less well-defined fields, which are known by local names. These are the Willet, Plum Creek, Say Farm, Girty, Shellhammer, Roaring Run, and Rockville fields. A fuller description of all these fields, accompanied by a map giving location, and a list giving owners, approximate elevations, depths, and reference numbers of the wells, will be found in Bulletin No. 256. The relation of gas fields in this area to the gas and oil fields of western Pennsylvania is shown in fig. 4 on the illustration sheet.

The relation of the gas fields to the geologic structure appears to be definite and uniform. It will be seen by reference to the structure and economic geology map that the producing wells are near the crests or far up on the flanks of anticlinal folds, and that a number of holes located in the synclines are unproductive. Formerly it was the practice to pursue drilling operations along certain lines, such as N. 23° E., or N. 35° E., but now that the anticlinal theory of the accumulation of gas is generally understood, much useless work is avoided and the direction of further drilling is determined by geologic structure rather than by compass.

GAS SANDS.

Natural gas is found at six horizons in the wells in this quadrangle. All these sands are not productive in the same field, although three or four of them may yield gas in the same well. The first reservoir encountered is the Murrysville sand, which is about 1100 feet below the Upper Freeport coal. It is known in some Armstrong County fields as the Butler gas or Salt sand. The Hundred-foot sand is found from 100 to 125 feet below the top of the Murrysville. These two are the most productive sands in the region.

In the Shellhammer field a horizon locally gas bearing lies from 30 to 50 feet below the bottom of the Hundred-foot and is known as the Pine Run sand. The top of it is about 1400 feet below the Upper Freeport coal.

The Fifth sand which is an important gas horizon, occurs from 1700 to 1900 feet below the Upper Freeport coal and from 600 to 700 feet below the top of the Murrysville sand. Wells which go very deep find the Speechley sand at about 2500 feet below the Upper Freeport coal and the Tiona sand from 100 to 150 feet below the top of the Speechley. A description of the section, as revealed by deep wells, appears under the heading "Stratigraphy."

GAS FIELDS.

Only brief mention is made here of the seven gas fields in the quadrangle.

Willet field.—A group of wells on the south branch of Plum Creek takes its name from Willet, at the mouth of Sugar Camp Run, in Indiana quadrangle. Gas was discovered in this region on the Kelly farm in December, 1890. Drilling was continued to the southwest and the field extended to Dutch Run in this quadrangle. The gas-producing sand occurs about 1100 feet below the Upper Freeport coal and is known as the Murrysville or Salt sand. The field is on the Dutch Run anticline.

Plum Creek field.—About 20 wells near the mouth of Plum Creek make a small field which has been developed since 1898. The field is located at the southern end of the Dutch Run anticline and gets its gas in the Murrysville sand.

Say Farm field.—In Plum Creek Township, north of Elderton, there is a group of wells known as the Say Farm field. The development of this field began in 1897, when a successful well (A) was completed on the A. L. Say farm 2 miles southeast of Whitesburg. The wells are on the crest and upper flanks of the Roaring Run anticline, and take gas from the Murrysville and Hundred-foot sands.

Girty field.—About 45 wells in the vicinity of Girty are grouped in a separate field. They are located on the broad, double crest of the Roaring Run anticline and are good producers after several years of activity. The Murrysville and Hundred-foot sands are the reservoirs in this field also.

Roaring Run field.—The territory in this field extends along the valley of Roaring Run. The portion of the field within the Elders Ridge quadrangle contains about 20 wells, which are, for the most part, close to the axis of the Roaring Run anticline. Drilling began here in 1894, and progressed rapidly, so that nine wells were put down in six months. The Hundred-foot sand yields the most gas in this field.

Shellhammer field.—The gas field in the vicinity of Mateer, Burrell Township, takes its name from the farm on which the first producing well in the field was drilled. Operations began in 1899 and the field now contains about 30 wells. Gas is derived from the Hundred-foot and Pine Run sands. The Shellhammer field seems to be located on a low anticlinal fold, which crosses Crooked Creek a short distance below Cochran Mills, and which was called the Apollo anticline by Platt.

Rockville field.—The group of wells on the Greendale anticline in the northwest corner of the quadrangle is known as the Rockville field. The development of the field began in December, 1893, when a good flow of gas was struck on the Kealor farm. The producing sands in this field are the Murrysville or Salt, the Hundred-foot, and the Fifth sands.

Miscellaneous wells.—There are a number of wells in the quadrangle which can not properly be included in any of these fields. A group on the bend of Crooked Creek 3 miles below Cochran Mills was drilled largely by the Carnegie Natural Gas Company. Many of these wells are producing.

A well on the Hugh Blakley farm, a mile north of West Lebanon, which was located on the axis of the Elders Ridge syncline, got a strong flow of gas. On the other hand, a well drilled on the same axis at the creamery on the Smith farm near Elders Ridge yielded a very little gas, which was more than could be expected from its location. A second well, drilled to the Fifth sand on the same farm in 1903, was absolutely "dry".

A well at Salina and another at the mouth of Blacklegs Creek in the Elders Ridge syncline have yielded enough gas to light a few burners only, while a well between these two at the mouth of Long Run was unproductive. In a few cases deep holes sunk near the crest of an anticline have been very light "gasers" or unproductive. Among these are the Lohr No. 2, on the Dutch Run anticline north of Advance, the Ramsey well, on Dutch Run between the Willet and Plum Creek fields, and a well half a mile west of Kent on the Jacksonville anticline.

POSSIBLE EXTENSION OF FIELDS.

The delineation of the geologic structure on the structure and economic geology map suggests the directions in which there is the most chance of further drilling being remunerative. Territory which has not as yet been thoroughly tested and which promises to be gas bearing is (1) the narrow strip between Dutch Run and Russell Hill, extending from the Willet field to the Plum Creek field, and (2) along the crest of the Jacksonville anticline from Lewisville to Watts Hill at the head of Reeds Run.

DISPOSAL OF GAS.

The gas produced in the fields of this quadrangle is carried by pipe lines to more or less distant markets. The Indiana County Gas Company pipes gas from the Willet and Plum Creek fields to the town of Indiana. The Carnegie Natural Gas Company, Philadelphia Company, Peoples Natural Gas Company, and Pittsburg Plate Glass Company carry large quantities of gas by 16- and 20-inch trunk pipe lines to Pittsburg. The Apollo Gas Company furnishes gas for manufacturing purposes to the American Sheet and Tin Plate Company at Vandergrift, Hyde Park, and Leechburg.

OIL.

A trace of oil has been detected at various horizons in a number of wells drilled in this quadrangle. Only one well is producing oil, and that is in very small quantity. This is located on the St. Clair farm, a quarter of a mile east of Whitesburg, on the axis of the Apollo syncline. It sprays one barrel of oil every two days and the gas is said to have a minute pressure of 2 pounds. The rock pressure of this well is 70 pounds.

LIMESTONE.

Several thin and two heavy beds of limestone in the Allegheny and Monongahela formations are exposed in the area under discussion. It happens that the lowest rock in the geologic column here exposed is the Vanport limestone, which outcrops at two points on Crooked Creek, and the highest is the Benwood limestone, which crowns the hills at Elders Ridge. The limestone which lies a few feet below the Upper Freeport coal is generally considered a valuable fertilizer when burned. The Pittsburg limestone is also used for the same purpose. It is quarried in a small way on the Simon Townsend farm east of Olivet.

The Vanport limestone is quarried by stripping on the Coleman and Anderson farms on Crooked Creek near Girty and burned in open heaps. The lime thus made is used for enriching farm land and for all kinds of plastering.

SANDSTONE.

Sandstone suitable for building purposes occurs in several localities within the Elders Ridge quadrangle. The principal beds are the Kittanning, Freeport, and Butler, of the Allegheny formation, and the Mahoning, Saltsburg, Morgantown, and Connellsville, of the Conemaugh formation. These sandstones are mostly gray and buff, and vary from soft and loose-textured to hard and compact rocks. But few stone buildings have been constructed within this area, so the durability of the dressed stone is not known. The Kittanning, Freeport, and Butler sandstones are conspicuous in the bluffs on Crooked Creek below South Bend. The Kittanning sandstone was quarried at Girty many years ago for flagstones and tombstones. The Mahoning is particularly heavy at Jacksonville, and forms the top of the bluff at Cochran Mills. The Saltsburg is well developed in the vicinity of Lewisville and Salina, and on the ridge between Long Run and Roaring Run. A heavy sandstone which seems to be at the horizon of the Morgantown is conspicuous on the hilltops in the extreme northeast corner of the quadrangle and in the vicinity of West Lebanon.

Fifty feet below the Pittsburg coal a fairly heavy sandstone is often seen in this quadrangle. This is at the horizon of the Connellsville and is the highest sandstone in the area except the Pittsburg, which is not strongly developed here.

ARGILLACEOUS MATERIAL.

Fire clay.—Two beds of fire clay in the Allegheny formation are known to be of some value. They are the Upper Freeport and Lower Kittanning clays. The first of these lies a few feet below the Upper Freeport coal and is known as the Bolivar clay. The type locality is Bolivar on Conemaugh River, where the clay occurs from 10 to 20 feet below the Upper Freeport coal and is worked extensively. This clay is mined at Salina on Kiskiminitas River, by the Kier Fire Brick Company from a seam which varies from 6 to 13 feet in thickness. It includes both the hard flint clay and the soft plastic clay.

Stoneware clay.—On Crooked Creek just above Girty the geologic section is as follows:

Section at Girty.

	Feet.
Sandstone, used for flagstones	25
Shale and clay	1
Lower Kittanning coal	2½
Clay, impure	4
Potter's clay	4
Shales, ferruginous	25
Vanport limestone	7
Total	68½

The potter's clay which occurs a few feet below the Lower Kittanning coal is white, of fairly good quality, and is from 3 to 5 feet thick. Judging by the quality of the articles made from it, this is more properly a stoneware clay. Apparently it exists in some abundance and can be raised at little cost. The present method is stripping where the bed is from 2 to 4 feet below the surface. The McNees & George pottery at Girty, which has been conducted in a small way for twenty-five years, uses this clay. The industry can not be greatly enlarged because there is no railroad at this point. The stoneware articles made at this pottery are crocks, jugs, and pump tile. They are much esteemed in the neighborhood.

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

WATER.

The drainage system extends to all parts of the quadrangle, so that running water can be found within a short distance of any point. The largest stream is Kiskiminitas River, which has a width of about 500 feet, but is very shallow at many points. The other waterways are classed as creeks and runs. They are clear and pure, there being little cause for pollution, and the aeration over long stretches broken by riffles keeps the water potable.

This quadrangle is distinctly a rural district, devoted to agriculture; and, as is usual in such cases, the supply of water is drawn almost entirely from shallow wells and springs. It may be stated that in general springs are numerous, and water may be obtained at almost any point by sinking a well 10 to 30 feet below the surface. Water troughs are located commonly at the roadside springs.

Among the rocks which are known as good water bearers are the Mahoning sandstone, which lies just above the Upper Freeport coal and outcrops over the great part of this quadrangle, and the Pittsburg sandstone, which overlies the Pittsburg coal and is found in the southern portion of the quadrangle between Long Run and Blacklegs Creek.

The village of Avonmore, which has a population of about 700, derives its water supply from wells sunk in the sands and gravels of the river terrace on which it is built. Elderton, which is the next largest place, with a population of 300, is dependent upon private wells sunk to bed rock.

May, 1904.

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

TOPOGRAPHY

PENNSYLVANIA
ELDERS RIDGE QUADRANGLE

LEGEND

RELIEF
(printed in brown)

Figures *(showing heights above mean sea level instrumentally determined)*

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

DRAINAGE
(printed in blue)

Streams

Springs

CULTURE
(printed in black)

Roads and buildings

Churches and school houses

Private and secondary roads

Railroads and tramways

Tunnels

County lines

Township lines

City, village, and borough lines

Triangulation stations

Bench marks

H. M. Wilson, Geographer in charge.
Triangulation by A. H. Thompson.
Topography by Frank Sutton, E. B. Clark, and J. H. Wheat.

SURVEYED IN 1902 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.

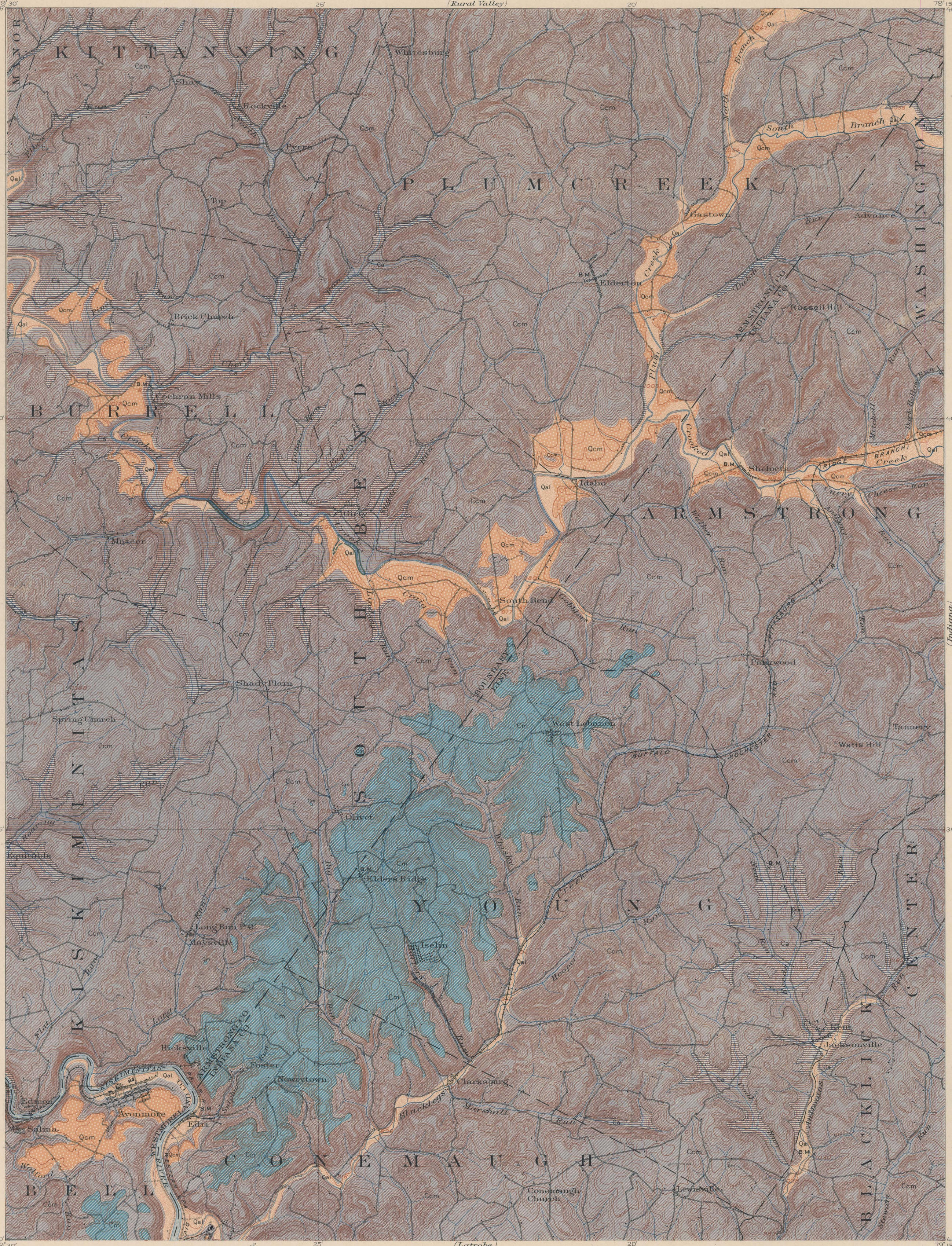
Datum is mean sea level.

Edition of April 1904, reprinted Feb. 1905.

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

AREAL GEOLOGY

PENNSYLVANIA
ELDERS RIDGE QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

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

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

CARBONIFEROUS — *Pennsylvanian*

Cm — Monongahela formation *(shale, limestone, and occasionally coarse sandstone; Pittsburg coal at the bottom)*

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

Ca / Cv — Allegheny formation and Vanport limestone lentil *(shale, sandstone, thin limestone, fire clay, and several beds of coal; Upper Freeport coal at the top)*

H. M. Wilson, Geographer in charge.
Triangulation by A. H. Thompson.
Topography by Frank Sutton, E. B. Clark, and J. H. Wheat.

SURVEYED IN 1902 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 Mar. 1905

Geology by Ralph W. Stone,
assisted by Lester H. Woolsey,
under the direction of M. R. Campbell.

SURVEYED IN 1902 IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

U.S. GEOLOGICAL SURVEY
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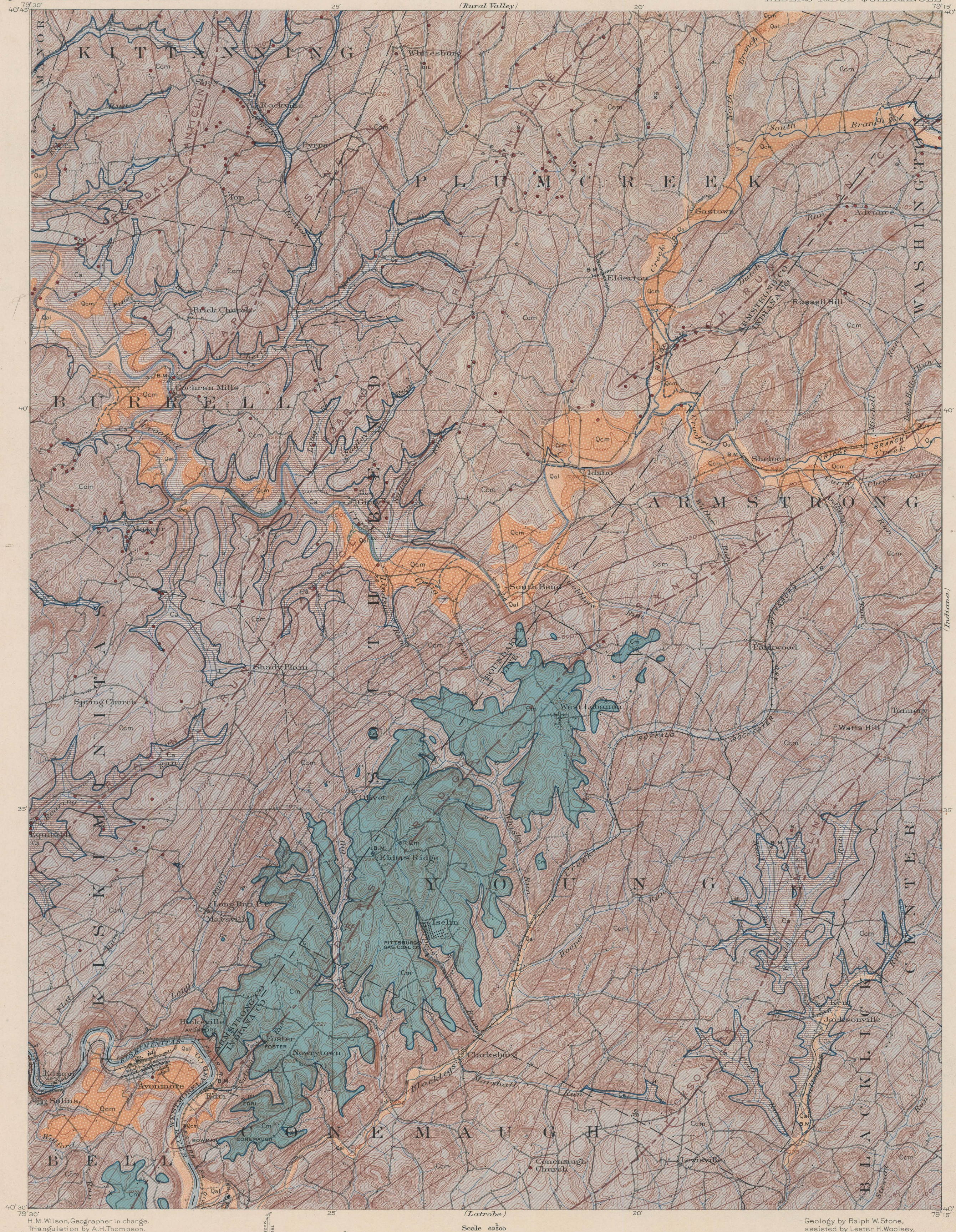
STRUCTURE AND ECONOMIC GEOLOGY

PENNSYLVANIA
ELDERS RIDGE QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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QUATERNARY

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

- Cm — **Monongahela formation** *(shale, limestone, and occasionally coarse sandstone; Pittsburg coal at the bottom)*
- Ccm — **Conemaugh formation** *(sandstone, shale, and limestone, with a few small coal beds)*
- Ca, Cv — **Allegheny formation and Vanport limestone lentil** *(shale, sandstone, thin limestone, fire clay, and several beds of coal; Upper Freeport coal at the top)*

Coal mines
Local coal banks
Gas wells
Deep wells, product unknown

Sections of numbered wells are shown on well-section sheet

Known productive areas

Important coal *(area underlain by Pittsburg coal)*

Coal outcrops *(Pittsburg, pb, Upper Freeport, uf, and Lower Freeport, lf, coals)*

Structure contours *(showing the elevation above sea and the lay of the Upper Freeport coal horizon)*

H.M. Wilson, Geographer in charge.
Triangulation by A.H. Thompson.
Topography by Frank Sutton, E.B. Clark, and J.H. Wheat.

SURVEYED IN 1902 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.
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Edition of Mar. 1905

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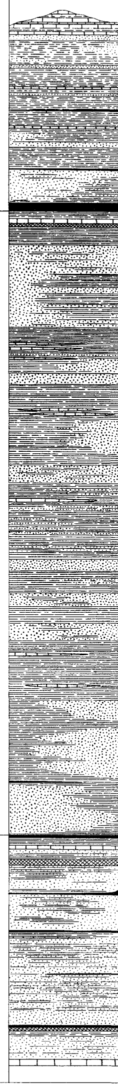
COLUMNAR SECTION

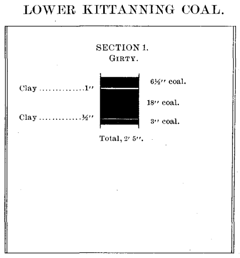
GENERALIZED SECTION FOR THE ELDERS RIDGE QUADRANGLE.
SCALE: 1 INCH=100 FEET.



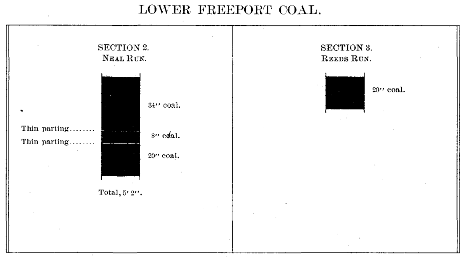
System.	Series.	Formation Name.	Symbol.	Thickness in Feet.	Names of Members.	Character and Distribution of Members.	General Character of Formations.
CARBONIFEROUS	PENNSYLVANIAN	Monongahela formation.	Cm	200±	Benwood limestone.	Blue limestone with calcareous shale beds. Outcrops at the top of a number of hills near Elders Ridge.	The most important coal-bearing formation of southwestern Pennsylvania. Composed chiefly of shales, but contains also thin limestones and locally developed sandstone. Only a portion of the Benwood limestone is present.
					Sewickley coal.	Persistent bed, but too thin and broken by partings to be of value.	
					Redstone coal.	Thin bed, of no value in this quadrangle.	
					Pittsburg sandstone.	Locally developed as massive sandstone. Sometimes represented by sandy shale.	
					Pittsburg coal.	Bed of coal, 6 to 10 feet thick, of great value.	
		Conemaugh formation.	Ccm	630±	Pittsburg limestone.	One to 6 feet of limestone of good quality. Burned into lime for fertilizing purposes.	Chiefly shales of various colors, green, drab, and red the most pronounced, interstratified with beds of coarse sandstone which are fairly persistent, but which occasionally lose their distinctive character. Contains also a few thin beds of limestone and coal.
					Connellsville sandstone.	Variable bed of coarse sandstone 40 to 60 feet below the Pittsburg coal.	
					Morgantown sandstone.	Massive sandstone about 180 feet below the Pittsburg coal.	
					Ames limestone.	Thin and inconspicuous; green, full of crinoid stems and brachiopods.	
					Saltsburg sandstone.	Coarse sandstone, massive in southern part of quadrangle, but often replaced by shale and shaly sandstone in northern part. Outcrops near Ebenezer and Salina.	
					Mahoning sandstone.	Coarse sandstone. Generally present, but occasionally replaced by sandy shale.	
		Allegheny formation.	Ca	240±	Upper Freeport coal.	Exposed in many places. Generally about 4 feet thick.	Sandstone and shale, with several beds of limestone and fire clay and four beds of coal locally of value.
					Bolivar fire clay.	Excellent hard clay, averaging 5 feet thick at Salina, where it is mined.	
					Lower Freeport coal.	Generally present, but thin. It thickens locally north of Kent and is mined at Neal Run.	
					Upper Kittanning coal.	Generally thin, but has been mined at the mouth of Cherry Run.	
					Middle Kittanning coal.	Extremely thin and valueless, sometimes absent.	
					Lower Kittanning coal.	About 3 feet thick, and outcrops on Crooked Creek near Girty.	
					Vanport limestone.	Eight to 10 feet of gray, fossiliferous limestone. Outcrops on Crooked Creek near Girty.	

SECTION OF COAL SEAMS IN ELDERS RIDGE QUADRANGLE AND VICINITY.
SCALE: 1 INCH=5 FEET.

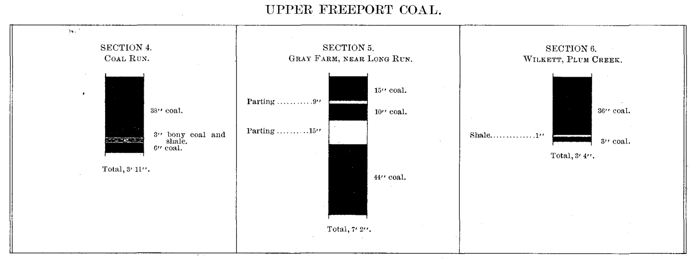
LOWER KITTANNING COAL.



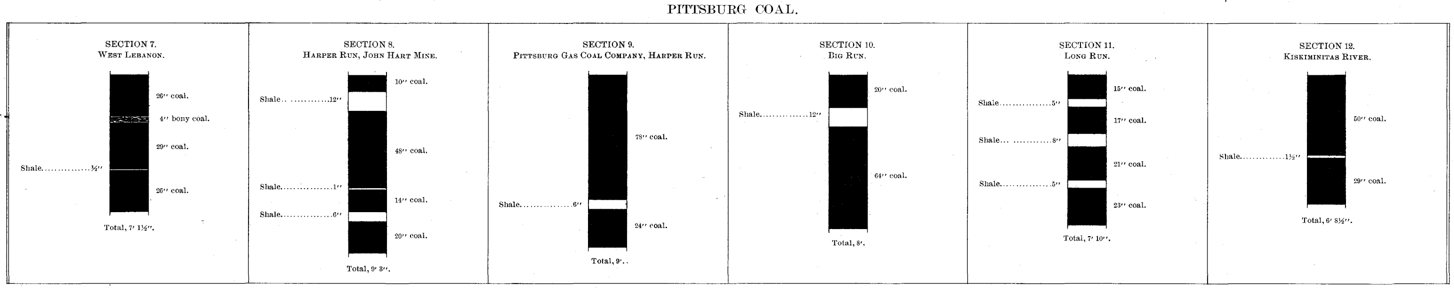
LOWER FREEPORT COAL.



UPPER FREEPORT COAL.

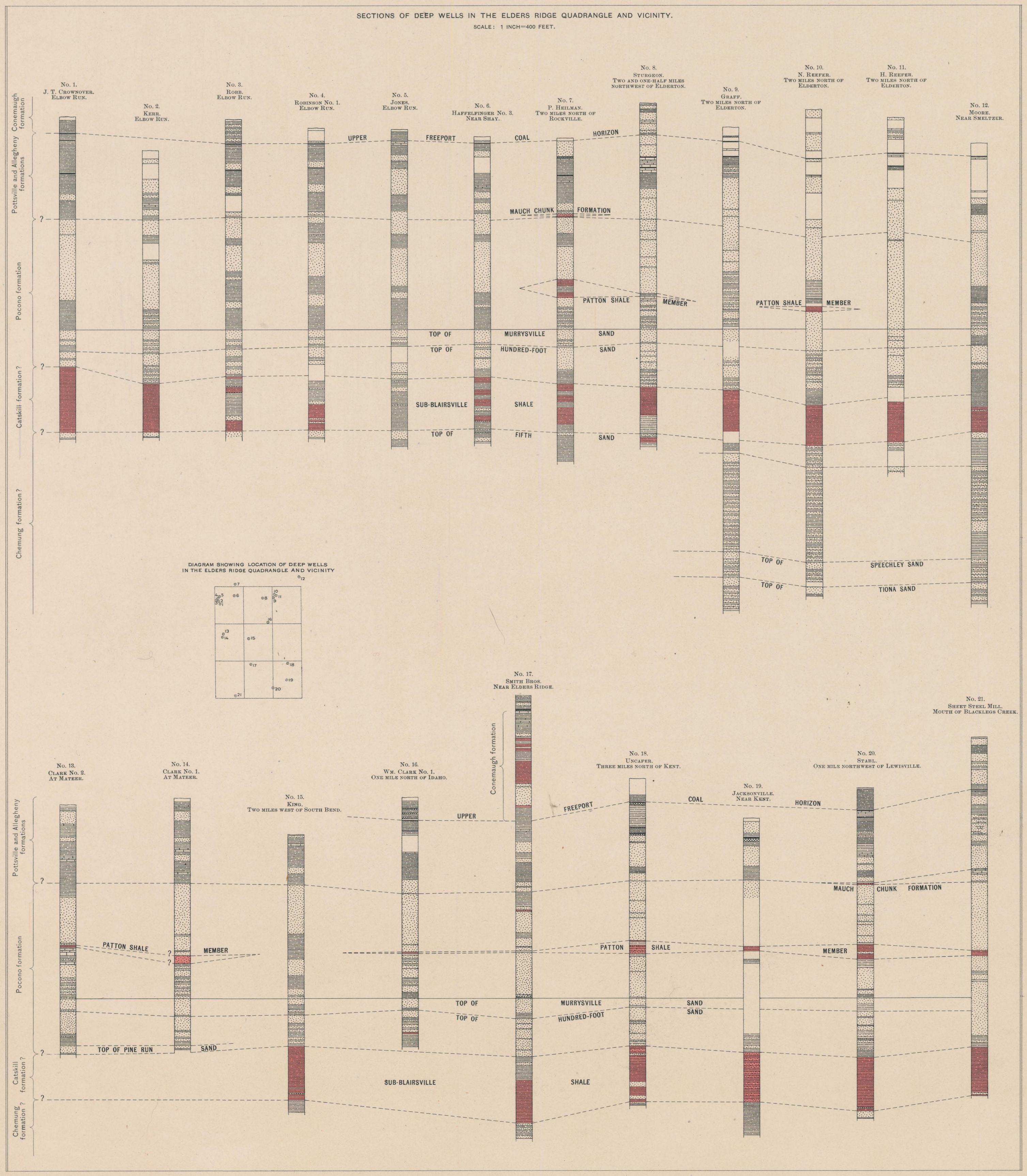


PITTSBURG COAL.



RALPH W. STONE,
Geologist.

WELL SECTIONS



RALPH W. STONE,
Geologist.

ILLUSTRATIONS

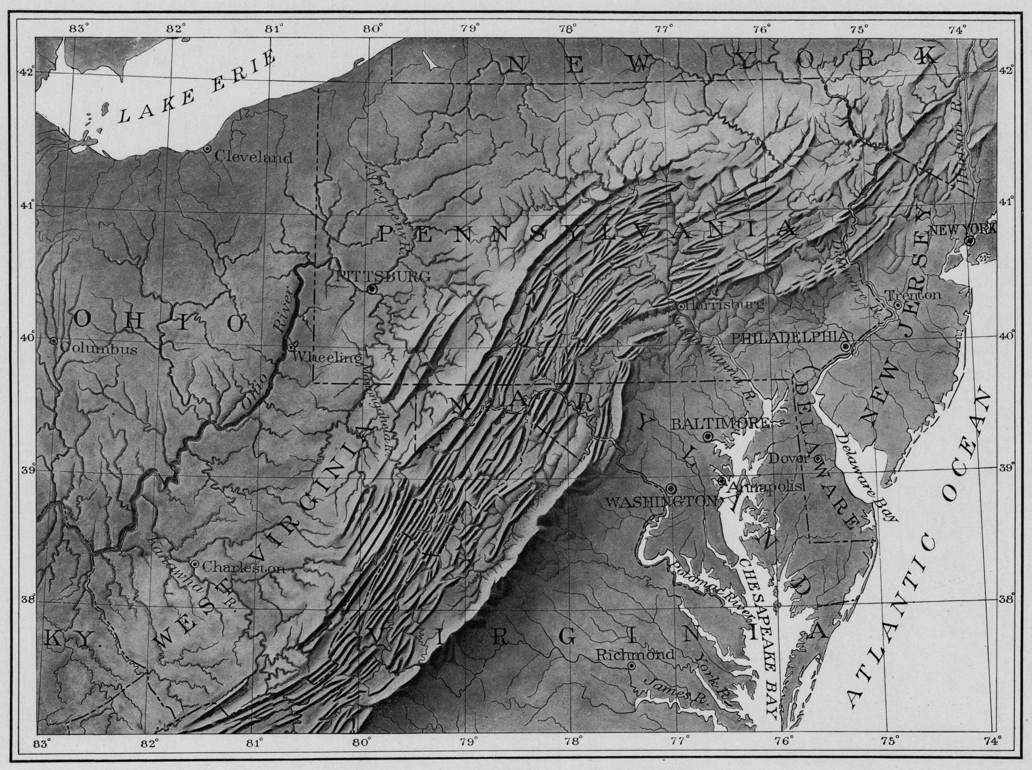


FIG. 3.—RELIEF MAP OF THE NORTHERN APPALACHIAN MOUNTAINS.

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

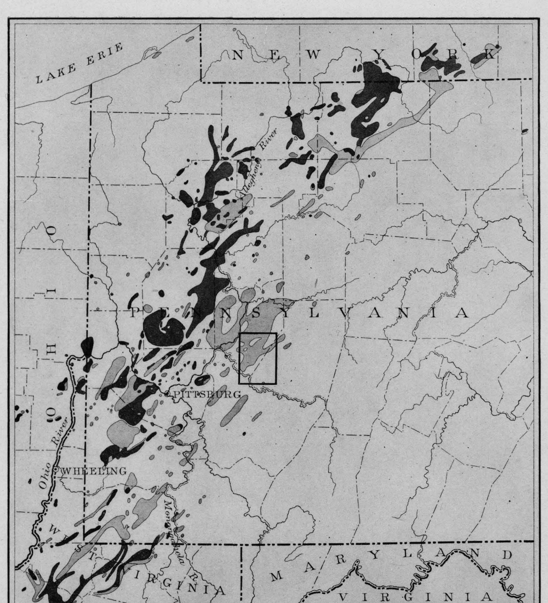


FIG. 4.—MAP SHOWING THE DISTRIBUTION OF THE GAS AND OIL POOLS IN WESTERN PENNSYLVANIA.

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 Elders Ridge quadrangle is shown by the rectangle.

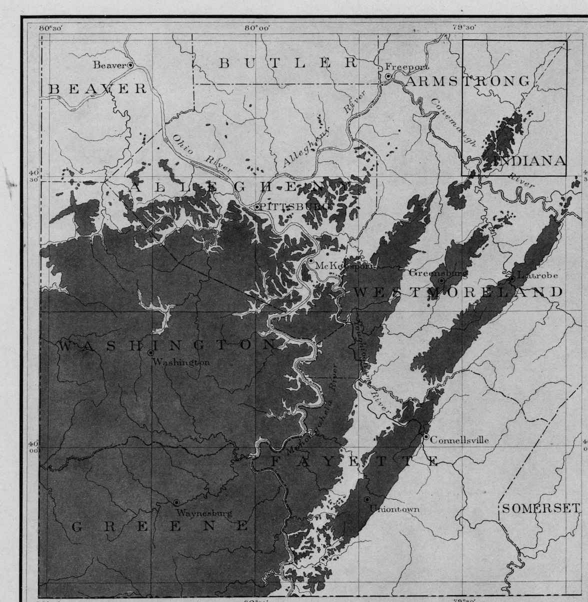


FIG. 5.—MAP SHOWING THE AREA OF THE PITTSBURG COAL IN PENNSYLVANIA.

The Elders Ridge quadrangle is at the northeastern extremity of the field, as indicated by the rectangle.

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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
62	Menominee Special	Michigan	25
63	Mother Lode District	California	50
64	Uvalde	Texas	25
65	Tintic Special	Utah	25
66	Colfax	California	25
67	Danville	Illinois-Indiana	25
68	Walsenburg	Colorado	25
69	Huntington	West Virginia-Ohio	25
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
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94	Brownsville-Connellsville	Pennsylvania	25
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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

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