DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

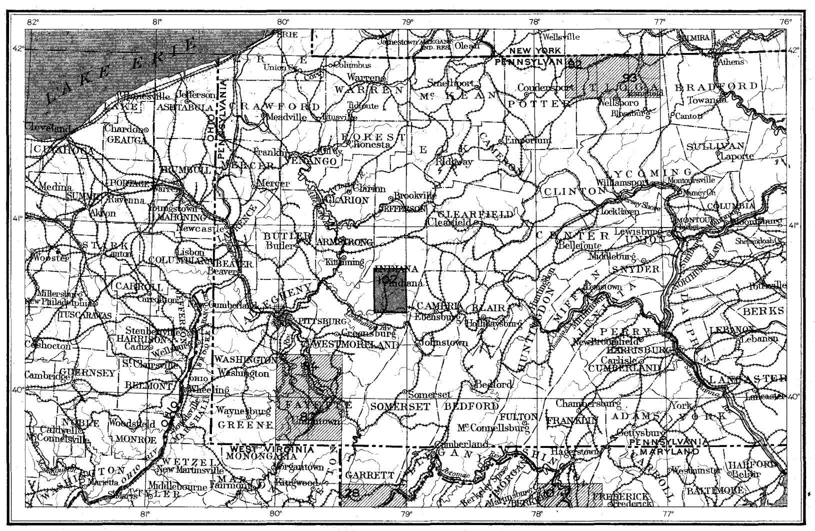
OF THE

UNITED STATES

INDIANA FOLIO

PENNSYLVANIA

INDEX MAP



SCALE: 40 MILES-1 INCH

AREA OF THE INDIANA FOLIO

AREA OF OTHER PUBLISHED FOLIOS

CONTENTS

LIBRARY EDITION

INDIANA FOLIO
NO. 102

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

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

1904

GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES.

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

THE TOPOGRAPHIC MAP.

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

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

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

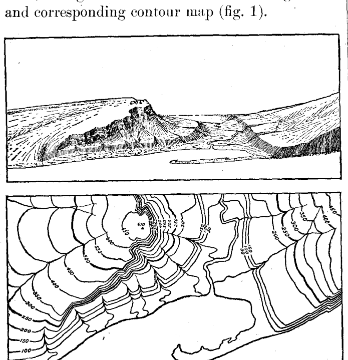


FIG. 1.—Ideal view and corresponding contour map.

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

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

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

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

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

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

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

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

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

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

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

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

THE GEOLOGIC MAPS.

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

KINDS OF ROCKS.

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

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

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

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

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

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

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

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

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

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

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

FORMATIONS.

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

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

AGES OF ROCKS.

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

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

(Continued on third page of cover.)

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

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

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

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

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

Symbols and colors assigned to the rock systems.

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

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

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

SURFACE FORMS.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

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

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

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

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

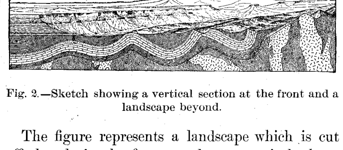


Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

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

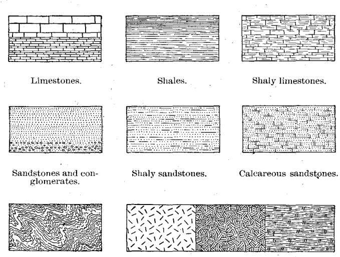


Fig. 3.—Symbols used in sections to represent different kinds of rocks.

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

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

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

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

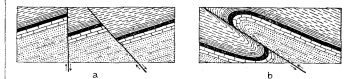


Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

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

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

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

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

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

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

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

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

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

CHARLES D. WALCOTT,
Director.

Revised January, 1904.

DESCRIPTION OF THE INDIANA QUADRANGLE.

By George B. Richardson.

GEOGRAPHY.

LOCATION AND AREA.

The Indiana quadrangle, which embraces one-sixteenth of a square degree of the earth's surface, extends from latitude 40° 30′ to 40° 45′ and from longitude 79° 00′ to 79° 15′, and has an area of about 227 square miles. It is situated in Indiana County, Pennsylvania, and is named from the town of Indiana, which is in the central portion of the quadrangle.[1]

TRIANGULATION DATA.

The triangulation stations described below, determined by the United States Geological Survey, give precise locations for several points within and adjacent to the Indiana quadrangle. Their locations are shown in fig. 1. These stations are

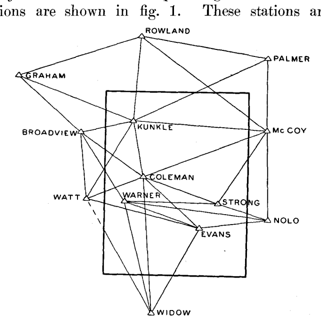


FIG. 1.—Diagram showing triangulation stations on which the survey of the quadrangle is based.

marked by stone posts 42x6x6 inches, set about 3 feet in the ground, in the center of the top of which are cemented bronze tablets marked "U. S. Geological Survey—Pennsylvania."

KUNKLE, INDIANA COUNTY.

On land owned by Philip Kunkle; about 3 miles north of Creekside post-office, near western end of a high ridge having scattered trees on the eastern end. Latitude, 40° 42′ 28.78″. Longitude, 79° 12′ 14.09″.

COLEMAN, INDIANA COUNTY.

In White Township, about 2 miles west of Indiana, on land owned by D. Coleman.

Reference marks: Stone sunk 2 feet below surface of ground in direction of Kunkle station; distant 10.2 feet to cross on stone. Stone sunk 18 inches below surface of ground in direction of Warner station; distant 12.3 feet to cross on stone. Latitude, 40° 38′ 09.95″. Longitude, 79° 11′ 02.71″.

ROWLAND, INDIANA COUNTY.

On a high hill on land owned by W. S. Rowland; about 4 miles north of Plumville, in North Mahoning Township, and near the line between North Mahoning and South Mahoning townships. Latitude, 40° 36′ 29.07″. Longitude, 79° 11′ 32.36″.

WARNER, INDIANA COUNTY.

About 3 miles southwest of Indiana, in White Township, on the highest part of a bare, round-top hill, on land owned by Mr. Warner. Latitude, 40° 36′ 29.07″. Longitude, 79° 13′ 10.50″.

NOLO, INDIANA COUNTY.

About one-fourth mile north of Nolo post-office, on land owned by Mr. McCaffery, on high ground, but not the highest point.

Reference marks: Stones set 1 foot below surface of ground, with cross on top, and set on line with Evans and McCoy; distant 10 feet from station. Latitude, 40° 34′ 28.50″. Longitude, 78° 57′ 41.33″.

STRONG, INDIANA COUNTY.

In Cherryhill Township, about 2 miles southwest of Greenville village, on the highest hill in the immediate vicinity, on land owned by H. B. Strong. There is a lone tree on the southwest part of the hill. Latitude, 40° 35′ 58.92″. Longitude, 79° 03′ 14.39″.

EVANS, INDIANA COUNTY.

On Evans Hill, Brush Valley Township, on land owned by John Evans, on highest part of hill, cleared of timber with the exception of two small chestnut trees. Latitude, 40° 34′ 13.27″. Longitude, 79° 05′ 06.43″.

INDIANA NORMAL SCHOOL, INDIANA COUNTY.

(Not occupied.)

Station mark: Cupola of Normal School Building. Latitude, 40° 37′ 02.69″. Longitude, 79° 09′ 31.86″.

WIDOW, INDIANA COUNTY.

In Blacklick Township, about 6 miles east of Blairsville, on the Blairsville and Ebensburg pike, on a bare hill about 20 rods south of the road, on land owned by the heirs of J. W. Thompson. Latitude, 40° 26′ 57.89″. Longitude, 79° 09′ 54.27″.

WATT, INDIANA COUNTY.

About 1 mile southwest of Tannery post-office and 1¾ miles northeast of Parkwood post-office, on the highest point of the western one of two hills about the same height and 1 mile apart. The land is owned by Thomas Watt. Latitude, 40° 36′ 02.99″. Longitude, 79° 16′ 45.32″.

BROADVIEW, INDIANA COUNTY.

About 3½ miles north of Shelocta and a few rods east of the Armstrong–Indiana county line, on a high, bare hill, with some timber on the southwest slope. The land is owned by John Russell. Latitude, 40° 41′ 16.95″. Longitude, 79° 17′ 28.00″.

GRAHAM, ARMSTRONG COUNTY.

About 1 mile east of Blanket Hill post-office, on a bare ridge of cultivated land owned by the Graham heirs and rented by W. A. Blose.

Reference marks: A chestnut tree 24 inches in diameter, magnetic bearing S. 23° W., distant 415 feet. A dead chestnut tree 18 inches in diameter, S. 86° W., distant 257 feet. Latitude, 40° 46′ 17.28″. Longitude, 79° 24′ 50.74″.

M'COY, INDIANA COUNTY.

About 1 mile southeast of Taylorville post-office, on a bare, round-top hill owned by James McCoy. Latitude, 40° 41′ 59.77″. Longitude, 78° 58′ 08.22″.

PALMER, INDIANA COUNTY.

About 2½ miles south of Rochester Mills post-office, in Grant Township, on a very high, partly cleared ridge, on land owned by Mr. Palmer.

Reference marks: Stones set 1 foot below surface of ground, with cross on top, in line with stations Rowland and McCoy; distant 10 feet from station. Latitude, 40° 47′ 40.71″. Longitude, 78° 58′ 32.74″.

SPIRIT LEVELING DATA.

BLAIRSVILLE, ALONG PENNSYLVANIA RAILROAD, TO HOMER.

	Feet.
Blairsville, Pennsylvania Railroad passenger station; northeast corner of, on foundation offset, Pennsylvania Railroad bench mark No. 60, a square chiseled mark	1,011.908
Blairsville, Walnut street bridge; northeast wing wall of, on coping stone, aluminum tablet, marked "1003 PITTSBURG"	1,003.076
Blairsville, Maple street crossing; top of rail at	1,010
Turner station, top of west rail at	1,100
Tunnel station, 900 feet north of; in a cut, stone, chiseled mark	1,090.98
Smiths station, road crossing; top of west rail at	1,074
Smiths station, 1.5 miles north of, bridge over small stream; on northwest abutment of, chiseled mark	968.05
Blacklick station, opposite; top of west rail	967
Blacklick station, 900 feet north of; west side of railroad, rock, chiseled mark	972.05
Blacklick station, 6 miles north of, railroad bridge over Two Lick Creek; southwest corner of south abutment, on coping stone, bronze tablet, marked "981 PITTSBURG"	980.509
Blacklick station, 1 mile north of; at road crossing, top of east rail	1,009
Rugh station, opposite; top of west rail	1,028.5
Rugh station, 5 miles north of; at road crossing, top of west rail	1,019
Graceton, 0.5 mile south of station; bridge over small stream; southwest wing wall, on coping stone, chiseled mark	1,020.37
South Graceton, road crossing; top of rail at	1,063.0
Graceton, opposite station; top of rail	1,060
Graceton, 1.8 miles north of station; small culvert, top stone, chiseled mark	1,042.20
Homer, 1 mile south of; small culvert, northeast coping stone, chiseled mark	1,014.36
Homer, 600 feet south of station; bridge over Yellow Creek; northwest wing wall, on coping stone, aluminum tablet, marked "1019 PITTSBURG"	1,019.092

HOMER, ALONG PENNSYLVANIA RAILROAD, TO INDIANA.

	Feet.
Homer, opposite station; top of rail	1,023
Homer, 1 mile north of; small culvert, chiseled mark	1,047.08
Two Lick, 2 miles south of station; bridge over Two Lick Creek; northwest wing wall, coping stone, chiseled mark	1,048.12
Two Lick, opposite station; top of rail	1,057.4
Two Lick, 1 mile north of; stone bridge, northeast coping stone, chiseled mark	1,109.27
Two Lick, 1.1 miles north of; stone bridge No. 9, northwest coping stone, chiseled mark	1,120
Two Lick, 1.6 miles north of; 3 miles south of Indiana; bridge, top of rail	1,127.7
Reed station, 900 feet south of; on a cut, on west side of railroad, stone, chiseled mark	1,137.11
Reed station, 600 feet south of; at road crossing, top of rail	1,145.5
Reed station, opposite; top of west rail	1,149
Reed station, 600 feet north of; at road crossing, top of rail	1,163
Normal, 1 mile south of; bridge, northwest wing wall, chiseled mark	1,227.89
Indiana, 1.3 miles south of; small bridge, northwest wing wall, chiseled mark	1,235.36
Indiana, Normal School campus; south meridian stone	1,292.51
Indiana, Normal School campus, on north meridian stone in; copper tablet, marked "1299 PITTSBURG 1900"	1,299.022

INDIANA, VIA CREEKSIDE, GAIBLETON, PENN RUN, AND BRUSH VALLEY, TO HOMER.

	Feet.
Indiana, School street crossing; top of rail	1,302
Indiana, Church street crossing; top of rail	1,307.2
Indiana, opposite station; top of west rail	1,309.3
Indiana, 75 feet west of station; stone set in street, chiseled mark	1,311.20
Indiana, 1.7 miles northwest; south side of road, nail in root of chestnut tree	1,432.68
Indiana, 2 miles northwest of; summit, on root of large double chestnut tree, paint marked	1,497.80
Indiana, 2.25 miles west of; on west side of road, on root of oak tree, "No. 24" made by coal prospectors	1,390.10
Indiana, 2.5 miles northwest of; nail in root of oak tree	1,354.10
Indiana, 2.7 miles northwest of; on east side of road, nail in root of large oak tree	1,219
Indiana, 4 miles northwest of; nail in telephone pole	1,130.15
Creekside, 1 mile southwest of; iron bridge over Crooked Creek, southwest wing wall, coping stone, chiseled mark	1,020.80
Creekside, M. E. church, entrance to; in southwest corner stone, copper tablet, marked "1034 PITTSBURG"	1,033.678
Creekside, 1.75 miles north of; covered bridge, northeast abutment, coping stone, chiseled mark	1,046.76
Chambersville, 1 mile south of; covered bridge over Crooked Creek, southeast wing wall, coping stone, chiseled mark	1,047.71
Chambersville, 300 feet south of post-office; on east side of road, rock, chiseled mark	1,072.96
Chambersville, 1.24 miles north of; 500 feet south of schoolhouse, at road leading west, nail in root of oak tree	1,065.15
Gaibleton, 1 mile south of post-office; east side of road, rock, chiseled mark	1,150.93
Gaibleton, 650 feet south of post-office; double-arched stone bridge, west side of road, on coping stone, north arch, aluminum tablet, marked "1087 PITTSBURG"	1,086.388
Kintersburg, in crossroad at; chiseled mark	1,104.56
Tanoma, 0.5 mile west of post-office; south side of road, rock, chiseled mark	1,140.52
Tanoma, Tanoma House; bay window, in top foundation stone of, aluminum tablet, marked "1132 PITTSBURG"	1,132.225
Tanoma, 1.5 miles southeast of; at crossroad, stone, chiseled mark	1,173.05
Tanoma, 2.25 miles south of; oak tree standing in road, nail in root of	1,401.49
Tanoma, 4 miles east of; 30 feet north of schoolhouse, on west side of road, rock, chiseled mark	1,285.02
Tanoma, 4.25 miles east of; covered bridge, southeast wing wall, coping stone, chiseled mark	1,191.61
Penn Run, 2 miles west of post-office; south side of road, rock, chiseled mark	1,265.47
Penn Run, 1 mile west of post-office; on rock under wild cherry tree, chiseled mark	1,404.46
Penn Run, Presbyterian Church, on lower stone step of; bronze tablet, marked "1475 PITTSBURG"	1,474.578
Pikes Peak, 1.5 miles southwest of; north side of road, rock, chiseled mark	1,423.11
Pikes Peak, 2.2 miles southwest; bridge over Yellow Creek	1,262
Brush Valley, 2.5 miles northeast of post-office; south side of road, by red house, stone, chiseled mark	1,385.30
Brush Valley, 300 feet northeast of post-office; nail in root of oak tree	1,403.47
Brush Valley, Union House, entrance to; in south end of top stone step of, bronze tablet, marked "1448 PITTSBURG"	1,448.267
Brush Valley, 1.5 miles west of; nearly opposite chestnut tree on north side of road; south side of road, rock, chiseled mark	1,585.86
Brush Valley, 3 miles west of; south side of road, by log house, rock, chiseled mark	1,505.73
Homer, 2.25 miles east of; north side of road, under large white oak, rock, chiseled mark	1,526.84
Homer, 2 miles east of; on west side of road, rock, chiseled mark	1,396.66
Homer, opposite schoolhouse; corner of street, stone, chiseled mark	1,061.93

CUMMINS BRIDGE TO SHELOCTA.

	Feet.
Creekside, 1 mile southwest of; iron bridge over Crooked Creek, southwest wing wall, coping stone, chiseled mark	1,020.80
Shelocta, 3.5 miles east of; south side of road, nail in root of oak tree	1,052.40
Shelocta, 2.75 miles east of; under clump of oak trees, rock, chiseled mark	1,054.80
Shelocta, 1.25 miles east of; south side of road, near barn and nearly opposite house on north side of road, rock, chiseled mark	1,013.65
Shelocta, 0.25 mile east of; at intersection of roads, near covered bridge, rock, chiseled mark	994.45
Shelocta, covered bridge over Crooked Creek at west end of; northeast wing wall of, coping stone, bronze tablet, marked "992 PITTSBURG"	991.414

GENERAL RELATIONS.

Appalachian province.—The Indiana quadrangle lies within the Appalachian province—a well-defined area whose different parts have a closely related history. This province extends from the Atlantic Coastal Plain on the east to the Prairie Plains of Ohio and Indiana and the lowlands of the Mississippi River on the west, and from New York to Alabama. Both topographically and geologically the Appalachian province is naturally divided into three longitudinal belts. Fig. 14, on the Illustration sheet, shows these divisions for the northern part of the province.

Piedmont Plateau.—The easternmost division of the Appalachian province is the Piedmont Plateau, which in Pennsylvania is a hilly region of complex structure. It is underlain largely by crystalline rocks of pre-Cambrian age. The western limit of the plateau is formed by the Blue Ridge, which extends into Pennsylvania nearly to the Susquehanna River, where it is known locally as the South Mountain. Eastward the Piedmont Plateau reaches to the "fall line" which extends in a northeast-southwest direction through Philadelphia and Trenton, and marks the eastern boundary of the crystalline rocks and the western limit of the flat-lying sediments of the Atlantic Coastal Plain.

Appalachian ridges and valleys.—The central belt of the Appalachian province is characterized by a series of longitudinal northeast-southwest ridges and intervening valleys. The rocks of this region are of Paleozoic age and include limestones, sandstones, and shales, which have been much folded and faulted. As shown by fig. 14, this region occupies central and northeastern Pennsylvania.

Allegheny Plateaus.—On the west the Appalachian ridges generally are sharply limited by the Allegheny Front. This is a bold southeastward-facing escarpment, which defines the eastern termination of the third great division of the Appalachian province—the Allegheny Plateaus. The Allegheny Front is not prominent among the ridges of the anthracite belt in northeastern Pennsylvania, but farther south the escarpment becomes more pronounced. It is well marked where it is crossed by the Pennsylvania Railroad at the Horseshoe Curve, and thence continues southwestward across Maryland into West Virginia and Tennessee, where the Allegheny Front is represented by the eastern escarpment of the Cumberland Plateau.

As implied by the name Allegheny Plateaus, the general topographic character of the western division is that of a plateau—an upland contiguous on the one hand to the Prairie Plains and the lowlands of the Mississippi, and on the other hand to the Appalachian ridges and valleys. This region is underlain by Paleozoic sedimentary rocks and includes the Appalachian bituminous coal field. The structure of the Allegheny Plateaus is simple compared with that of the central Appalachian belt. The strata lie nearly flat and their regularity is broken only by small faults and by low, broad folds.

Topographically the western division of the Appalachian province is composed of a number of plateaus of different altitude, the surface features of which are dissimilar.

[1] The Indiana quadrangle is included in the area surveyed by W. G. Platt in 1877, and his report on Indiana County (HHHH), published by the Second Geological Survey of Pennsylvania, has been frequently consulted in the preparation of this folio.

The most pronounced plateau is along the eastern limit of the division and extends practically the entire length of the Appalachian province. In central Alabama the surface of this plateau has an elevation of 500 feet above sea level. The altitude increases to 1700 feet at Chattanooga, 2400 feet at Cumberland Gap, 3500 feet at New River, and probably 4000 feet at its culminating point in central West Virginia. From this point it descends to about 2800 feet on the southern line of Pennsylvania and to 2000 or 2200 feet in the central part of the State. North of this region the plateau character of the surface is widely developed in the northern counties of Pennsylvania and throughout southern New York, where the altitude ranges from 2000 to 2400 feet. The surface is best preserved as a plain in Alabama and Tennessee, where it constitutes the Cumberland Plateau. This feature is fairly well developed as far as the Kentucky line, but thence northward stream dissection has progressed so far as to greatly obscure the character and the former extent of the plain. Still, there are many areas of high land, as far north as southern New York, that seem to mark a former more or less even surface.

The flat-topped surface of this plateau slopes westward, and it is generally separated from the next lower plateau by a more or less regular westward-facing escarpment. This escarpment is most pronounced in Tennessee, where it has a height of 1000 feet and separates the Cumberland Plateau on the east from the Highland Plateau on the west. Toward the north the height of the escarpment diminishes to 500 feet in central Kentucky, and north of Ohio River its development is so indistinct that no traces of it have been recognized. In southern Pennsylvania the escarpment becomes more pronounced where the hard rocks of Chestnut Ridge rise abruptly above the plains formed on the soft rocks of the Monongahela and Allegheny valleys, but there the surface of the uppermost plateau is so greatly dissected that it can be recognized with difficulty. Toward the central part of the State the plateau surfaces that are usually separated by this escarpment approach each other and the escarpment is merged in a mass of irregular hills which seem to represent all that remains of the higher plateau.

A second plateau surface is well developed as a separate and distinct feature in Tennessee and Kentucky. It is known in Tennessee as the Highland Plateau and in Kentucky as the Lexington Plain. This second plateau also slopes to the west, but along its eastern margin it holds a constant altitude throughout these States of about 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 position is more difficult to determine. The plateau appears to rise from an altitude of 700 or 800 feet in Indiana to 1000 feet in Ohio, 1200 to 1300 feet in southwestern Pennsylvania, and probably 1600 to 1800 feet throughout the northern part of the State and the southern part of New York. The surface features of this plateau are variable, but there is not so much diversity as in the higher one. In Kentucky and Tennessee this lower plateau is preserved in large areas as a nearly featureless plain, but in other States it was less perfectly developed, and it has suffered greatly from dissection since it was elevated.[1]

TOPOGRAPHY.

Physiographic relations.—The two characteristic plains of the Allegheny Plateaus described above are represented in the Indiana quadrangle, but their features are so indistinct as to be almost unrecognizable. Chestnut Ridge represents the escarpment which elsewhere divides the lower, western plateau from the higher plateau on the east.

West of Chestnut Ridge rounded hilltops and divides, ranging in elevation from 1250 to 1400 feet, are thought to mark the lower, western plateau. It is supposed that they are the remnants of a more or less even surface which was produced by long-continued stream action when the entire region was nearer sea level than now, probably in Tertiary time. Later uplift and exposure to subaerial conditions have caused such erosion of the country as to leave in western Pennsylvania only the present faint traces of the old surface of denudation.

The top of Chestnut Ridge is the sole remnant in the quadrangle of the older and higher plateau. Remnants of this plateau are strikingly apparent in the area lying eastward, in the even-crested sky line formed by the tops of Dias Ridge and Laurel Hill as seen from the top of Chestnut Ridge. It is thought that this sky line marks an old land surface which once constituted an extensive and approximately flat low-lying plain. The geologic date of the formation of this old plain, the last traces of which are now passing away, is not known, but, possibly, when detailed mapping shall have progressed across the State to the Atlantic Coast, this physiographic stage can be correlated with a similar stage there recognized and referred to Cretaceous time.

Surface relief.—Chestnut Ridge is the most pronounced topographic feature of the Indiana quadrangle. The ridge enters in the south-central part and extends northeastward across the quadrangle. It is a narrow highland belt, the distance from valley to valley on either side being only about 5 miles. The western slope is the steeper, there being a change in altitude of 800 feet from the top of the ridge to Two Lick Creek, while on the east the fall to Brush Valley is only about 500 feet. The ridge is dissected, but within the limits of the quadrangle is crossed by only one stream, Yellow Creek, which flows in a narrow gorge. The top of the ridge is characterized by a number of knobs, ranging in elevation from 1700 to 1900 feet. Chestnut Ridge marks the position of an anticline, which will be referred to below. It is capped by heavy sandstone, blocks of which litter the slopes and make the region difficult of access.

Dias Ridge, sometimes called Nolo Ridge, occupies a small area in the southeast corner of the quadrangle. It is similar to Chestnut Ridge, from which it is separated by a gently undulating valley formed in shale and drained by Brush Creek.

West of Chestnut Ridge the country is more open and the topography is less rough. The region is occupied by three southwestward-flowing streams, Two Lick and Crooked creeks, which have cut broad and well-pronounced valleys in the general upland surface, and the South Branch of Plum Creek, which drains the northwest corner of the quadrangle. The divides between these creeks form low, ill-defined ridges, the tops of which are marked by isolated, rounded knobs. In the southwest corner of the quadrangle the hilltops range between 1250 and 1400 feet in elevation. The divide between Two Lick and Crooked creeks is a higher area, much of which is above 1500 feet, and a number of hilltops reach 1600 feet. Between Crooked Creek and the South Branch of Plum Creek the surface is lower, the hills averaging only about 1400 feet.

The area adjacent to the town of Indiana is characterized by gently undulating topography, marked by a few low, rounded hills. This open stretch contrasts strongly with the rougher surrounding country, and doubtless accounts for the fact that this part of the country was settled early, the relatively fertile, gently rolling country being naturally more attractive than the ridges.

Drainage.—The drainage of the Indiana quadrangle passes entirely into Allegheny River. The main waterways are Two Lick, Yellow, and Brush creeks, which flow southward to join the Allegheny by way of Black Lick Creek and Conemaugh River, and Crooked Creek, with its tributary, South Branch of Plum Creek, which, flowing westward, reaches the Allegheny by a more direct route. The northeast corner of the quadrangle is but a few miles from the divide between the Atlantic and the Gulf of Mexico, where the headwaters of the West Branch of Susquehanna River approach those of Two Lick Creek.

An interesting feature of the local drainage is the abnormal direction of flow of the headwaters of McKee Run and Crooked Creek. Branches of McKee Run heading near Grove Chapel have courses which suggest that they have not always flowed into Crooked Creek, and some tributaries of Crooked Creek in the vicinity of Tanoma and Onberg likewise are reversed. Between Onberg and Tanoma, Crooked Creek flows northward, while its branches flow southward. These facts suggest that in an earlier stage of stream development in this region the drainage of the area between the towns of Indiana and Dixonville was different from the existing system. There seems to have been a reversal of drainage, in consequence of which certain streams which formerly were tributary to Two Lick Creek now flow into Crooked Creek. For some reason, streams draining into Crooked Creek had the advantage over those which flowed into Two Lick, whereby the Crooked Creek drainage was enabled to cut back the divides at the expense of the Two Lick drainage until finally the headwaters of certain branches of Two Lick were tapped and their drainage was turned into Crooked Creek.

GEOLOGY.

STRATIGRAPHY.

CARBONIFEROUS SYSTEM.

Character and thickness.—The rocks exposed at the surface in the Indiana quadrangle, except the alluvium found in the creek bottoms, are all of Carboniferous age. Fig. 15, on the Illustration sheet, shows the extent of the northern portion of the Appalachian bituminous coal field and the position of the Indiana quadrangle, from which it is seen that the area under consideration is within the coal field, though it lies just outside the region of the Pittsburg coal.

The surface rocks belong chiefly to the Conemaugh and Allegheny formations, but where Two Lick and Yellow creeks and Allen Run cut through Chestnut Ridge the Pottsville formation is exposed, and on Yellow Creek, for a short distance probably, the Mauch Chunk shales also outcrop. From the lowest geologic horizon to the highest, only about 1100 feet of rocks in vertical thickness intervene. These rocks are shales, sandstones, thin limestones, and coals, whose sequence is shown on the Columnar Section sheet.

The different sections illustrate the variability of the succession. Though a section in one part of the quadrangle may have approximately the thickness and general character of a corresponding section in another part, it is likely to show many minor variations. This is very apparent in the field. On attempting, for instance, to trace a sandstone which at one locality is thick and prominent, it may be found that it soon becomes more shaly and less prominent, and finally may lose its distinctive features and pass into a sandy shale, or even into a shale with no sand admixture. Farther along the same horizon the sandy phase may reappear, so that the horizon may again be marked by a prominent sandstone. The strata therefore frequently occur as lenses, and just as a sandstone merges into a shale, so limestones and shales pass by transition into one another from point to point. Any phase may be strongly developed locally and elsewhere may fade out or merge into something else. Such changes are characteristic of these Upper Carboniferous rocks.

Too much emphasis, however, must not be laid upon this irregularity. Over widely extended regions uniform conditions prevailed and sedimentation resulted in strata which occur without much variation at the same horizon in large areas, and which can be traced many miles. Such horizons serve very useful purposes in determining the geologic position of a series of rocks, and they make convenient division lines in mapping. The Pittsburg coal, the Upper Freeport coal, and the Pottsville sandstone are examples of strata that are persistent and distinguishable over wide areas.

Some idea of the character of the rocks which underlie the Indiana quadrangle, but which do not outcrop within it, is furnished by the records of deep wells that have been sunk in search of gas. The records of several wells are shown on Columnar Section sheet 2. It must be borne in mind, however, that the holes were churn-drilled and that the value of such records varies with the care exercised by the recorder. The interpretation of these records is accordingly only tentative.

The following record of the McGara well, near Chambersville, gives a detailed section of the underlying rocks of the Indiana quadrangle. The well began about the horizon of the Upper Freeport coal and was drilled 3220 feet. The lower 1520 feet are composed of a series of sandstones and shales about which very little is known.

Record of the McGara well, near Chambersville (No. 11.)

	Thickness in feet.	Depth in feet.
Drive pipe (passing through Upper Freeport coal)	34	34
Limestone	11	45
Slate	12	57
Limestone	2	59
Slate	25	84
Yellow sand	15	99
Coal	6	105
Limestone	8	113
Slate	55	168
Fire clay	8	176
Slate and shells	100	276
Coal	3	279
Shale	75	354
Sand	20	374
Slate	50	424
Limestone	10	434
Slate	30	464
Salt sand	256	720
Slate	10	730
White sand	18	748
Gray sand, hard	25	773
Slate	10	783
White sand	135	918
Red rock	3	921
White sand	87	1008
Slate and shells	45	1053
Gray and white sand, hard	70	1123
Slate and shells	80	1203
Dark-gray sands	24	1227
Slate and shells	80	1307
Slate	6	1313
Slate and shells	80	1393
Gray sand	12	1405
Slate and shells	45	1450
Red rock	24	1474
Blue sand	6	1480
Red rock	220	1700
Slate and shells	60	1760
Gray and white sand	45	1805
Slate and shells	10	1815
White sand	20	1835
Slate and shells	315	2150
White sand	7	2157
Slate shells	114	2271
Gray sand	15	2286
Slate and shells	59	2345
White sand, hard	15	2360
Slate and shells	50	2410
Sand	12	2422
Slate and shells	128	2550
Dark sand and shells	40	2590
White flaky sand	18	2608
Slate	32	2640
Gray and white sand, little gas	18	2658
Slate with occasional shells	100	2758
Slate	75	2833
Slate, shells, colored sands	30	2863
Shells, very hard	110	2973
Black slate	12	2985
White slate	25	3010
Slate and shells, hard	25	3035
Slate with finer shells	185	3220

All the wells which go deep enough show a conspicuous series of red shales and sandstones, the top of which lies between 1400 and 1500 feet below the Upper Freeport coal. Their average thickness in this region is about 350 feet. These rocks probably constitute a part of what formerly was called the Red Catskill, but as a distinct bed they are not known in outcrop, and consequently they have not received a specific name.

An interval of about 550 feet above the top of the Devonian red beds is shown by the different records to be occupied by a series of rocks which is largely shaly, but which includes several beds of sand. In one of these sandstones, lying about 1100 feet below the Upper Freeport coal, natural gas in paying quantities has been found, a fact which will be referred to more fully under the heading "Mineral resources." The exact stratigraphic horizon of this series can not now be stated, but it is near the base of the Carboniferous and the top of the Devonian.

Immediately above this horizon a conspicuous but not very thick band of red shales and sandstones about 900 feet below the Upper Freeport horizon has been reported in a number of well records. These red rocks average 50 feet in thickness in the area under consideration. They outcrop at Patton, on Redbank Creek, from which occurrence Campbell has named them the Patton shale. David White has found fossils in the Patton shale which show that it is a member of the Pocono formation.

Lying above the Patton shale, and averaging in thickness about 450 feet, is a great mass of sandstones with a few interbedded shales, which the well drillers call the "Big Injun sands." These sands constitute the top of the Pocono formation.

Mauch Chunk shale.—Of the rocks exposed at the surface in the Indiana quadrangle the Mauch Chunk shale is the oldest, though very little is known of it within this area. The records of

[1] Campbell, M. R., Geographic development of northern Pennsylvania and southern New York: Bull. Geol. Soc. America, vol. 14, pp. 277-296.

deep wells show an interval of shale at the Mauch Chunk horizon between the Pottsville formation and the Pocono sandstone. In some records these shales are reported red and in others no mention of the color is made. The thickest occurrence recorded in this vicinity is in the Pickels well, on Chestnut Ridge, in Burrel Township, where 114 feet of red sands and shales are reported at the Mauch Chunk horizon. Northwestward the thickness diminishes considerably.

This scanty representation of the Mauch Chunk is interesting because of the well-known westward thinning of the formation and of the erosional unconformity which separates the Pottsville from underlying rocks. Farther northwest, in the vicinity of Kittanning, M. R. Campbell and David White have recently shown that the Pottsville rests directly on the Pocono, with no intervening Mauch Chunk.

Along Yellow Creek where it crosses the Chestnut Ridge anticline there is sufficient interval for the Mauch Chunk to occur unless the Pottsville is unusually thick, but the rocks underlying the normal thickness of Pottsville in the Yellow Creek gorge are concealed by a talus of heavy sandstone blocks. Inasmuch as in the region immediately south and southwest of the Indiana quadrangle the Mauch Chunk shales are well represented, and because within this area some red material has been reported at the Mauch Chunk horizon in deep-well records, the presumption is that these rocks do outcrop in the Indiana quadrangle. This was the determination of the Second Geological Survey of Pennsylvania, and the Mauch Chunk is mapped accordingly.

Pottsville formation.—The Pottsville formation in this general vicinity consists of two beds of sandstone separated by an interval of shale which sometimes carries a bed of coal. But within the Indiana quadrangle, because of poor or incomplete exposures, no exact sections can be measured. Most of the records of deep wells within the quadrangle do not show distinctly this three-fold division, but they give a general thickness of about 100 feet for the formation.

The Pottsville formation outcrops in three localities in the Indiana quadrangle—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline.

On Two Lick Creek the Pottsville occupies a small area near water level, the presence of the formation being made conspicuous by large blocks of sandstone in the creek. On Allen Run for about a mile large blocks of sandstone near water level are thought to mark the outcrop of the Pottsville. Along Yellow Creek the outcrop of this formation is greater. A heavy sandstone is there well developed, but the exposures are poor for detailed study. The hill-slopes from the top of the formation down to the creek are strewn with huge blocks of a fine-textured, compact, whitish sandstone. Here the Pottsville measures about 100 feet.

Allegheny formation.—Overlying the Pottsville is the Allegheny formation, which is widespread in its occurrence and distinct in its definition. The Allegheny formation has been called the Lower Coal Measures, but in conformity with the custom of denoting formations by geographic names it has been named the Allegheny formation, from Allegheny River, where it is prominently exposed. The top of the Allegheny formation is marked by the Upper Freeport coal and the formation is delimited below by the Pottsville sandstone.

Next to the Conemaugh the Allegheny is the most widespread formation of this quadrangle, and its outcrop is important because of the associated coal beds. The map shows these rocks to outcrop in areas crossed by anticlinal axes along Chestnut Ridge, Rayne Run, Crooked Creek, McKee Run, and the South Branch of Plum Creek.

The thickness of the Allegheny formation in the Indiana quadrangle is about the same as in adjoining regions. Although there are striking differences in stratigraphy, yet the total thickness of the formation is rather uniform. About 300 feet is the average, as the following well records show: The Winsheimer well, 2½ miles west of Homer, gives a thickness of 285 feet, while the diamond-drill hole near Graceton records 318 feet without certainty that the top of the Pottsville was reached. A diamond-drill hole near Gettysburg, about 7 miles northeast of the quadrangle, shows a thickness of 303 feet for the Allegheny formation; the gas wells on the South Branch of Plum Creek below Willet, about 300 feet; the St. Clair well, a mile south of Indiana, 301 feet; and the Lawrence well, in Blacklick Township, a few miles southwest of the quadrangle, 300 feet.

The Allegheny formation is extremely variable in its composition and no single section can represent, except in a general way, the sequence of the rocks. This fact is strikingly shown by numerous diamond-drill sections located within short distances of one another. An inspection of those shown on Columnar Section sheet 1 gives an idea of the constitution of the Allegheny formation in the Indiana quadrangle.

The formation consists of shales, sandstones, a few thin limestones, and several beds of coal, some of which are of considerable economic importance. The Upper Freeport coal lies at the top of the formation and is rather persistent in its occurrence. This stratum is, however, subject to variations, which will be discussed under the heading "Mineral resources." Below this coal at an interval varying from 0 to 40 feet the Freeport limestone and Bolivar fire clay members are often present, and these also will be referred to again. Then, after an interval of from 20 to 80 feet of dark shales, another coal sometimes occurs, which is called the Lower Freeport. Below are drab or dark-colored shales or sandy shales, sometimes a thin bed of limestone, and occasionally a heavy sandstone. This sandstone shows a thickness of 63 feet in bore hole No. 1, near Graceton, where its top occurs 100 feet below the Upper Freeport coal.

About the middle of the Allegheny formation sometimes occur two or three beds of coal which are called the Kittanning coals. Only one of these, so far as known, is well developed in the Indiana quadrangle. This occurs about 200 feet below the Upper Freeport and is called the Lower Kittanning coal. Drill records show in places a heavy sandstone above this coal, and also one below. Thus, in a drill hole north of Yellow Creek, near the east side of the quadrangle, a heavy sandstone was encountered whose top is 165 feet below the Upper Freeport coal; and drill hole No. 1, near Graceton, shows 54 feet of sandstone about 30 feet below the Lower Kittanning coal.

In places limestone occurs associated with these coals. A bed of impure limestone 8 feet 9 inches thick was found in a drill hole on Ramsey Run 175 feet below the Upper Freeport coal; and in the same hole 4 feet 5 inches of gray limestone occur 238 feet below the Upper Freeport. The former occurrence is noteworthy because the limestone appears in the horizon of the Vanport (Ferriferous) limestone member. West of the quadrangle this limestone is well developed and is an important key rock. Eastward it thins out. In the Indiana quadrangle the presence of the Vanport limestone member is recorded in only this diamond-drill hole, and its outcrop is found at only one locality—along the axis of the Chestnut Ridge anticline, on the north slope of Yellow Creek. Here fragments of limestone were found 80 feet above the top of the Pottsville and 20 feet below the Lower Kittanning coal.

From the horizon of the Vanport limestone member to the base of the formation the rocks are usually shales, among which one or two thin and unimportant layers of coal sometimes occur.

Conemaugh formation.—The rocks belonging to the Conemaugh formation, which directly overlies the Allegheny, have been called the Lower Barren Measures because they rarely carry workable coal and they lie between formations which do contain valuable coal beds. But for the sake of uniformity in geologic nomenclature the rocks have been named the Conemaugh formation, from their outcrop along Conemaugh River. The Conemaugh formation is widespread in its occurrence and is well defined. It is delimited above by the Pittsburg coal and below by the Upper Freeport, both coals being excluded from the formation.

The Conemaugh formation, as shown by the geologic map, extends over most of the Indiana quadrangle. Except in the Chestnut Ridge region and a few other districts where the Allegheny formation outcrops, Conemaugh rocks are everywhere exposed at the surface. The entire thickness of the formation is not present in the Indiana quadrangle. In the region to the southwest of the area under consideration these rocks have a rather constant thickness of from 600 to 700 feet, but there is evidence that this thickness increases somewhat northeastward. The best interpretation that can be given to several diamond-drill records in the southwestern part of the Indiana quadrangle, toward the center of the Latrobe syncline, places the Upper Freeport coal at an elevation of 650 to 680 feet, while adjacent hills on which the Pittsburg coal has not been found rise to a little more than 1300 feet. These figures call for a thickness of over 600 feet for the Conemaugh formation, an estimate which is borne out by facts in the territory to the south. A deep well at the Columbia Plate Glass Works at Blairsville gives an approximate thickness of 675 feet for the Conemaugh. The Lawrence well on Greys Run, about a mile south of the southwest corner of the Indiana quadrangle, shows a thickness of at least 680 feet for the Conemaugh formation when there is added to the well record the thickness of rocks on an adjacent hill on which the Pittsburg coal does not outcrop.

As a whole the Conemaugh formation is composed largely of drab and reddish shales, but it is also characterized by the occurrence of important beds of sandstone. Minor beds of limestone and some coal are also included within the formation.

There are four principal sandstones, but these occur as lenses or beds of limited extent and of local thickness instead of uniformly persistent strata. They therefore form members of the Conemaugh formation rather than distinct formations by themselves. The names given to these sandstones are those adopted in other localities where the Conemaugh formation occurs, and their relative positions are approximately the same. Actual identity in correlation can not be established because of the noncontinuity of the deposits as traceable beds. In lithologic character these sandstones resemble one another so closely that they can not be distinguished, but their stratigraphic position serves to identify them. They range from hard, compact, fine-textured white or buff sandstones to friable and coarser-textured, much iron-stained sandstones. Locally these rocks become conglomeratic, the pebbles of quartz occasionally attaining the size of beans. The sandstones vary in thickness from a few feet to 60 or 70 feet. A common measurement when they are well developed is between 20 and 30 feet.

The Connellsville sandstone member in this quadrangle is thin bedded, drab, and micaceous. It occurs about 80 feet below the Pittsburg coal, though in the type locality this interval is only about 50 feet. The Connellsville sandstone member outcrops in the Indiana quadrangle on only a few hills in the southwest corner, adjacent to the Pittsburg coal area.

The Morgantown sandstone member occurs about 500 feet above the Upper Freeport coal and is usually well developed. It is present on the hills west of Homer, on White, Coleman, and Warner hills, and between Grove Chapel and Tanoma.

The top of the Saltsburg sandstone member is about 200 feet above the Upper Freeport coal. This sandstone outcrops at several localities in this quadrangle and occasionally is strongly developed, but at several places where its presence would be expected the sandstone phase is not present. The Saltsburg sandstone member occurs at Homer, at Edgewood, and along the road crossing the hill northwest of Ideal. It is also well developed on Dias Ridge, in the southeast corner of the quadrangle. It appears at the bend in the road between Indiana and Mechanicsburg just south of Two Lick Creek, and again on this road a little lower down the dip of the east flank of the Latrobe syncline, a short distance north of the creek. Thence southwestward it forms a bench along the hillside to the railroad cut south of Reed station. It shows in the western limb of the Latrobe syncline on the road along McCartney Run a half mile west of Reed, where it has been quarried. This occurrence of the Saltsburg sandstone member is mentioned in detail because it gives a surface demonstration of the existence in this region of the Latrobe syncline.

The Mahoning sandstone member occurs at the base of the Conemaugh formation. It is generally present within this quadrangle, and its outcrop being contiguous to that of the Upper Freeport coal the position of the Mahoning can be easily followed on the map. This sandstone is prominent on Chestnut Ridge, about KcKee Run, and between Chambersville and Gaibleton. It is poorly developed or not present at its horizon in Dixon Run and in the South Branch of Plum Creek. It is recorded in several diamond-drill records, though in others it is absent. A striking example of change in sedimentation, characteristic of the Coal Measures, is well shown by the distribution of the Mahoning sandstone member. It is strongly developed as a massive conglomeratic sandstone on the ridge north of Penn Run and east of Two Lick Creek, but in the nearby valley of Dixon Run is scarcely recognizable.

Drab shales and sandy shales, occasionally interbedded with bluish and reddish shales, are the most abundant rocks of the Conemaugh formation. They occur between the sandstones that have just been mentioned and replace them where they are not developed. Locally the reddish shales attain prominence. For instance, the small hill east of the freight station in Indiana shows such a local development. These shales are about 350 feet above the Upper Freeport coal.

Only a few outcrops of limestone were observed in the Conemaugh formation. On the hillside east of the road between Cherry Run and Two Lick Creek, about 1½ miles southwest of Homer, is a thin bed of limestone carrying brachiopods. This bed occurs about midway in the Conemaugh formation and probably represents the Ames (Crinoidal) limestone member. Another exposure of what is believed to be this limestone occurs near the road forks at the head of Mudlick Run. In Brush Valley, about three-quarters of a mile northwest of Rico, underlying a coal which is there locally developed, is a limestone which has been quarried. This coal and limestone are thought to belong to the Elk Lick horizon and to be somewhat over 300 feet above the Upper Freeport coal.

The Conemaugh formation carries several coal beds, some of which within the Indiana quadrangle locally attain workable thickness. These coals are not persistent and their occurrence is most irregular. They will be considered under the heading "Mineral resources."

QUATERNARY SYSTEM.

Alluvium—The flood plains of the streams are composed of alluvium, consisting of sand, clay, and silt. This material is made up of disintegrated rock particles which have been washed down from the hillsides and deposited in their present positions in times of high water. The most conspicuous occurrences are along the larger creeks and are mapped, but similar deposits too small to be shown on the map occur along all the streams. The alluvium is fine grained and where well developed makes valuable farm land.

STRUCTURE.

The Indiana quadrangle, situated as it is in the northeastern part of the plateau region not far from the Allegheny Front, conforms in geologic structure with the Allegheny Plateau. The rocks are bent into a series of low folds, which decrease in magnitude westward.

Structure contours.—The structure of the Indiana quadrangle is shown on the Structure and Economic Geology sheet, by means of red contour lines. This method of representation may not at first be readily understood, but a little consideration will show that it is both a comprehensive and a detailed way of showing the position of the rocks.

The structure contours are drawn with reference to the Upper Freeport coal, the contour interval being 100 feet and the datum plane sea level. Ideally everywhere along any contour line the coal is at the same elevation, and everywhere along the next contour above the elevation of the coal is 100 feet higher. The intersection of surface contours and structure contours of the same elevation marks the position of the outcrop of the Upper Freeport coal. Where the elevation of the surface at any point is greater than the elevation of the coal at that point, as shown by contiguous structure contours, the approximate depth of the coal below the surface may be found by subtraction. Where the elevation of the surface is less than the corresponding elevation of the coal the latter has been removed by erosion and the contours simply show structure.

Suppose, for instance, the position of the Upper

Freeport coal is desired at the bridge crossing Two Lick Creek in the northern part of the town of Homer. It will be seen by the map that the elevation of the surface at this point is a little under 1020 feet and that the bridge is a little above the 800-foot structure contour. The Upper Freeport coal, therefore, is here about 1020 minus 800 feet, or about 220 feet, below the surface.

These structure contours, from the nature of the data on which they are based, can not be made absolutely accurate, and this fact must be borne in mind. Nevertheless, the more facts used in their construction the more correctly can they be drawn. In the region southwest of the Indiana quadrangle, in the Connellsville basin, there is a great mass of mine data giving instrumentally determined elevations of the coal. Structure contour lines constructed on this basis are very accurate and show that the main folds are complicated by many minor variations. In the Indiana quadrangle there are no such available data, and the broadly curved contour lines illustrating the structure of this region represent only the main features. Doubtless here, as in the region farther south, the rock structure is intricately warped, but the details of these fluctuations can be determined only by actually following any one stratum over a considerable area, as in coal mining.

The structure contours of the Indiana quadrangle are based on the position of the Upper Freeport coal, determined by its outcrop and by the records of a number of diamond-drill and deep-well borings.[1] Moreover, the roads within the quadrangle have been traversed and the positions of the different rocks noted. This information, taken in connection with the records of the drill holes, often gave valuable data regarding the position of the Upper Freeport coal horizon. But over much of the quadrangle the surface rocks are shale, sandy shale, and shaly sandstone having little individuality, so that in many places information on which to draw structure contours is very meager. It is believed, however, that the main structural features of the quadrangle have been determined.

Chestnut Ridge anticline.—The most persistent and pronounced fold within the quadrangle is the Chestnut Ridge anticline. This is one of the strongly developed folds of the Allegheny Plateau and can be traced for miles. The axis of the anticline corresponds with the crest line of Chestnut Ridge and crosses the southeastern part of the Indiana quadrangle in a slightly curved line. From Conemaugh River to the southern limit of the area under consideration the pitch of the Chestnut Ridge anticline is northward, causing the elevation of the Upper Freeport coal along the axis to fall from a reported altitude of 2300 feet on Conemaugh River to 1700 feet in the southern part of the Indiana quadrangle. This descent of the axis continues for a short distance in the area under consideration and then rises, bringing the coal again above 1700 feet on the road between Mechanicsburg and Indiana. Northeastward the axis continues to rise, so that the coal occurs above 1800 feet near the road between Indiana and Pikes Peak. Farther northeast the axis falls again, until about halfway between Penn Run and Two Lick Creek the coal on the axis is below 1600 feet. Thence the axis rises, and where it leaves the quadrangle the Upper Freeport has an elevation of nearly 1600 feet. The slope of the flanks of the Chestnut Ridge anticline is generally steeper on the west, and the height of the fold is most pronounced in the southern part of the quadrangle. Here there is a rise of over 1000 feet in the position of the Upper Freeport coal from the trough of the syncline west of Chestnut Ridge to the crest of the anticline at the top of the ridge. Toward the north this difference in elevation decreases to 600 feet and less. On the eastern slope of the anticline there is an interval of from 400 to 700 feet between the coal at the crest of the arch and the coal at the base of the adjacent trough.

Brush Valley syncline.—The syncline immediately east of the Chestnut Ridge anticline is marked by the valley of Brush Creek and is called the Brush Valley syncline. The exact position of the axis and the depth of this fold are not well known, but from the information at hand the relations seem to be as represented by the contours. The Upper Freeport coal lies beneath the surface in Brush Valley within the Indiana quadrangle. This coal has an elevation of less than 1200 feet in the middle of the basin north of Rico, and thence southward gradually rises, with the axis of the fold, so as to outcrop at an elevation of about 1300 feet at the old Oberdorff mill on Brush Creek, half a mile south of the quadrangle.

Nolo anticline.—East of the Brush Valley syncline, occupying the southeast corner of the quadrangle, is the northwestern flank of the Nolo anticline. This fold was so named by W. G. Platt because its axis passes near the town of Nolo. Within the Indiana quadrangle the Nolo anticline is topographically marked by Dias Ridge. The Upper Freeport coal is not brought to the surface within the quadrangle by this fold but by outcrops in the valleys of Blacklick and Little Yellow creeks, and by the occurrence of recognizable sandstone on the ridge it is known that the Upper Freeport horizon rises from approximately 1200 feet in the Brush Valley syncline to over 1800 feet on the Nolo anticline.

Latrobe syncline.—West of Chestnut Ridge there is a well-marked syncline which has been named from the town of Latrobe, in Westmoreland County, where it is well developed. This fold has been traced from Indiana to Scottsdale, and its southward continuation is known as the Uniontown basin. Between Blairsville and Indiana the Latrobe syncline rises and flattens out. Along the axis of the syncline on Conemaugh River the elevation of the Upper Freeport coal horizon is about 300 feet above sea level, while south of the town of Indiana the position of this coal along the same axis is over 1000 feet. A mile south of Indiana there is a local rise of the Latrobe syncline, producing a small arch across the trend of the axis. North of the town the syncline pitches downward for a short distance, only to rise again toward Crooked Creek. In the region between Indiana and Crooked Creek there is little to indicate the geologic structure, but northeast of the creek the Latrobe syncline is split in two by a southward-plunging anticline whose axis extends along Rayne Run.

The axis of the eastern fork of the Latrobe syncline passes between Dixon and Rayne runs and rises northeastward, so that the Upper Freeport coal, which on the axis near Tanoma has an elevation of about 1100 feet, on the same axis in the northeast corner of the quadrangle has an elevation of nearly 1500 feet.

The western fork of the Latrobe syncline is not well marked. Its axis passes east of Kellysburg and rises northward gradually.

Richmond anticline.—The axis of the anticline which divides the Latrobe syncline extends from Rayne Run northeastward between the towns of Deckers Point and Marion Center and is well marked near the town of Richmond, on Little Mahoning Creek. This fold rises sharply northward, so that the Upper Freeport horizon, which at the mouth of Rayne Run has an elevation of about 1150 feet, on the highland northeast of the Indiana quadrangle is over 1700 feet above the sea.

Jacksonville anticline.—In the southwestern part of the quadrangle the rocks of the western flank of the Latrobe syncline rise gradually westward to the crest of the next succeeding fold, the Jacksonville anticline. Consequently the Upper Freeport coal, which in the trough of the Latrobe syncline west of Graceton has an elevation of about 600 feet, on the crest of the Jacksonville anticline has an altitude of over 1200 feet. This fold has been called the Saltsburg anticline, but it is thought desirable to refer to it here as the Jacksonville anticline. The fold is well developed near the town of Jacksonville, on Aultmans Run, about 2 miles from the western edge of the Indiana quadrangle. The use of this local name seems preferable, because it is not yet known whether the fold is the same one that crosses the Conemaugh above Saltsburg.

The so-called Indiana anticline.—The structure here outlined is very different from what was formerly supposed, and this change of interpretation needs a word of explanation. The map of Indiana County issued by the Second Geological Survey of Pennsylvania shows the Indiana anticline extending in a straight line across the county and passing through the town of Indiana. This supposed fold has been thought to be continuous on the southwest with the Fayette anticline in Westmoreland County, and on the northeast with the Richmond anticline, but it has been determined that this interpretation is incorrect. The Richmond and Fayette anticlines are not continuous. The former pitches southwestward and the latter pitches northeastward, and the area between Conemaugh River and Crooked Creek along the extension of the axes of these folds is occupied chiefly by the Latrobe syncline. It is an odd coincidence that the axes of the Richmond and Fayette anticlines fall in line with each other, and it is not surprising that these folds have been thought to be continuous, for in the intervening region surface exposures are poor and the structure can be deciphered only by detailed work. The present determination is fully proved by the records of about 50 diamond-drill holes lately put down by the Rochester and Pittsburg Coal and Iron Company.

McKee Run anticline.—A low anticline which crosses McKee Run and which, therefore, may be called the McKee Run anticline, causes the Upper Freeport coal to outcrop for a short distance along that run. This anticline was formerly supposed to be a continuation of the Jacksonville anticline, but diamond-drill records indicate that the axes of the Jacksonville and McKee Run anticlines do not coincide, and the structure has accordingly been so represented on the map. The Jacksonville fold merges into the next syncline to the west about 5 miles west of Indiana, and the axis of the McKee Run fold strikes into the northwest flank of the Latrobe syncline in the vicinity of Edgewood.

The McKee Run anticline is a low, gentle fold which makes itself apparent by bringing the Upper Freeport coal to the surface at an elevation of about 1100 feet on McKee Run, and also on Crooked Creek at approximately the same elevation. The axis crosses this creek about halfway between Chambersville and Gaibleton, but its northeastward extension is not plain. This anticline is important because of the occurrence of gas along its northwest flank in the vicinity of Creekside.

Elders Ridge syncline.—West of the McKee Run anticline is a syncline whose axis is not well located, but it probably extends a little to the east of Dark Hollow Run and rises gradually northeastward. This syncline is a continuation of that which carries the Pittsburg coal on Elders Ridge and which, therefore, may be called the Elders Ridge syncline. The depth of this basin in the Indiana quadrangle is fairly well fixed by a diamond-drill hole about 2 miles west of Creekside, which shows that the elevation of the Upper Freeport coal is there below 900 feet; and the depth of this syncline is also indicated by the deep well on the Little farm, about 1½ miles northwest of Chambersville, which shows the coal horizon to be at an elevation of about 1040 feet.

Roaring Run anticline.—In the northwest corner of the Indiana quadrangle the fold next succeeding the Elders Ridge syncline is an anticline whose axis has been found to coincide with that of the anticline which extends along Roaring Run in Armstrong County. The axis of this fold crosses the South Branch of Plum Creek less than half a mile outside of the western edge of the quadrangle and extends northeastward, apparently crossing Sugarcamp Run about 1 mile above its mouth. The Roaring Run anticline causes the Upper Freeport coal to outcrop at an elevation of about 1100 feet, but the fold is a low one, for there is a difference in elevation of only about 40 feet between the coal at the axis and at the point where it passes under the creek near Willet. This anticline is important because of the many gas wells that are located along its axis.

MINERAL RESOURCES.

The mineral resources of the Indiana quadrangle include coal, natural gas, clay, sandstone, limestone, water, and soils.

COAL.

Coal is the most important of the mineral resources of the Indiana quadrangle, and for many years a number of small banks, to supply local demands, have been in operation. Up to the present time, however, little active mining has been carried on within the area. Only two mines, those of the McCreary Coal and Coke Company at Graceton, are now (July, 1902) being operated on a large scale. There are, however, indications of approaching greater activity. A number of diamond-drill holes have lately been put down to test the deep-lying coal, and the Buffalo, Rochester and Pittsburg Railway is extending its road to Indiana from Punxsutawney, presumably for the purpose of opening mines.

The Pittsburg coal outcrops a short distance to the south, but is not present in the Indiana quadrangle because the rocks containing it have been eroded from the surface. There are a few hills in the southwest corner of the quadrangle that are just high enough to carry this coal if the Conemaugh formation had its usual thickness of 600 feet; but, as already stated, there is evidence of a local thickening of the Conemaugh, which would account for the absence of the Pittsburg coal.

The Pittsburg being absent, the coals of the Indiana quadrangle are limited to those which occur in the Conemaugh and Allegheny formations.

Country banks show the presence of coal of workable thickness in the Conemaugh in a few localities, but by far the most important coal beds belong to the Allegheny formation.

In this connection it may be observed that some misconceptions exist regarding the occurrence and names of coals in this formation. The common opinion that the Allegheny coals are very regular is probably due partly to the fact that a number of generalized sections have been published showing a definite number of coal beds, and that these sections have been wrongly assumed to have wide application.

The generalized sections of this formation in the Allegheny Valley contain seven coals, which have been named Upper Freeport, Lower Freeport, Upper Kittanning, Middle Kittanning, Lower Kittanning, Clarion, and Brookville, while in the sections representing the formation in the first basin west of the Allegheny Front these coals have been designated by letters E, D′, D, C′, C, B, and A respectively. These coals are all found somewhere, and the generalized sections are meant to show simply their relative positions. It is an error, however, to assume that all these coals must occur everywhere throughout the area in which the formation is found.

Some workers in the field, not thoroughly realizing the facts as to the distribution of the coal, have assumed that these seven coal beds are actually continuous over wide areas, and that wherever a coal is found in the Allegheny formation it must be correlated with one of the coals in the general section. But a careful consideration of the records of diamond drills that have pierced the entire formation or a study of complete natural exposures shows that often fewer than seven beds of coal occur in the Allegheny formation, and that when neighboring sections are compared the coals in one can not always be correlated with those of the other.

It is important to draw attention to these conditions, but at the same time it is by no means asserted that none of the coals of the Allegheny formation have a widespread and continuous distribution, for the Lower Kittanning in particular is remarkably persistent. When this variability is borne in mind it becomes evident that it should not be lightly assumed that the presence of a bed of coal in one locality in the approximate stratigraphic position of a coal in another locality necessarily implies that the two coals are identical. Such identity appears to be tacitly assumed in the wide application of the same names for the coal beds of the Allegheny formation. But in the absence of proof of continuity it would seem to be preferable to have it understood that these names signify only approximate stratigraphic position of the several coals, rather than identity. It is in this sense that the names of the coals of the Allegheny formation will be used in the present folio.

COALS IN THE ALLEGHENY FORMATION.

The Allegheny coals of workable thickness within the Indiana quadrangle, so far as known, are the Upper Freeport, Lower Freeport, and Lower Kittanning. Their outcrops are shown on

[1] I am especially indebted to Mr. Robinson and Mr. Arms, of the Rochester and Pittsburg Coal and Iron Co.; to Mr. Hinterleitner, of Spangler, Pa.; to Mr. McCreary and Mr. Bierer, of the McCreary Coal and Coke Co.; to Mr. Clements, of the Indiana Gas Co.; to Mr. Stuart, of the Conemaugh Gas Co., and to Mr. Mullen, of Indiana, for much valuable information.

the Structure and Economic Geology sheet. The whole area of the quadrangle is indicated as underlain by workable coal except the valley portions below the outcrops of Lower Kittanning coal.

UPPER FREEPORT COAL.

The Upper Freeport is the most important coal in the quadrangle. Numerous openings have been made along the outcrop of this bed, and most of the drill holes which have penetrated its horizon have struck coal. Though it occurs generally throughout the area under consideration, it is not everywhere of equal importance, and locally it is either absent or becomes so thin as to be of little use. The Upper Freeport coal outcrops in six more or less distinct areas in the Indiana quadrangle. These areas are along Chestnut Ridge, on Dixon, Rayne, and McKee runs, on Crooked Creek, and along the South Branch of Plum Creek.

Chestnut Ridge.—Chestnut Ridge is the most extensive of these areas, and numerous country banks have been opened on the coal, as shown on the map.

The principal coal workings within the quadrangle are those of the McCreary Coal and Coke Company at Graceton. This company operates two mines in the Upper Freeport coal and manufactures coke. The mines are located on the outcrop, favorably for gravity drainage. The dip of the coal is regular, being about 8½ per cent toward the mouth of the mine. In mine No. 1 the section in fig. 2 was measured:

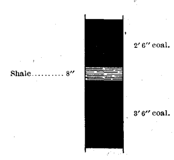


FIG. 2.—Section of the Upper Freeport coal in McCreary mine No. 1, Graceton.

The coal averages 6 feet in thickness and is parted about 3½ feet from the base by shale, which varies from 4 to 12 inches. The upper bench carries considerable sulphur and only the lower bench is used, after washing, for making coke. An analysis, by Dr. E. T. Allen, of the United States Geological Survey, of a sample of this coal (unwashed) from Graceton gave:

Analysis of coal from McCreary mine No. 1, Graceton, Pa.

	Upper bench.	Lower bench.
Moisture	.60	.61
Volatile combustible matter	27.72	27.14
Fixed carbon	61.73	63.89
Ash	9.95	8.36
	100.00	100.00
Sulphur	5.23	2.38
Phosphorus	.018	.005

The coke is bright, hard, and has well-developed cell structure. The entire product of the mines is used by one company in making steel, and the coke is said to have a good reputation. Following is the average result of several analyses, made for the company, of coke from mine No. 2:

Analysis of coke from McCreary mine No. 2, Graceton, Pa.

Ash	9.82
Sulphur	1.08
Phosphorus	0.017

The only other mine with railroad connection in this quadrangle is a small one on the Upper Freeport coal, operated by the Glenmore Coal and Coke Company, near the mouth of Tearing Run. As yet this coal has not been coked. A measurement in the mine is given in fig. 3.

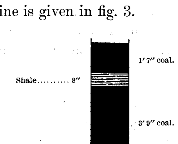


FIG. 3.—Section of the Upper Freeport coal in the Glenmore mine, near the mouth of Tearing Run.

A number of openings have been made on the Upper Freeport coal on Chestnut Ridge; in the southern part of the quadrangle, and measurements show that in this region there is little variation in the thickness of the coal. Thus at a bank on the farm of John L. Henry, on the road between Homer and Heshbon, 1¼ miles east of Graceton, the coal underlies the Mahoning sandstone and shows the following section (fig. 4):

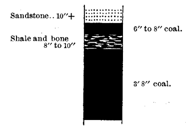


FIG. 4.—Section of the Upper Freeport coal in the Henry coal bank, 1¼ miles east of Graceton.

In the Gamble mine the section shown in fig. 5 is exposed.

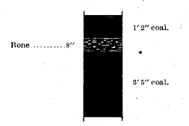


FIG. 5.—Section of the Upper Freeport coal in the Gamble mine.

Similar measurements are reported in DeArmy's, Brown's, Oberdorff's and other coal banks in this vicinity.

Farther north there are fewer openings on the Upper Freeport coal. Where exploited in the vicinity of Evans Hill the bed is reported to be of little value. This, however, appears to be only local, for on Two Lick Creek southeast of Indiana the banks of McHenry and Agey show that the coal is well developed. W. G. Platt reported the section shown in fig. 6 in these mines.

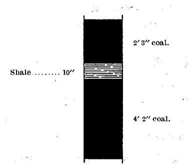


FIG. 6.—Section of the Upper Freeport coal in McHenry and Agey coal banks, on Two Lick Creek, southeast of Indiana.

Northward the Upper Freeport coal again decreases in thickness. On the top of the ridge in the vicinity of the road between Indiana and Greenville, openings on the farms of William Barnet and J. S. Ralston showed the following section (fig. 7):

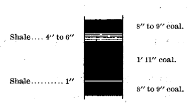


FIG. 7.—Section of the Upper Freeport coal in Barnet and Ralston coal banks, between Indiana and Greenville.

In the several coal banks near Greenville there is further evidence of thinning. W. G. Platt reported the following measurement in this vicinity (fig. 8):

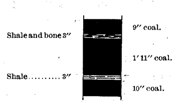


FIG. 8.—Section of the Upper Freeport coal in coal banks near Greenville.

North of Greenville the Upper Freeport coal appears to be unimportant within the quadrangle. It is inconspicuous beneath the massive Mahoning sandstone which forms the ridge north of Penn Run, and on the 1600-foot hill shown on the edge of the map about 2 miles north of Greenville the Upper Freeport has not been found. A sandstone thought to be the Mahoning caps this hill, and a thin bed of coal supposed to be the Lower Freeport occurs below the limestone on the hillside.

The Areal Geology sheet may be misleading here because the boundary line between the Allegheny and Conemaugh formations commonly marks the outcrop of the Upper Freeport coal, whereas here the boundary line, which is drawn at the supposed horizon of the Upper Freeport, does not mark the presence of the coal, but merely shows the line of separation of the two formations. This is shown on the Structure and Economic Geology sheet by the absence of the heavy line representing the Upper Freeport coal along the boundary in the northern portion of the area.

Dixon and Rayne runs.—In the valley of Dixon Run the Upper Freeport coal is unimportant. Probably this statement is true for most of the Rayne Run area also, but there the stratigraphic position of the workable coal is not yet determined, as will be set forth more fully under the heading "Lower Freeport coal." The uncertainty of the Upper Freeport in this region is indicated by the fact that a diamond-drill hole put down between Dixon and Rayne runs, 1½ miles northeast of Tanoma, shows no coal at this horizon.

Crooked Creek.—Between Chambersville and Gaibleton the McKee Run anticline causes the Upper Freeport coal to appear a few feet above water level for about 1½ miles along Crooked Creek. The Mahoning sandstone is well developed and the Freeport limestone has been quarried at a few localities. Several small openings have been made on the coal in this region. At Simon Fisher's bank, close to the level of the creek, opposite Chambersville, the section shown in fig. 9 is exposed.

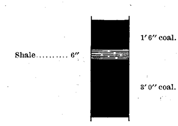


FIG. 9.—Section of the Upper Freeport coal at Simon Fisher's coal bank, opposite Chambersville.

The general character of this coal is indicated by the following analysis, by McCreath, of a sample from the Brady mine:

Analysis of coal from Brady mine.

Water	.950
Volatile matter	31.420
Fixed carbon	55.215
Sulphur	1.215
Ash	11.200
	100.000

Coke, per cent, 67.630.
Color of ash, dirty gray.

South Branch of Plum Creek.—Along the South Branch of Plum Creek and its tributary, Sugarcamp Run, a coal is exposed which is thought to be the Upper Freeport, although the Mahoning sandstone is not present. The coal is underlain by limestone, and the deep wells in this vicinity strike the gas sand at the same distance below this coal as do the wells near Creekside, where the coal is known to be the Upper Freeport.

Openings have been made at several places along the outcrop, which is not far above water level. In the Brown bank 33 inches of coal were measured. At the Parke and Trusal banks, on Sugarcamp Run, the coal measures 3 feet 5 or 6 inches, parted by a 1-inch band of shale 5 inches from the base. W. G. Platt reports a thickness of 3 feet 4 inches, including a 1-inch shale parting near the base, in the Marlin bank near the mouth of Sugarcamp Run.

A sample of the coal from the main bench of the Marlin bank was reported upon by McCreath, of the Second Geological Survey of Pennsylvania, as follows:

Analysis of coal from Marlin bank.

Water	1.100
Volatile matter	31.890
Fixed carbon	60.736
Sulphur	1.279
Ash	4.995
	100.000

Coke, per cent, 67.01.
Color of ash, cream.

McKee Run.—On McKee Run the Upper Freeport coal outcrops near water level for about half a mile, and several banks have been opened within this distance. At the Spence Brothers' mine the following section was measured (fig. 10):

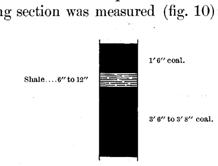


FIG. 10.—Section of the Upper Freeport coal at the Spence Brothers' mine, on McKee Run.

Underground occurrence of the Upper Freeport coal.—Concerning the underground occurrence and condition of the Upper Freeport coal within the Indiana quadrangle considerable information exists because of the recent diamond-drill explorations carried on by the Rochester and Pittsburg Coal and Iron Company and by others. Through the courtesy of those in charge the depth of the Upper Freeport horizon is given to the public now for the first time on Columnar Section sheet 1, but there is little available information as to the thickness and character of the coal.

In the Latrobe syncline south of Indiana the Upper Freeport has been rather carefully explored, and in general there seems to be a good body of coal. In the continuation of the basin northeast of Indiana not so much exploration has been carried on, but judging from the scanty information available the Upper Freeport seems to be variable in its occurrence. It appears to thin out in the northeast part of the quadrangle, where the Lower Freeport is the most important coal.

In Brush Valley very little information exists concerning the character of the Upper Freeport. The indications are, however, that the coal decreases in thickness from its development of 6 feet on Chestnut Ridge, but not enough drilling has been done to thoroughly test the region.

Still less information exists concerning the underground development of the coal in the Elders Ridge syncline within the Indiana quadrangle.

LOWER FREEPORT COAL.

The Lower Freeport coal is not persistent nor often very thick in the Indiana quadrangle. Blossoms of this coal were noted at several localities and the bed was penetrated in several drill holes, but so far as known it attains workable dimensions only in the northeastern part of the quadrangle, in the vicinity of Dixon and Rayne runs.

Dixon Run.—In the valley of Dixon Run several coal banks have been opened on a coal which is supposed to be the Lower Freeport. The Mahoning sandstone is not conspicuous in this region, but the workable coal is overlain by limestone, and farther up by a thin bed of coal, which are thought to be respectively the Upper Freeport limestone and coal. Moreover, in the adjacent valley of Buck Run, which is just off the northeast edge of the quadrangle, a coal supposed to be the Lower Kittanning occurs about 160 feet below this bed. This interval corresponds very well with measurements made in other parts of the area under discussion, and affords corroborative evidence of the Lower Freeport age of the Dixon Run coal.

This coal is mined by Ed Woodison on the top of the divide between Dixon and Buck runs, about a mile north of Two Lick Creek, where a measurement of 4 feet 4 inches of coal was obtained. From this point the dip of the western flank of the Chestnut Ridge anticline carries the coal rapidly down nearly to water level in the valley of Dixon Run. In the banks along the run south of Dixonville the coal varies from 3 feet 6 inches to 4 feet. At the Black bank, half a mile north of Dixonville, it measures from 4 feet 2 inches to 4 feet 4 inches.

Rayne Run.—In the valley of Rayne Run a number of country coal banks have been opened, but whether this coal is the Upper or the Lower Freeport is uncertain. The Mahoning sandstone, which, when present, serves as a guide to the identification of the Freeport coals, is not well developed in this region. Locally a limestone occurs beneath the main coal, which would tend to show that it is the Upper Freeport, but, on the other hand, a thin coal outcrops from 20 to 40 feet above the main seam, which implies that the latter coal is the Lower Freeport. If this be so, the limestone would be the Lower Freeport instead of the Upper Freeport limestone, which usually is better developed.

This is an illustration of a difficulty that occasionally besets the correlation of coals. If the Mahoning were well developed here, or if both the Upper and the Lower Freeport limestones were present, or if there were a complete section connecting the coals under consideration with some definite horizon either above or below, there would be no doubt. Or if these questionable coals were separated by a greater vertical interval the general geologic structure would throw important light on the subject. Again, the presence of fossils would be important. Occasionally cases of this kind arise, when the question must be left open for further light. It is tentatively assumed that the thin upper coal is the Upper Freeport. Fortunately the distance between the coals is so small that the resulting error in mapping, on either supposition, is not great.

At Bottsford's bank, about half a mile north of Rayne post-office, on the road to Marion Center, the coal measures 3 feet 10 inches; and on the farms of John Little and J. E. Manners, in the valley west of Bottsford's bank, similar conditions prevail. That is, the main coal is almost directly underlain by limestone, and about 30 feet above is the outcrop of a thinner bed of coal with no sandstone exposed. In the H. Edwards bank, on Crooked Creek, a mile below Tanoma, there is a bed of coal which measures 3 feet 2 inches; and in the Walker bank, on Crooked Creek, about half a mile below Rayne Run, the coal is reported to be 2 feet 8 inches thick.

KITTANNING COALS.

The Kittanning coals seem to be represented in the Indiana quadrangle by only one principal bed. This is shown by the few diamond-drill records that give the thickness of the entire Allegheny formation, and field observations on the outcrops confirm their testimony. The records, however, show the occasional presence of other thin coals belonging to the Kittanning group, and it is possible that further drilling will reveal a greater thickness of these coals.

The principal Kittanning coal occurs about 200 feet below the Upper Freeport and is considered to be at the Lower Kittanning horizon. The occurrence of this coal at the surface is limited to the deeper valleys of the Chestnut Ridge region, and the map shows the approximate line of outcrop. This line has been checked by the location of several country banks, but in the intervals between local mines the outcrop line is based on structure contours.

Several old banks have been opened on this coal in the southern part of the quadrangle, but measurements could not be made in them. Along Furriers Run southwest of Evans Hill there are two old openings, on the farms of Mrs. Douglas and William Lewis, where the coal is reported to range from 3½ to 4 feet thick.

Along the flanks of the ravine of Yellow Creek where it cuts through Chestnut Ridge there are several banks on this coal. At Fetterman's, near Yellow Creek, west of the road which passes just east of Moose and Strongs hills, the coal is said to measure 3 feet 8 inches; and at Campbell's bank, at the head of the run in the bend of the road on the north side of Yellow Creek south of Strongs Hill, the coal is 4 feet thick. This also is the measurement in the bank on the east side of the road passing southward from the Indiana-Greenville pike to the Yellow Creek ford, northwest of Moose Hill.

Two Lick Creek between Sample Run and Ramsey Run flows approximately parallel to the strike of

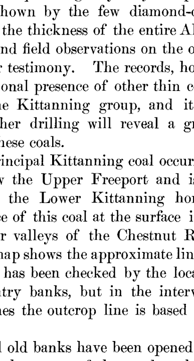


FIG. 11.—Section of the Lower Kittanning coal in coal banks above Ramsey Run.

the rocks, and in this interval several openings have been made on the Lower Kittanning coal. Between a quarter of a mile and 1 mile above Ramsey Run there are three coal banks in which the coal has approximately the section shown in fig. 11.

Along the Indiana-Greenville pike near the Two Lick Creek bridge are two old openings on opposite sides of the stream, where this coal measures about 3½ feet. Farther up the creek several old openings are passed before Lydick's, just above the mouth of Allen Run, is reached. Here there is the unusual section shown in fig. 12.

On Penn Run and its tributaries there are several banks opened on the Lower Kittanning coal. At Green's, near the road extending northwestward from Greenville to Penn Run, the coal measures 3 feet 10 inches; and at Atherson's, on the north fork of Penn Run, 1½ miles due north of Greenville, this coal is mined and is said to vary from 3 feet 10 inches to 4 feet 3 inches.

Several other openings have been made on this coal in Two Lick Valley, in the eastern part of the

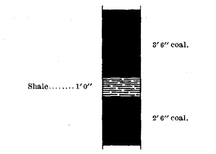


FIG. 12.—Section of the Lower Kittanning coal at Lydick's coal bank, above the mouth of Allen Run.

quadrangle, but the banks are not being worked and measurements in them could not be made.

The underground extension of the Lower Kittanning can be inferred from the records of only a few drill holes, but these indicate that the horizon is a persistent one. A drill hole near Graceton shows a thickness of 3 feet 3 inches of this coal. The presence of a coal 1 foot 4 inches thick at the base of the Allegheny formation is also shown by the drill at Graceton.

In Brush Valley, although the results of diamond drilling thus far are not very promising for the discovery of thick deposits of the Freeport coals, there is indication that one at least of the Kittanning coals is well developed. Thus far only two drill holes in the valley have reached the lower coal horizon, and these did not penetrate the base of the Allegheny formation. The records of these drills show the presence of a bed of coal about 170 feet below the Upper Freeport horizon. A further reason for expecting that these lower coals may be present in Brush Valley is that along Blacklick Creek at Vintondale, only a few miles from the Indiana quadrangle, active coal mining in the Kittanning horizon is being carried on. The exact stratigraphic position of this Blacklick coal has not yet been determined, but diamond-drill sections furnished by Mr. C. R. Claghorne show the general occurrence of two of the Lower Allegheny coals about 35 feet apart and measuring 2 feet 6 inches and 4 feet.

COALS IN THE CONEMAUGH FORMATION.

Records of diamond-drill holes show much variability in the number, position, and thickness of coal seams in the Conemaugh formation. The number of coals present in a vertical thickness of 300 feet above the Upper Freeport horizon varies from none to five. Generally these coals measure only a few inches. There are, however, at a few localities in this quadrangle, occurrences of Conemaugh coals of workable thickness. These areas are in the vicinity of Gaibleton, south of Onberg, and in Brush Valley.

About Gaibleton there are two coals above the Upper Freeport horizon. The lower of these has been exposed in an old bank on the east side of Pine Run near its mouth, and another bank which is thought to be on the same coal has been opened near the roadside a mile southeast of Gaibleton. This coal is reported to be about 2 feet thick, and it is estimated to be 60 feet above the Upper Freeport coal. The higher coal in the neighborhood of Gaibleton is exposed in a few banks along Brush Run and on the hills west of Rayne Run. This coal is reported to be about 3 feet thick, and it is estimated to be 130 feet above the Upper Freeport.

On the headwaters of Crooked Creek, between Onberg and Ideal, there are also several banks opened on coal in the Conemaugh formation. The following section (fig. 13) was measured in one bank:

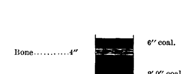


FIG. 13.—Section of coal in the Conemaugh formation in coal bank between Onberg and Ideal.

It is reported that this coal averages about 3 feet in thickness. The coal clearly lies above the Mahoning sandstone, which is well developed toward Two Lick Creek. It is estimated that the interval between this coal and the Upper Freeport horizon is about 100 feet. There is no present evidence that this coal is continuous with that on Brush Run.

In Brush Valley, on a hillside three-quarters of a mile northwest of Rico, there is an old bank in which the coal is reported to be 3½ feet thick and to overlie a bed of limestone. This outcrop seems to be of small extent, but it is interesting because of the clue furnished as to the depth of the Brush Valley syncline. The relation of the coal and limestone, taken in connection with the records of a few drill holes in this valley, suggests that this coal may be referred to the Elk Lick horizon, which generally occurs somewhat over 300 feet above the Upper Freeport.

Another coal, reported to be 3 feet thick, occurs in Brush Valley in an old opening on the west fork of Brush Creek about 1½ miles southwest of Mechanicsburg. The best evidence available makes it probable that this coal is a little less than 200 feet above the Upper Freeport.

It is thought that the coal near water level at the old Oberdorff mill, about 200 rods above the mouth of Brush Creek, is the Upper Freeport. This coal is overlain by a massive sandstone and underlain by limestone, but absolute correlation has not yet been established.

NATURAL GAS.

Occurrence.—Natural gas has been successfully exploited in two localities within the Indiana quadrangle, about Creekside on Crooked Creek and in the vicinity of Willet on the South Branch of Plum Creek. Wells have been drilled elsewhere, as shown on the map, but, although gas has been reported from some of them, no wells within the quadrangle outside of the two areas named have produced gas in paying quantities. Oil has not been found in the quadrangle.

General relations.—The position of the two gas-producing areas is shown by the locations of the wells on the Structure and Economic Geology map. The Creekside field is a small, isolated one, while the Plum Creek area forms the northern end of a larger producing field known as the Willet field. It is interesting to note that these two gas fields lie among the most easterly in the entire producing area. East of Chestnut Ridge no important occurrences of gas or oil have been found, the producing area being confined to the region of gently folded rocks that lies to the west of that ridge. Eastward the rocks have been too much folded and broken to favor the retention of whatever oil or gas they may once have contained. The relation of these areas to the oil and gas fields of the northern Appalachians is shown in fig. 16, on the Illustration sheet.

Relation to structure.—The relation between the structure of the rocks and the occurrence of gas and oil in the Appalachian field has long been recognized. By far the largest proportion of gas wells are located well up the flanks or along the axes of anticlines, while oil is associated with the flanks of synclines. These relations are explainable by supposing a natural distribution, according to gravity, of the liquids and gases which exist in the interstices formed by the loosely fitting rock particles. For instance, suppose a folded bed of sandstone to be permeated by gas, oil, and water; the heavier water would tend to seek the low-lying troughs of the synclines, while the lighter oil would ascend the flanks of the synclines, and the still lighter gas would tend to seek the arches of the anticlines.

The occurrence of gas within the Indiana quadrangle is no exception, the wells in the vicinity of Willet being along the flank of the Roaring Run anticline, while those of the Creekside field extend along the McKee Run anticline. Two deep wells have been drilled on the west flank of the Chestnut Ridge anticline, the Phillips well, on Yellow Creek 1½ miles northeast of Homer, and the Porterfield, on Two Lick Creek east of Indiana. While no important amounts of gas were obtained it is interesting to note that some gas was found in the extreme eastern locality and that gas now escapes from the Phillips well. No wells have been put down along the Richmond anticline within the quadrangle.

Stratigraphic position of the gas sand.—Gas in paying quantity has been found at only one geologic horizon within the Indiana quadrangle, though some of the deep wells report the presence of a little gas at several horizons. The important gas sand in this region occurs about 1100 feet below the Upper Freeport coal and about 400 feet above the top of the red beds previously described as marking the upper part of the Devonian system. These intervals are remarkably constant, varying only by a few feet in all the records examined.

From the proximity of the fields and the constancy of the intervals between recognizable rock horizons it is probable that the same bed of sandstone carries the gas in both the Willet and the Creekside field, but with the present information it is impracticable to correlate this gas sand with that of other fields. While it is recognized that the familiar names of gas sands used by the drillers constitute a serviceable terminology, it should be understood that the names indicate only approximate geologic position instead of actual identity of sandstones. The gas sand in the fields under consideration has approximately the position of the Murraysville sand.

Willet field.—The gas-producing area of the Willet field within the Indiana quadrangle is limited to a few square miles in the vicinity of Willet. Gas was discovered in this region in the Kelly No. 1 well in December, 1890, and other wells were soon put down. In 1891 gas was piped to Indiana, which since that date has been supplied from the Willet field by the Indiana Gas Company. Efforts have been made to find a northeastern extension of this producing area, but thus far without success. To the southwest, however, there are a number of good wells, some of which contribute to the Indiana supply, while gas from other wells is piped to Pittsburg. Of the nine wells put down in this general vicinity within the Indiana quadrangle, six produce gas and three are failures. Thus far not one of the producing wells has been exhausted. No very systematic records have been kept of the pressure, but it is said that the Kelly No. 2 well, near the creek, not far from the northwestern edge of the quadrangle, had a rock pressure of 275 pounds when the well was drilled in 1891 and a minute pressure of 125 pounds through a 5⅝-inch casing. In 1901 the rock pressure in this well had decreased to 100 pounds. One of the best wells in the Plum Creek field was drilled in 1901 on Dutch Run about 4 miles southwest of the point where the South Branch of Plum Creek leaves the Indiana quadrangle. This is the Boyer well, which is reported to have had a rock pressure of 350 pounds and a minute pressure of 245 pounds in a 6¼-inch casing.

The gas sand in the Willet field varies from 15 to 25 feet in thickness and is a uniform, moderately compact, light-gray sandstone, admirably adapted for the storage of gas.

Creekside field.—The gas-producing area of the Creekside field, as now known, is limited to about 1 square mile along Crooked Creek, in the vicinity of Creekside. This pool was first struck in March, 1900, and in the fall of 1901 the wells came into the control of the Indiana Gas Company and the gas was piped to Indiana. Seven wells have been sunk in this field. Four of these are reported to be good, or fairly good, and three are dry. Rock pressure in the best Creekside well is reported to have been 325 pounds, and the minute pressure 105 pounds in a 4-inch casing.

The Creekside gas sand, while thought to belong to the same horizon as that in the Willet area, is of much coarser texture, being sometimes conglomeratic.

BRICK-MAKING MATERIAL.

This is widely distributed in the Indiana quadrangle, but it has not received much attention. It consists of shale and fire clay. These are of sedimentary origin and are composed of fine-textured, more or less decomposed rock fragments. These deposits occupy well-marked stratigraphic positions and often are persistent over considerable areas.

Shale.—Fine-textured and homogeneous deposits of shale are of widespread occurrence in both the Conemaugh and Allegheny formations and outcrop over a large part of the area under discussion. These shales are not utilized except for the manufacture of building brick on a small scale in the town of Indiana, nor have they been well tested, 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 bricks but for making paving bricks and for many other uses to which clay is applied. In conjunction with associated beds of limestone these shales also might be used in the manufacture of cement.

Fire clay.—Fire clay is clay that will resist a high degree of heat. It is utilized in the manufacture of fire brick and other articles for which clay is adapted. Valuable beds of fire clay are present in the Allegheny formation, the most famous being the Bolivar clay, which is extensively worked at Bolivar, on Conemaugh River. At the type locality it occurs from 10 to 20 feet below the Upper Freeport coal. Another valuable deposit of fire clay often occurs below the Lower Kittanning coal. This bed is extensively worked at New Brighton, near the mouth of Beaver River.

In the Indiana quadrangle no attempts have been made to utilize fire clay. Diamond-drill records show several beds of fire clay in the Allegheny formation, as may be seen by referring to Columnar Section sheet 1. An outcrop of homogeneous, fine-textured, hard, drab fire clay, reported to be from 6 to 8 feet thick, was observed at the Bolivar horizon, on the property of J. S. Ralston, just south of the Indiana–Greenville road, near the summit of Chestnut Ridge. Other outcrops should be sought on the hill slopes of the Allegheny formation going down from the Upper Freeport coal, likely horizons being a few feet below the Upper Freeport coal and below the Lower Kittanning coal.

SANDSTONE.

Sandstone suitable for building purposes occurs in many localities within the Indiana quadrangle. The principal beds are the Connellsville, Morgantown, Saltsburg, and Mahoning, of the Conemaugh formation; the Freeport and Kittanning, of the Allegheny formation, and the Pottsville sandstone. No elaborate tests of these sandstones have been made, and but few stone buildings have been constructed within the area under consideration. A notable stone structure is the county court-house at Indiana, which is said to be built of Mahoning sandstone.

The available sandstones are of a variety of colors and textures, varying from whitish and greenish, through buff, brown, and red, and from soft and loose-textured to hard and compact rocks. They can be obtained in blocks of convenient size, which apparently can be easily dressed.

The Pottsville sandstone in several localities outside of this quadrangle is crushed and used for making glass. In the area under consideration this rock is a pure sandstone, generally free from iron stains. It occurs, as mapped, along Yellow Creek adjacent to the Chestnut Ridge anticline, on Two Lick Creek at the eastern edge of the quadrangle, and in a small area on Allen Run.

LIMESTONE.

Thin beds of limestone which have been referred to as occurring in both the Conemaugh and Allegheny formations are available for making lime for use as a fertilizer. The limestone most used is the Freeport deposit, which lies between the Upper and Lower Freeport coals. This limestone generally ranges from 2 to 6 feet in thickness and is found in a number of localities within the quadrangle. Limestone in connection with suitable deposits of shale is a possible source of crude material for the manufacture of cement.

WATER.

The Indiana quadrangle is well supplied with water. A number of creeks and runs make flowing water widely accessible, springs are frequent, and water for domestic use is easily obtained from shallow wells.

Deep-seated underground water is also available. The different beds of sandstone receive water at their outcrops, and being pervious and commonly overlain and underlain by relatively impervious shales, the sandstones are saturated with water and constitute reservoirs. Since there are several synclinal basins within the Indiana quadrangle artesian water thus becomes available. That is, if holes be sunk to water-bearing sandstones in proper places, water will rise in the holes to different heights, and sometimes to the surface, according to the artesian head. This artesian head is determined by the difference in height between the elevation of the outcrop of the sandstone and its elevation in the well. Promising localities for artesian water are in synclinal areas where sandstone outcrops along adjacent anticlines. In the basin of the Latrobe syncline west of Homer, for instance, artesian water has been found in the Mahoning sandstone which outcrops on Chestnut Ridge. Large supplies of artesian water, however, should not be expected.

Seven wells were drilled in Indiana between 1883 and 1891, from which the town was supplied with water. But in 1899 this source proved insufficient and recourse was had to Two Lick Creek, which now supplies water of a much inferior quality. One of these wells was put down 3300 feet in search of gas, having been located along the supposed Indiana anticline; the other six range in depth from 175 to 350 feet. Water in them is derived from both the Mahoning and Saltsburg sandstones. In five of these wells the water is reported not to have risen above the horizon at which it was struck, but in two it rose 20 feet.

There are also three successful deep wells in use at the State Normal School in Indiana. These were sunk from 190 to 210 feet below the surface. Some water is derived from the Saltsburg sandstone, but the main supply comes from the Mahoning. In these wells the water is reported to rise 120 feet above the water-bearing horizon.

SOILS.

Excepting the alluvium in creek bottoms the soils of the Indiana quadrangle are derived from the immediately underlying rocks. Being the products of the disintegration and decomposition of sandstones, shales, and thin limestones, more or less mixed with the remains of animal and vegetable life, the soils of the area under consideration are mostly sandy and clay loams. The gently undulating topography of the greater part of the quadrangle causes farming to be an important industry, and with intelligent care the soils give profitable returns. Chestnut and Dias ridges, however, are forest areas. Their steep slopes are strewn with sandstone blocks and the soil is lean and sandy.

July, 1902.

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

STATE OF PENNSYLVANIA
GEORGE W. MC NEES, SIMON HARROLD,
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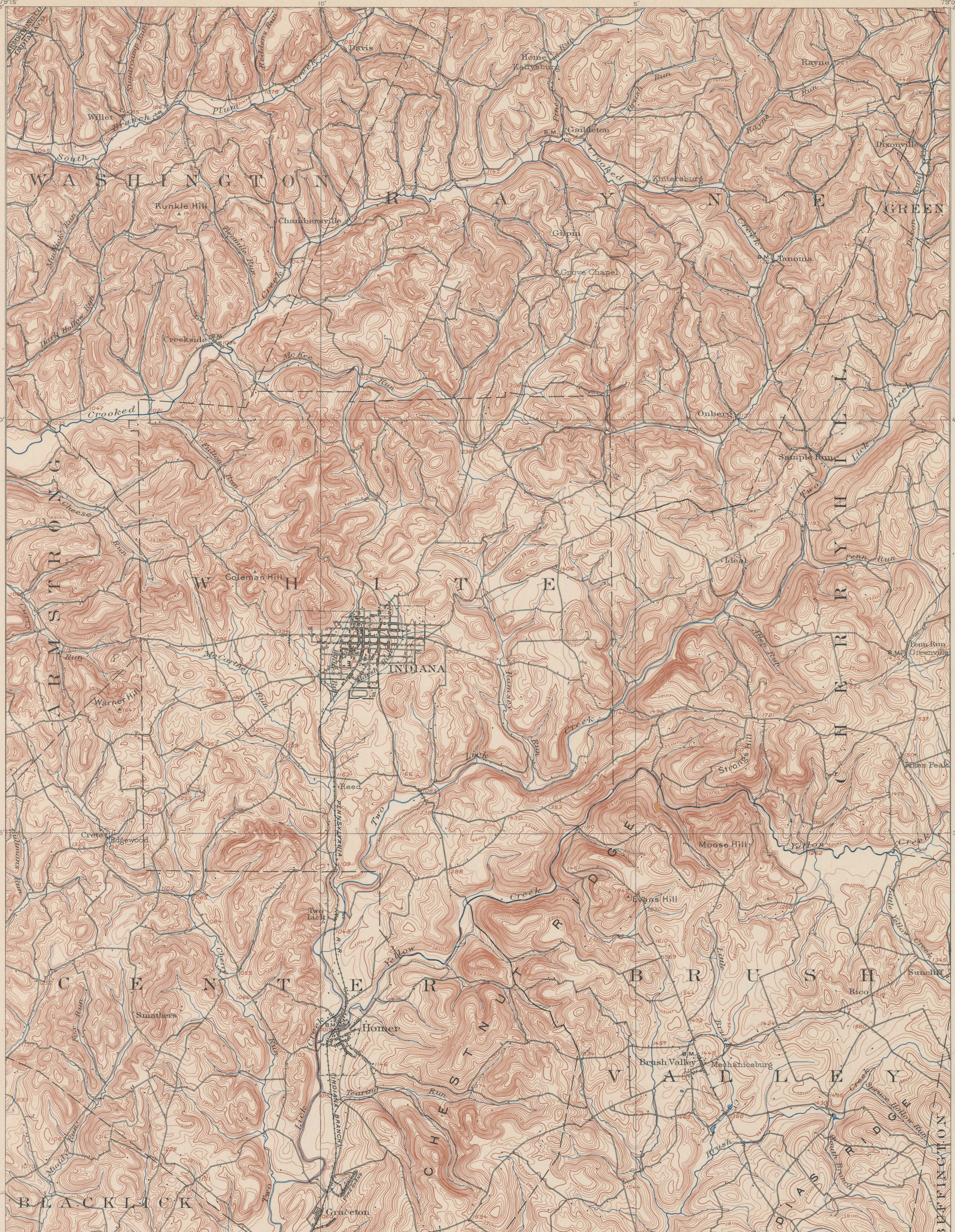
TOPOGRAPHY

PENNSYLVANIA
INDIANA QUADRANGLE



LEGEND

RELIEF
(printed in brown)

Figures
(showing heights above mean sea level instrumentally determined)

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

DRAINAGE
(printed in blue)

Streams

Lakes and ponds

CULTURE
(printed in black)

Roads and buildings

Churches and school houses

Private and secondary roads

Railroads

Dams

Coke ovens

County lines

Township lines

Town lines

Triangulation stations

B.M.
×
Bench marks

H.M.Wilson, Geographer in charge.
Control by A.H.Thompson, Frank Sutton and J.D.Forster.
Topography by Frank Sutton and T.G.Basinger.
Surveyed in 1900 in cooperation with the State of Pennsylvania.

(Latrobe)

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 June 1903.

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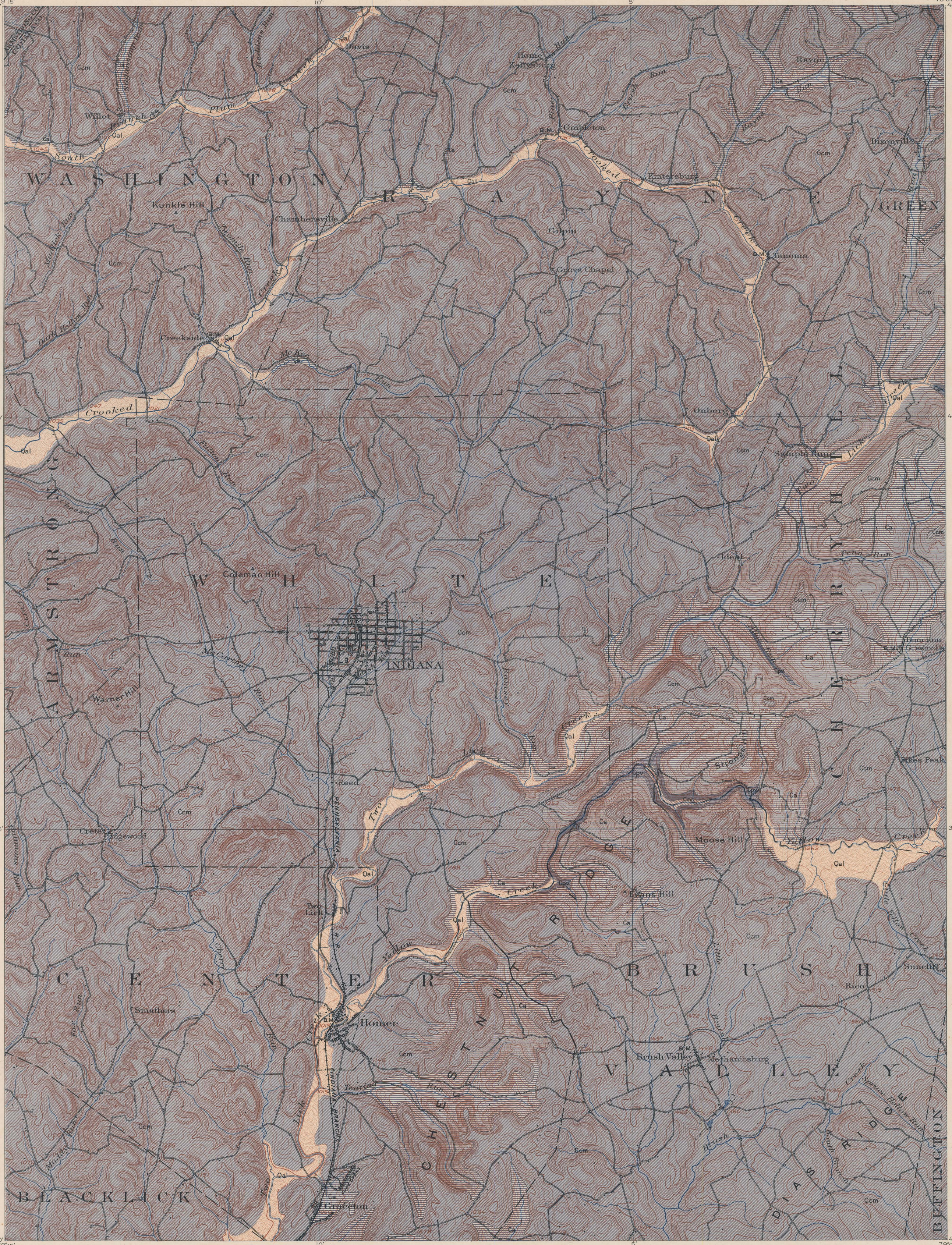
AREAL GEOLOGY

PENNSYLVANIA
INDIANA QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

Recent

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

CARBONIFEROUS

Pennsylvanian series

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

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

Cpv — Pottsville formation *(massive sandstone and shale)*

Mississippian series

Cmc — Mauch Chunk shale *(red and green shale)*

(Latrobe)

H. M. Wilson, Geographer in charge.
Control by A. H. Thompson, Frank Sutton and J. D. Forster.
Topography by Frank Sutton and T. G. Basinger.
Surveyed in 1900 in cooperation with the State of Pennsylvania.

TRUE NORTH
MAGNETIC NORTH
4°
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 July 1903.

Marius R. Campbell, Geologist in charge.
Geology by George B. Richardson.
Surveyed in 1901 in cooperation with the State of Pennsylvania.

U.S.GEOLOGICAL SURVEY
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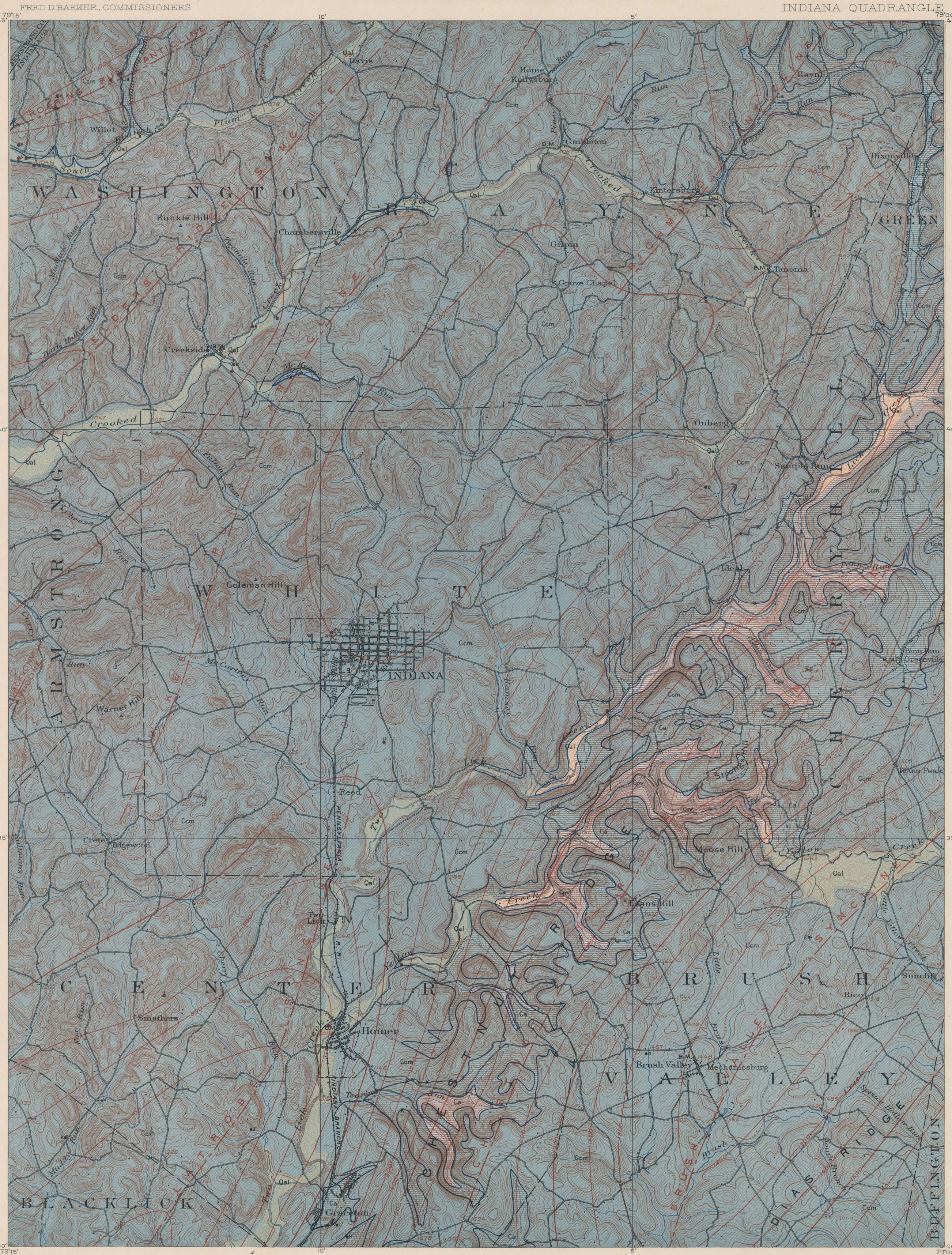
STRUCTURE AND ECONOMIC GEOLOGY

PENNSYLVANIA
INDIANA QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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

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

CARBONIFEROUS
- *Pennsylvanian series*
  - Ccm — Conemaugh formation *(sandstone, shale, and limestone with a few small coal beds)*
  - Ca — Allegheny formation *(shale, sandstone, thin limestone, fire clay and several workable beds of coal; Upper Freeport coal at the top)*
  - Cpv — Pottsville formation *(massive sandstone and shale)*
- *Mississippian series*
  - Cmc — Mauch Chunk shale *(red and green shale)*

- ⚒ *Coal mines*
- × *Local coal banks*
- ◉ *Deep wells drilled for gas*
- ◉ P *Productive gas wells*
- • *Diamond drill holes whose records are published in this folio*

Known productive areas

Coal outcrops *(Upper Freeport, Lower Freeport, Lower Kittanning, and other coals; broken line indicates that the presence of coal is doubtful)*

Coal *(area underlain by coal of probably workable thickness; depth to Upper Freeport coal horizon may be calculated from the structure contours)*

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

H.M.Wilson, Geographer in charge.
Control by A.H.Thompson, Frank Sutton, and J.D.Forster.
Topography by Frank Sutton and T.G.Basinger.
Surveyed in 1900 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 July 1903.

Marius R.Campbell, Geologist in charge.
Geology by George B.Richardson.
Surveyed in 1901 in cooperation with the State of Pennsylvania.

COLUMNAR SECTION SHEET 1

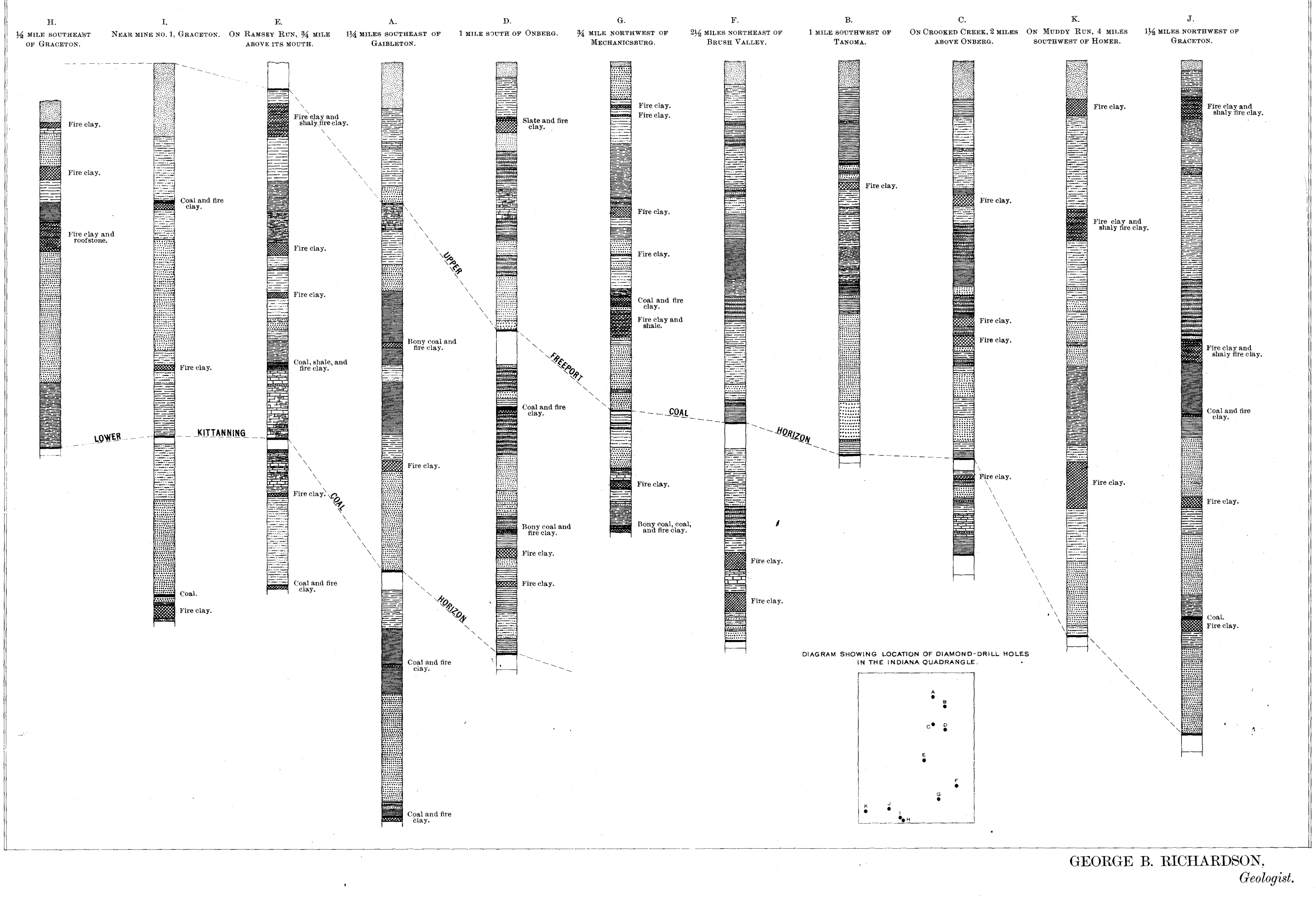
GENERALIZED SECTION OF THE ROCKS OF THE INDIANA QUADRANGLE.

SCALE: 1 INCH=200 FEET.

Period.		Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Names of Members.	Character and Distribution of Members.	Character of Formation.
CARBONIFEROUS	PENNSYLVANIAN SERIES	Monongahela formation.				Pittsburg coal.	Not present in the quadrangle.	Not present in the quadrangle.
		Conemaugh formation.	Ccm		700±	Connellsville sandstone. Morgantown sandstone. Saltsburg sandstone. Mahoning sandstone.	Thin-bedded drab sandstone. Occurs on a few hills in the southwest corner of the quadrangle. Massive buff sandstone. Occurs on hills west of Homer, and on White, Coleman, and Warner hills. Massive buff sandstone. Occurs at Homer and Edgewood and on Dias Ridge. Massive sandstone, often conglomeratic. Occurs above the Upper Freeport coal on Chestnut Ridge, along Crooked Creek near Chambersville, and along McKee Run.	Chiefly drab and reddish shales, with interbedded sandstones, a few thin limestones, and coal beds. The sandstones are not persistent strata but lenses, which form conspicuous outcrops. Locally, in the vicinity of Gaibleton, south of Onberg, and in Brush Valley, some of the coal beds attain workable dimensions.
		Allegheny formation.	Ca		300±	Upper Freeport coal. Freeport limestone. Bolivar fire clay. Lower Freeport coal. Kittanning coals. Vanport (Ferriferous) limestone. Clarion-Brookville coals.	Generally present at the top of the formation. Freeport limestone and Bolivar fire clay not always present. Occurs infrequently. It is mined on Dixon Run. The Lower Kittanning is the most important of the Kittanning coals. It outcrops along the deeper gorges of Chestnut Ridge. Feebly developed. It outcrops in Yellow Creek gorge. Unimportant in the quadrangle.	Shales and sandstones, with occasional beds of limestone and fire clay, and several workable beds of coal.
		Pottsville formation.	Cpv		100±			Massive sandstone and interbedded shale.
	MISSISSIPPIAN	Mauch Chunk shale.	Cmc		50±			Red and green shales.

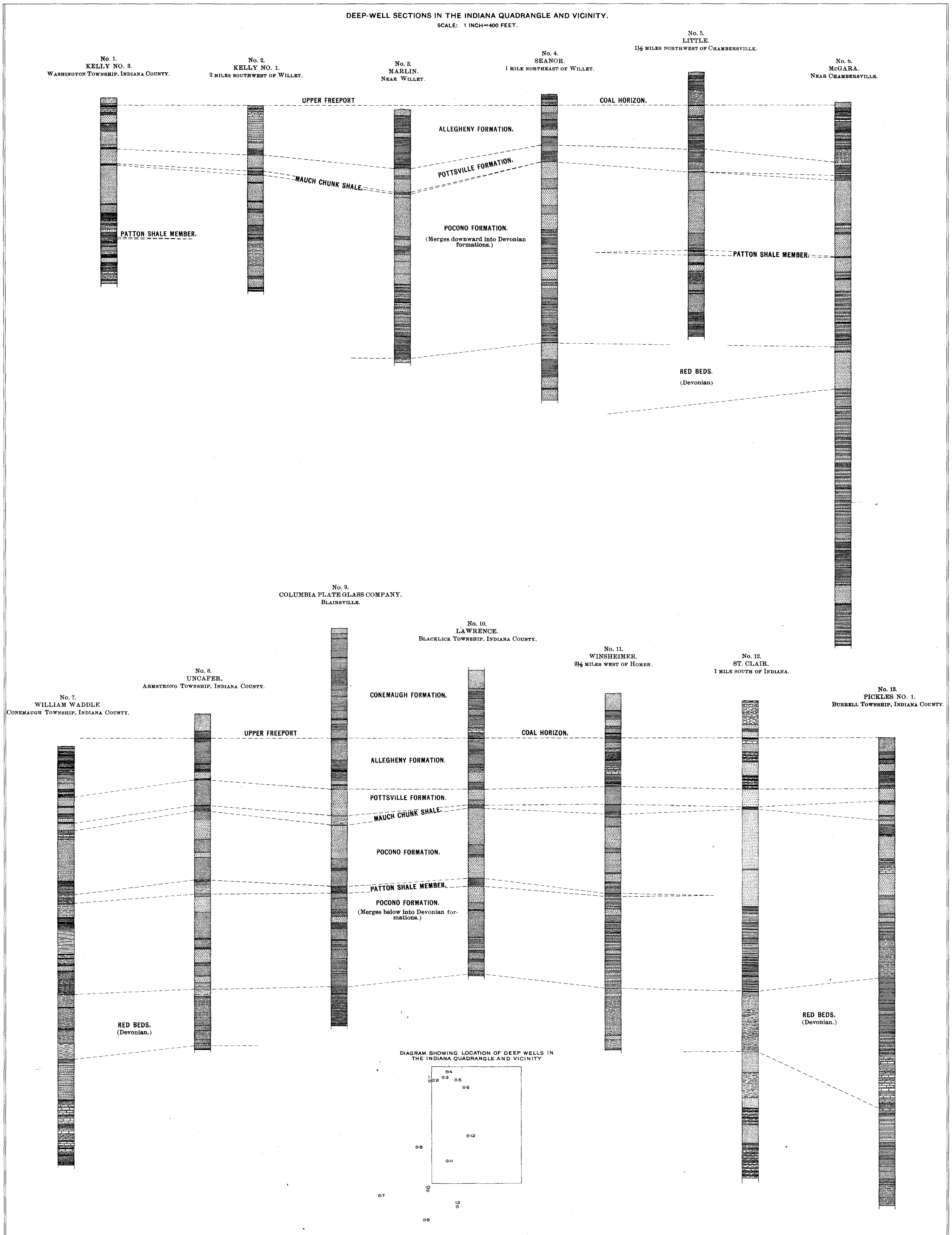
RECORD OF DIAMOND-DRILL HOLES.

SCALE: 1 INCH=50 FEET.



GEORGE B. RICHARDSON,
Geologist.

COLUMNAR SECTION SHEET 2



GEORGE B. RICHARDSON,
Geologist.

ILLUSTRATIONS

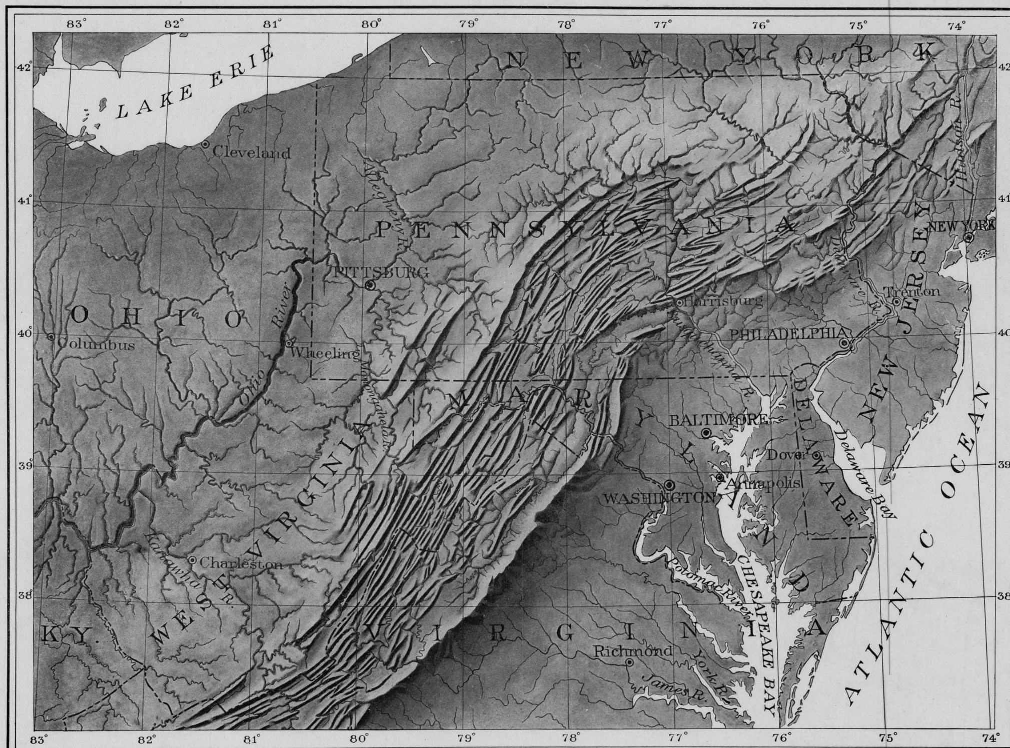


FIG. 14.—RELIEF MAP OF THE NORTHERN APPALACHIAN MOUNTAINS.

The Indiana quadrangle is situated on the plateau west of the belt of valley ridges, in the central western part of Pennsylvania.

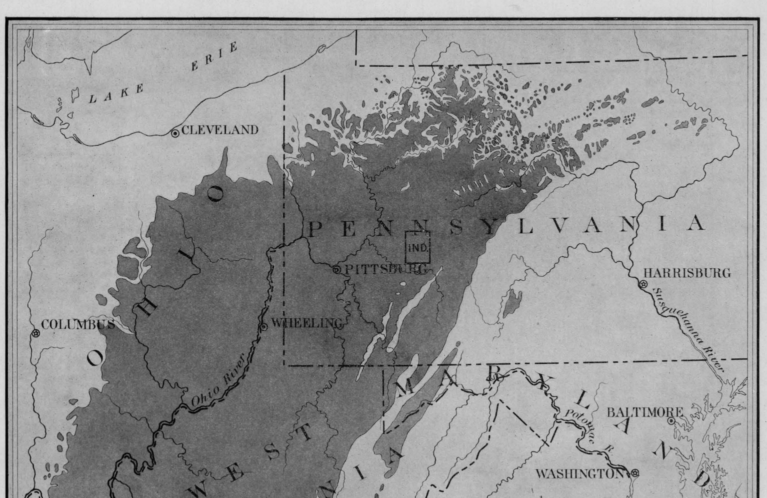


FIG. 15.—MAP SHOWING THE EXTENT OF THE NORTHERN PART OF THE APPALACHIAN COAL FIELD.

The position of the Indiana quadrangle within the coal field is shown by the rectangle.

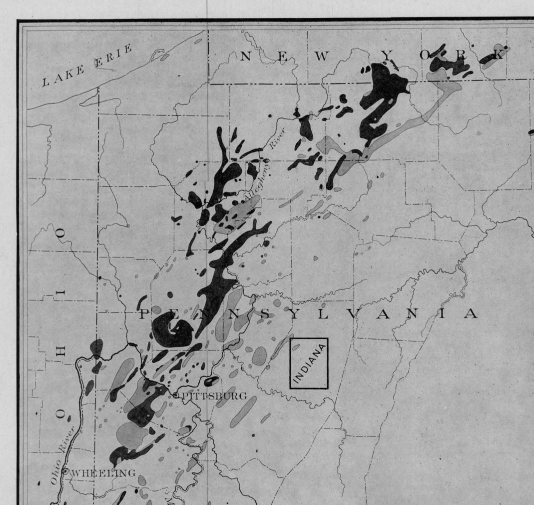


FIG. 16.—MAP OF THE OIL AND GAS PRODUCING AREAS OF THE NORTHERN APPALACHIANS.

Compiled from map by the Second Geological Survey of Pennsylvania, with additions by F. H. Oliphant, 1902. Black areas, oil; shaded areas, gas.

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54	Tacoma	Washington	25
55	Fort Benton	Montana	25
56	Little Belt Mountains	Montana	25
57	Telluride	Colorado	25
58	Elmoro	Colorado	25
59	Bristol	Virginia-Tennessee	25
60	La Plata	Colorado	25
61	Monterey	Virginia-West Virginia	25
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81	Chicago	Illinois-Indiana	50
82	Masontown-Uniontown	Pennsylvania	25
83	New York City	New York-New Jersey	50
84	Ditney	Indiana	25
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