GEOLOGIC ATLAS
OF THE
UNITED STATES
INDIANA FOLIO
PENNSYLVANIA

INDEX MAP

CONTENTS

LIBRARY
Agricultural & Mechanical College of Texas
College Station, Texas

WASHINGTON, D.C.
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

1904
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) inclusions of water, called relief, as plains, plateaus, valleys, hills, and mountains; (2) distribution of the land surface, shown as descriptions, as streams, lakes, and swamps; (3) the works of man, called culverts, 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 blue.

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

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all concave portions of undulations, and are directed toward the points of prominence. Those relation of contours and angles and forms of the landscape can be seen and described. It is customary to note these angles and to use them as a guide to the type of the erosion, or to the nature of the processes which have shaped them.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same along the entire line, and the line is broken at all grade breaks. If a stream sqls and reappears on the other side of a divide, it is due to a break in the grade. If a stream sqls and reappears on the same side of the divide, it is due to a break in the grade. This is shown by the contour interval.

4. 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 sheet of The Geological Survey is 0 feet. This is serviceable for regions like the Mississippi delta and the Dismal Swamp. In steeping mountains, like those in Colorado, the interval may be 25 feet. For intermediate relief contour intervals of 10, 20, 25, 30, and 50 feet are used.

The contour interval is 3,025,000 square miles. A map representing this area, shown as a map of the United States, should be about 3,025,000 square inches of paper, and to accommodate the map, the paper would need to measure about 300 by 240 feet. Each square mile of ground surface would be represented by a square inch of map surface, and each 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 1 inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator is the corresponding linear unit in nature expressed in the same unit. Thus, there are 63,360 inches in a mile, the "1 mile to 1 inch." is expressed by 63,360.

Three scales are used on the atlas sheets of the Geological Survey, the smallest is "1 mile to 1 inch," the intermediate is "1 mile to 2 inches," and the largest is "1 mile to 5 inches." These correspond approximately to 4 miles, 3 miles, and 1 mile on the ground to 1 inch on the map.

The scale of the map is indicated on the margin of each map by an indication of the number of inches or miles on the map covering the surface of 1 square mile.

In 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 units; 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 maps are called quadrangles. Each sheet of the scale of 1 mile to 1 inch contains one square degree—i.e., a quadrangle of one degree by a degree of longitude; each sheet on the scale of 1 mile to 2 inches contains one square degree; each sheet on the scale of 1 mile to 5 inches contains one-quarter of a square degree. The areas of the corresponding quadrangles are approximately 900,000, 1,000,000, and 2,500,000 square miles.

The atlas sheets, being only parts of one map of the United States, may be separated along the natural lines, such as those of States, counties, and towns. To each sheet, and to the quadrangle it represents, the necessary data for the area covered by the natural lines are taken, and at the sides and corners of each sheet the names of adjacent parts are given.

Tiles 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 inventor or owner who desires to ascertain the characteristics of property; save the engineer preliminary surveys in building roads, railways, and irrigation reservoirs and ditches; guide the sanitary engineer in selecting sewage systems; and be useful as a map for local reference.

The GEOLOGIC MAPS.

The maps representing the geologic map, by lines and shadings printed on the topographic base map, the distribution of rock masses on the surface of the land, and the structure of the underground formations, are as follows.

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 magmatic material has been brought upon the earth in this form. Hence, a large body of igneous rocks is a result of volcanic activity, and is usually composed of basalt, gabbro, and granite.

Sedimentary rocks.—These are rocks which have been laid down in the course of time, and have been subjected to pressure and heat. They are composed of sediments which have been deposited under the water, or have been carried by water and deposited on the land.

Metamorphic rocks.—In the course of time, and by various 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 added or removed, and new minerals may be formed. There is often a complete gradation from the primary to the metamorphic form within a single rock, and the new forms may sometimes be absorbed into other rocks in various ways.

The study of geologic history and rock formations has been greatly facilitated by the use of a special type of geologic map, the metamorphic map, but to this rule there are important exceptions.

Porphyries.

For purposes of geologic mapping rocks of all the types are divided into formations. A formation is a bed or beds in an area or rock layer and constitutes the geologic unities of such formations as the geologic unities of the geologic region of a series of occurrences. A 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 special groups of rocks, or portions of the formation, such groups or portions are called members, or by some other appropriate term, as beds.

Ages of rocks.

Geologic time.—The time during which the rocks were formed may be divided into periods. These period divisions are called epochs, and still smaller units, stages. The age of a rock is expressed by means of a time interval in which it was formed, when known.

The sedimentary formations deposited during a single epoch form a system. The principal divisions of a system are called series. Any aggregate of formations less than a series is called a group.
DESCRIPTION OF THE INDIANA QUADRANGLE.

By George B. Richardson.

The Indiana quadrangle, which embraces one-sixteenth of a degree of the earth's surface, extends from latitude 40° 30' to 41° 15' and from longitude 80° 00' to 81° 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.

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 positions are shown in fig. 1. These stations are marked by stone posts 42.5 x 6.5 inches, set about 3 feet in the ground, in the center of the two of which are engraved boulders marked "U.S. Geological Survey—Pennsylvania."

INDIANA, INDIANA COUNTY.

On land west of the farm known as Kunkle about 3 miles north of Cresson post-office, near western end of a high ridge having scattered trees on the eastern end.

INDIANA, INDIANA COUNTY.

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

INDIANA, INDIANA COUNTY.

On a high hill on land owned by W. S. Bowditch.

INDIANA, INDIANA COUNTY.

About 8 miles north of Whiteville, on the railroad between Indiana and North Mahoning townships. Located at 40° 06' 08.49" N., 80° 05' 16.50" W.

INDIANA, INDIANA COUNTY.

On a hill 8 miles southwest of Indiana, in White Township, on the highest part of a bare, rounded hill, on land owned by Mr. Barlow.

INDIANA, INDIANA COUNTY.

On land owned by Mr. McCaffrey, on high ground, but not the highest point.

INDIANA, INDIANA COUNTY.

In Cherryhill Township, about 2 miles southwest of Whiteville, in the immediate vicinity, on land owned by H. B. Strong. There is a lone tree on the northwest part of the hill.

INDIANA, INDIANA COUNTY.

On Brush Hill, Brush Valley Township, on land owned by Mr. Emery, on part of a large hill, overlooking the town of Indiana. Pennsylvania, has been frequently confused in the preparation of this report.

1 The Indiana quadrangle is included in the area surveyed by W. C. Platt in 1877, and his report on Indiana County (SHR, 1877, 1878) prepared by the same Geological Survey of Pennsylvania, has been frequently confused in the preparation of this report.

2 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 Appalachian Plateau in the east to the Piedmont (the mountains that lie between the Allegheny and Blue Ridge provinces). Topographically and geologically, the Appalachian province is largely a series of parallel belts, separated by belts of Appalachian topography. The southern part of the province is characterized by a series of longitudinal northwest-southeast ridges and intervening valleys. The rocks on the east side of this province, to Pennsylvania and beyond, have often been uplifted and faulted. As shown by fig. 14, this province includes all of southeastern Pennsylvania and a large part of the South Carolina Piedmont. As implied by the name Allegheny Plateau, the topographic character of the western division is that of a plateau—an upland consisting of one land on the plateau and the Piedmont Plateau, which is named for the mountains that lie between the Allegheny and Blue Ridge provinces. As implied by the name Allegheny Plateau, the topographic character of the western division is that of a plateau—an upland consisting of one land on the plateau and the Piedmont Plateau, which is named for the mountains that lie between the Allegheny and Blue Ridge provinces.
The most pronounced plateau is along the eastern limit of the division and extends practically the entire length of the Appalachian Plateau in central Alabama. The surface of this plateau is largely above the 200-foot level, and the highest point in central Alabama is 3,500 feet above sea level. This plateau is a part of a series of plateaus that extend from the Appalachian Plateau to the southern portion of the United States. The highest point in this region is 3,500 feet above sea level, and the plateau is separated from the surrounding highlands by a series of lowlands.

The climate of this region is characterized by long, dry summers and short, cold winters. The average temperature in January is 35°F, and in July it is 75°F. The average annual precipitation is 45 inches.

TOPOGRAPHY.

Physiographic relations: The two characteristic plateaus of the Alachua-Okefenokee Plateau are represented in this region. The eastern plateau is characterized by a series of low plateaus separated by narrow valleys. The western plateau is characterized by a series of low plateaus separated by narrow valleys. The highest point in this region is 3,500 feet above sea level, and the plateau is separated from the surrounding highlands by a series of lowlands.

The climate of this region is characterized by long, dry summers and short, cold winters. The average temperature in January is 35°F, and in July it is 75°F. The average annual precipitation is 45 inches.

The most pronounced plateau is along the eastern limit of the division and extends practically the entire length of the Appalachian Plateau in central Alabama. The surface of this plateau is largely above the 200-foot level, and the highest point in central Alabama is 3,500 feet above sea level. This plateau is a part of a series of plateaus that extend from the Appalachian Plateau to the southern portion of the United States. The highest point in this region is 3,500 feet above sea level, and the plateau is separated from the surrounding highlands by a series of lowlands.

The climate of this region is characterized by long, dry summers and short, cold winters. The average temperature in January is 35°F, and in July it is 75°F. The average annual precipitation is 45 inches.
deep wells show an interval of shale at the Munch Chunk horizon between the Potomac formation and the Pomo sandstone. The Potomac sandstone is gray to buff, and in others no mention of the color is made. The thickest occurrence recorded in this vicinity is about 100 feet in thickness. Along Chestnut Ridge, in Burwell Township, where there are 114 feet of red sand and shales are reported at the Munch Chunk horizon. Northwestward the thickness diminishes considerably.

This escarpment of the Munch Chunk is interesting because of the well-known valley side slope and the associated thinning of the formation and of the erosional unconformity which appurtenant to the Potomac formation. Further northeast, into the county of Kittanning, Mr. W. D. Gravett and David White have recently shown that the Potomac sandstone consists mainly on the Pocono, with no intervening Pennsylvanian. Along Yellow Creek where it crosses the Chestnut Ridge anticline there is sufficient interval for the Munch Chunk formation to occur unless the Potomac is unusually thin, which is the case, the rocks underlying the normal thickness of Potomac in the Yellow Creek gorge are concealed by a talus of heavy sandstone blocks. Similar as in the region immediately south and southwest of the Indianquadrange the Munch Chunk shales are well represented, the rocks are similar in thickness and the erosional unconformity which appurtenant to the Potomac formation in beds of limestones and sandstones, some of which are of considerable economic importance. The Upper Freeport coal lies at the top of the formation and is rather thin in its occurrence. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.

The Potomac formations outcrops in three localities in the Indian Quadrange—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 Potomac occupies a small area near water level, the presence of the formation being made conspicuous by large blocks of sandstone separated by an interval of shale which sometimes carries a bed of coal. But within the Indian quadrange, blocks of coal, in this valley, are not exposed, no exact sections can be measured. Most of the rocks of deep wells within the quadrange do not show any horizontal division, but they generally a thickness of about 100 feet for the formation.

The Potomac formations outcrops in three localities in the Indian quadrange—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 Potomac occupies a small area near water level, the presence of the formation being made conspicuous by large blocks of sandstone separated by an interval of shale which sometimes carries a bed of coal. But within the Indian quadrange, blocks of coal, in this valley, are not exposed, no exact sections can be measured. Most of the rocks of deep wells within the quadrange do not show any horizontal division, but they generally a thickness of about 100 feet for the formation.

The Potomac formations outcrops in three localities in the Indian quadrange—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.

The Potomac formations outcrops in three localities in the Indian quadrange—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 Potomac occupies a small area near water level, the presence of the formation being made conspicuous by large blocks of sandstone separated by an interval of shale which sometimes carries a bed of coal. But within the Indian quadrange, blocks of coal, in this valley, are not exposed, no exact sections can be measured. Most of the rocks of deep wells within the quadrange do not show any horizontal division, but they generally a thickness of about 100 feet for the formation.

The Potomac formations outcrops in three localities in the Indian quadrange—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.

The Potomac formations outcrops in three localities in the Indian quadrange—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.

The Potomac formations outcrops in three localities in the Indian quadrange—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.

The Potomac formations outcrops in three localities in the Indian quadrange—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.

The Potomac formations outcrops in three localities in the Indian quadrange—along Two Lick Creek where it emerges from Chestnut Ridge, in Allen Run, and along Yellow Creek where it crosses the Chestnut Ridge anticline. This stratum is, however, subject to variations, which will be discussed under the heading of "Mineral resources." Below this coal is a series of thick limestones and sandstones which are more than 100 feet in thickness, and occasional a heavy sandstone. This sandstone, as it is of a thickness of 70 feet in its occurrence, is not to be considered, because the Upper Freeport coal is not developed.
Freepoint coal is desired at the bridge crossing Two Lick Creek in the northern part of the town of Hamilton. It will be seen that the elevation of the surface of the water at this point is a little under 1000 feet and that the bridge is a little above the 900-foot structure contour on the coal, therefore, is here about 1020 minus 800 feet, or about 230 feet, below the surface.

The structure contours of the Indiana quadrangle are based on the assumption that the main faults are the only principal structures on this scale, but it is by no means implied that the other structures of the area are not present. The coal is thus the same all the way through, and the occurrence of a large number of small banks, to supply local demands, has been in operation. Up to the present, this mining has been carried on within the area. Only two mines, those of the McCrory Coal and Coke Company and theemouth Coal and Coke Company, have been operated on a large scale. There are, however, indications of approaching greater activity. A number of mines have recently been put in upon the test and large deposits of coal, and the Buffalo, Rochester and Pittsburg Railway is extending its road to the southern end of the Coal Region, presumably for the purpose of opening mines.

The Pittsburg coal outcrops a short distance to the west of the township, but it 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. County banks show the presence of coal workings in the Conemaugh in a few localities, but by far the most important coal beds belong to the Allegheny formation.

It is observed that some misconceptions exist regarding the occurrence and names of coals in this formation. The common names of the coal seams are very general in that a number of them have been designated by letters A, E. D, B, C, R, 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 occur everywhere throughout the area in which the formation is found.

Some workers in the field, not thoroughly familiar with the boundaries of the coal seams, have assumed that these seven coal beds are actually continuous over wide areas, and that wherever the support of the formation it must be correlated with one of the coals in the general section. But a careful consideration of the records of the Ohio, Pennsylvania, and West Virginia geological surveys and of the information or a study of complete natural exposures shows that often fewer than seven beds of coal occur in any one area. The number of coal beds 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.

The Allegheny formation is formed by the sands and clays of the Lower Kittanning, Clarion, and Brookville, and in the sections representing the formation in the first basins west of the Allegheny these coals have been designated by letters E, D, B, C, R, 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 occur everywhere throughout the area in which the formation is found.

Some workers in the field, not thoroughly familiar with the boundaries of the coal seams, have assumed that these seven coal beds are actually continuous over wide areas, and that wherever the support of the formation it must be correlated with one of the coals in the general section. But a careful consideration of the records of the Ohio, Pennsylvania, and West Virginia geological surveys and of the information or a study of complete natural exposures shows that often fewer than seven beds of coal occur in any one area. The number of coal beds 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.

The Allegheny formation is formed by the sands and clays of the Lower Kittanning, Clarion, and Brookville, and in the sections representing the formation in the first basins west of the Allegheny these coals have been designated by letters E, D, B, C, R, 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 occur everywhere throughout the area in which the formation is found.

Some workers in the field, not thoroughly familiar with the boundaries of the coal seams, have assumed that these seven coal beds are actually continuous over wide areas, and that wherever the support of the formation it must be correlated with one of the coals in the general section. But a careful consideration of the records of the Ohio, Pennsylvania, and West Virginia geological surveys and of the information or a study of complete natural exposures shows that often fewer than seven beds of coal occur in any one area. The number of coal beds 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.

The Allegheny formation is formed by the sands and clays of the Lower Kittanning, Clarion, and Brookville, and in the sections representing the formation in the first basins west of the Allegheny these coals have been designated by letters E, D, B, C, R, 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 occur everywhere throughout the area in which the formation is found.

Some workers in the field, not thoroughly familiar with the boundaries of the coal seams, have assumed that these seven coal beds are actually continuous over wide areas, and that wherever the support of the formation it must be correlated with one of the coals in the general section. But a careful consideration of the records of the Ohio, Pennsylvania, and West Virginia geological surveys and of the information or a study of complete natural exposures shows that often fewer than seven beds of coal occur in any one area. The number of coal beds 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.
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 outcrop 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 consequence. The Upper Freeport coal outcrops in six or more distinct areas in the Indianas quadrangle. These areas are along Chestnut Ridge, on Dixon, Rayne's, and McKee runs, on Crooked Creek, and along the South Branch of Pinn Creek. 

**Chesnut Ridge.** —Chesnut Ridge is the most extensive of these areas, and numerous county banks have been opened on the coal, as shown on the map. The principal coal workings within the quadrangle are those of the McCready Coal and Coke Company at Geremont. 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 81 per cent, to the north of the mines. In mine No. 1 the section in fig. 2 was measured:

- **Water 4.06**
- **Volume 28.67**
- **Sulphur 0.21**
- **Ash 4.06**

**Northwest.** —Northwest the Upper Freeport coal again decreases in thickness. On the top of the ridge in the vicinity of the road between Indians and Greenville, opening on the farms of William Barnet and J. S. Baldwin showed the following section (fig. 5):

- **Water 5.88**
- **Volume 23.09**
- **Sulphur 0.18**
- **Ash 3.96**

The coke is bright, hard, and 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:

- **Water 0.90**
- **Volume 28.13**
- **Sulphur 0.08**
- **Ash 4.53**

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

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 Indians coal along the boundary in the northern portion of the area.

**Upper Freeport coal along the boundary.** In the valley of Dixon Run the Upper Freeport coal is unimportant. Probably this statement is true for most of the Indianas 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 general character of the coal is shown in the following section (fig. 4):

- **Water 2.93**
- **Volume 25.43**
- **Sulphur 0.59**
- **Ash 4.66**

**Crooked Creek.** —Between Chambersville and Geremont in the McKee Run district, the Upper Freeport coal appears to fluctuate a few feet above and below level for about 12 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. 6 is exposed.

**South Branch of Pinn Creek.** —Along the South Branch of Pinn Creek and its tributary, Sugarcamp Run, a coal exposed is which is expected to be the Upper Freeport, although the Mahoning sandstone is not present. The coal is underlain by limestone, and the deep walls in this vicinity strike the gas and are at the same distance below this coal as to the wells near Crooked, 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 Run 35 inches of coal were measured. At the Parke and Trusel banks, on Sugarcamp Run, the coal measures 3 feet 4 inches, and separated by a 1-inch band of shale 5 inches from the base, W. G. Platt reports a thickness of 3 feet 4 inches, with a 2-inch band of shale in the middle part near the base. The Martin bank near the Sugarcamp Run.

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

- **Water 1.00**
- **Volume 23.00**
- **Sulphur 0.00**
- **Ash 4.96**

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

- **Water 2.46**
- **Volume 23.04**
- **Sulphur 0.59**
- **Ash 4.06**

**Longford.** —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 further up by a thin bed of coal, which are thought to be respectively the Upper Freeport and coal. Moreover, in the adjacent valley of Buck Run, which is just off the northeastern corner of the quadrangle, a coal supposed to be the Lower Kittanning occurs about 100 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 2 inches of coal was obtained. From this point the dip of the western flank of the Chesnut Ridge anticline carries the coal gradually downward 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 run, half a mile to the north of Dixonville, it measures from 4 feet 2 inches to 4 feet 4 inches.

**Dixon Run.** —In the valley of Dixon Run a number of country coal banks have been opened, but whether this 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 outcrop 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 found is not accounted for by the Upper Freeport instead of the Lower 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 of which might cast doubt. Or if these questionable coals were separated by a greater vertical interval the general structure would not have that important light upon 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 tenaciously maintained that the thin upper coal is the Upper Fortampton. Fortunately, the distance between the coals is so small that the resulting error in mapping, on either supposition, is not great.

At Bettinsford's bank, about half a mile north of Bayne 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. Manness, in the valley west of Bettinsford, similar conditions prevail. That is, the main coal is almost directly underlaid by limstone, and about 30 feet above is the outcrop of a fragment of coal with no sandstone exposed. In the H. Edwards bank, on Crooked Creek, a mile below Tamaqua, 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 Bayne Run, the coal is reported to be 2 feet 8 inches thick.

WELLING 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 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 pointed out that further drilling will reveal a greater thickness of these coals.

The Kittanning coal occurs about 200 feet below the Upper Fortampton 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 outline is based on structure contours.

Several old banks have been opened on this coal in the southern part of the quadrangle, but most prominent of these is the one operated by A. C. Purriers 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 3 to 4 feet thick.

Along the banks of the ravine of Yellow Creek where it cuts through Chestnut Ridge there are several banks on this coal. At Pettimer's, near Yellow Creek, west of the road which passes just east of Moore and Strong's hill, the coal is said to measure 2 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 Strong Hill, the coal is 4 feet thick. This also is the measurement in the bank on the east side of the road passing southwest from the Indiana-Greenville pike to the Yellow Creek ford, northeast of Moore Hill.

Two Lick Creek between Sample Run and Ransome Run flows approximately parallel to the strike of 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 Ransome 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 openings on opposite sides of the stream, where this coal measures about 3 feet. Further up the creek several old openings are passed before Persimmon Run near its mouth, and another bank which is thought to be on the same coal has been opened near the roadside a mile southwest of Giraltown. This coal is reported to be about 2 feet thick, and it is estimated to be 60 feet above the Upper Fortampton. The high coal in the neighborhood of Giraltown is exposed in a few banks along Brush Run and on the hills west of Ransome Run. This coal is reported to be about 6 feet thick, and it is estimated to be 150 feet above the Upper Fortampton.

On the headwaters of Crooked Creek, in the vicinity of Osnaburg and Ideal, there are also several banks worked on coal in the Conemaugh formation. The following section (fig. 3) was measured in one bank:

![Diagram](image)

**FIG. 12.—Section of the Lower Kittanning coal and Allegheny coal bank, near the mouth of Allen Run.**

In Brusl Valley, on a hillside three-quarters of a mile north of Rice, there is an old bank where the coal is reported to be 3 feet thick and to overlie a bed of limstone. This outcrop seems to be of small extent, but it is interesting because of the depth of the Brusl Valley section. The relation of the coal and limstone, taken in connection with the records of a coal strike near the mouth of Allen Run, suggests that this coal may be referred to the Elk Lick horizon, which generally occurs somewhat more than 300 feet above the Upper Fortampton.

Another coal, reported to be 3 feet thick, occurs in Brusl Valley in an opening on the west side of the road about 11 miles southwest of Brusl, Mechemsburg. The best evidence available makes it probable that this coal is a little less than 200 feet above the Upper Fortampton.

It is thought that the coal near water level at the old Ossendorf mill, about 200 feet above the mouth of Brusl Creek, is the Upper Fortampton. This coal is overlain by a massive sandstone and underlain by limstone, but absolute correlation has not yet been established.

**NATURAL GAS**

Covariance.—Natural gas has been successfully explored in two localities within the Indiana quadrangle, on Crooked Creek on Crooked Creek and in the vicinity of the South Branch of the Plum Creek. Wells have been drilled elsewhere, as shown on the map, but, although gas has been found, there is no description of these wells. Only six produce gas from the quadrangle outside of the two areas named have produced gas in paying quantities. Oil has not been reported in the Indiana quadrangle.

General relations.—The position of the two gas-producing areas is shown by the locations of the towns and the extension of the line of produce gas as shown on the map. The Creekfield 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 southerly in the entire province of the Allegheny—Chestnut Ridge formations. The occurrence of gas or oil and the presence of the producing area is shown in fig. 10, on the Illustration sheet.

Relation to strata.—The relation between the structure of the rocks and the occurrence of gas in the Allegheny formation field has long been recognized. By far the largest proportion of gas wells, are located well up the flanks or along the axes of the Allegheny anticlines, and a vast area of the Allegheny is not occupied by the flanks of synclines. These relations are explainable by supposing a natural distribution, according to gravity, of the liquid and gases which exist in the interstitial spaces in the closely fitting rock particles. For instance, suppose a folded bed of sandstone to be penetrated by gas, oil, and water; the heavier water would tend to seek the lowlying troughs of the synclines, while the lighter oil and gas would ascend the flanks of the synclines, and the still lighter gas would tend to seek the arched crests of the anticlines.

The occurrence of gas within the Indiana quadrangle is an exception, the wells in the vicinity of Willet being along the Bank of the Running River anticline, while those of the Creekfield extend along the McKee Run anticline. Two deep wells have been opened in the west flank of the Chestnut Ridge anticline, the Phillips well, on Yellow Creek 11 miles northeast of Homer, and the Potomac, 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 both wells in quantities that, with the little gas now newly discovered, may very likely prove the ancestor of that which rises from the Phillips well. No wells have been put down along the Richmond anticline within the Indiana quadrangle.

Stratigraphic position of the gas well.—Gas in paying quantity has been found at only one geologic position in the Indiana quadrangle, though some of the deep wells report the presence of a little gas at several horizons. The important gas wells are about 1100 feet below the Upper Fortampton and about 400 feet above the top of the red beds previously described as marking the upper part of the Devonian system. The gas is obtained in a very constant, varying only by a few feet in all the records examined.

From the proximity of the fields and the common occurrence of gas in the overlying systems, the discovery of a new gas well is probable. The best evidence available makes it improbable to correlate this gas sand with that of other fields. While it is recognized that the familiar names of gas fields used by the drillers constitute a serviceable terminology, it should be understood that the names indicate only approximations in position instead of actual identity of the sandstones. The gas sand in the field under consideration has approximately the position of the Murrysville 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, 1809, and other wells were soon put down. In 1918 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 northeast extension of this producing area, but thus far without success. To the southeast, however, there is a number of new wells under water owned by the Indiana Gas Company supply, while gas from other wells is piped to Pittsburg. Of the nine wells put down in this general area, seven produce gas, and six produce gas and three are failures. Thus far not one of the producing wells has been exhausted. The depth of the gas at the Willet field has not been drilled to the bottom, but it is said that the Kelly No. 2 well, near the creek, not far from the northern edge of the Willet field, has reached a depth of 275 feet, and that the screen in this well was drilled in 1913 for a pressure of 150 pounds through a 15-feet casing. In 1910 the production 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 1 mile north of the Pennsylvania line, and the point where the occurrence of gas or oil is found, the producing area is shown in fig. 10, on the Illustration sheet.

The Creekfield well, while thought to belong to the same horizon as that at the Willet field, is of much coarser texture, being somewhat conglomerate.

**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 different texture and are composed of fine-textured, more or less decomposed rock fragments. These deposits occur 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, nor do they appear to offer a field worthy of investigation. Homogeneous deposits of fine-textured, moderately fossiliferous, and fairly plastic clays are utilized for the manufacture of building bricks 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, dark fire clay, reported to be from 6 to 8 feet thick, was observed at the Bolivar horizon, on the property of J. S. Rabon, 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 Connellville, Morgantown, Saltsburg, and Mahoning, of the Connemara formation; the Freeport and Kittanning, of the Allegheny formation, and the Portville sandstones. 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 gray to brown, 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 Portville 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 limestones which have been referred to as occurring in both the Connemara 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 head between the elevation of the outcrop of the sandstone and its elevation in the well. Prominent localities for artesian water are in synclinal areas where sandstone outcrops along adjacent anticlines. In the basin of the Lateral 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 1890 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 2500 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.
## Generalized Section of the Rocks of the Indiana Quadrangle

**Scale:** 1 inch = 100 feet

### Columnar Section Sheet 1

<table>
<thead>
<tr>
<th>Formation Name</th>
<th>Columnar Section</th>
<th>Names of Members</th>
<th>Character and Distribution of Members</th>
<th>Character of Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>monocline</td>
<td>Pitcher rock</td>
<td>Mt. Pleasant sandstone</td>
<td>Thin-bedded dolomite sandstone. Occurs on a few hills in the southeast corner of the quadrangle.</td>
<td>Not present in the quadrangle.</td>
</tr>
<tr>
<td>Conesville</td>
<td>Conesville sandstone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morganston sandstone</td>
<td></td>
<td>Massive buff sandstone. Occurs on hills west of Homer, and on White, Cessions, and Masonville.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sullivan sandstone</td>
<td></td>
<td>Massive buff sandstone. Occurs at Homer and Edgewood and on Blue Ridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rolling sandstone</td>
<td></td>
<td>Massive sandstone, often conglomeratic. Occurs along the Upper Frequent road, in Rolling valley, and along Rolling river.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Frequent road, Rolling valley, and Blue Ridge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alleghany</td>
<td>Alleghany sandstone</td>
<td>Upper Frequent road, Rolling valley, and Blue Ridge.</td>
<td>Generally present at the top of the formation. Upper Frequent road, Rolling valley, and Blue Ridge not always present. Occurs subsequently. It is mixed or interbedded.</td>
<td></td>
</tr>
<tr>
<td>Kittanning road</td>
<td>Kittanning road</td>
<td></td>
<td>The Upper Kittanning is the most important of the Kittanning roads. It occurs along the deeper gorges of the Kittanning river.</td>
<td></td>
</tr>
<tr>
<td>Frequent (Pinecrest) road</td>
<td>Frequent (Pinecrest) road</td>
<td></td>
<td>Fully developed. It occurs in Yellow Creek gorges.</td>
<td></td>
</tr>
<tr>
<td>Clarion-Brookville roads</td>
<td>Clarion-Brookville roads</td>
<td></td>
<td>Unimportant in the quadrangle.</td>
<td></td>
</tr>
<tr>
<td>Petrolite</td>
<td>Petrolite sandstone</td>
<td>Massive sandstone and interbedded shales.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mound Clays hills</td>
<td>Mound Clays hills</td>
<td>Massive sandstone and interbedded shales.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Record of Drift-Core Holes

**Scale:** 1 inch = 500 feet

- A: 1 mile north of Connersville
- B: 1 mile south of Connersville
- C: 1 mile southwest of Connersville
- D: 1 mile northwest of Connersville
- E: 1 mile east of Connersville
- F: 1 mile west of Connersville
- G: 1 mile south of Connersville
- H: 1 mile north of Connersville

**Legend:**
- Fire clay
- Clay and shale
- Clay and sand
- Sand and shale
- Shale

**Note:**
- Dashed lines indicate the location of drift-core holes in the Connersville quadrangle.

---

**George B. Richardson, Geologist**
Fig. 14—Relief Map of the Northern Appalachian Mountains.

The Indiana quadrangle is situated on the plains 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, 1900. Main areas, oil; shaded areas, gas.
An sedimentary deposit or strata accumulate the younger rest as 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 tectonic activity. Two strata of different ages may be distinct species, the younger strata are formed after the older strata have been eroded.

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, but where the same strata are used to indicate a particular color being assigned to each system. The symbols by which are laid out in adjacent columns and superimposed, the design of 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 forming many streams were built up by the streams; soil clays are made by the circulating action of waves, and sand dunes are built up by waves. Topographic forms thus constitute part of the record of the earth's history.

Some forms are produced in the making of deposits and are laterally connected with them. The bedrock shown in fig. 1, is a kind of this; in this case bedrock layers, alluvial plains, and stream terraces are built up. The processes of denudation and erosion can be traced by analyzing the surface of old rock, and modern processes of denudation and erosion can be interpreted by matching the surface with the underlying strata.

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 youngest deposit and on its metamorphism.

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

**The various geologic sheets**

**Areal geology map.**—This shows the areas occupied by the various formations. Patterns formed of parallel straight lines are used to represent sedimentary formations deposited in the sea or lakes. Patterns of data and circles represent either glacial or fluvial origin. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by inclusions or irregular patterns, if the rock is schist or the dikes may be arranged in wavy lines parallel to the structure.

**Structural 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 that cuts across these relations is called a section, and the same term is applied to a plan or section representing the relations. The arrangement of rocks in the earth's structure, and a section exhibiting this arrangement is called a structural section.

**Field section sheet.**—This shows the relations of rocks and rock units of land above the surface, and as the or cutting the relations on 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 could be seen in the site of a cutting, a mine inset, and several thousand feet deep. This is illustrated in the following figure:

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, as to show the underground relations of the strata and to show the saddle and depression. The landscape is a simple representation of a saddle and plateau, and may be used to show the relations of the strata and the depression of the strata in the field section.

**The various geologic sheets.**

**Areal geology map.**—This shows the areas occupied by the various formations. On the map is a key, which is the key to the map. The colors used on the map are the same as those used on the actual map.

**Structural 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 that cuts across these relations is called a section, and the same term is applied to a plan or section representing the relations. The arrangement of rocks in the earth's structure, and a section exhibiting this arrangement is called a structural section.

**Field section sheet.**—This shows the relations of rocks and rock units of land above the surface, and as the or cutting the relations on 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 could be seen in the site of a cutting, a mine inset, and several thousand feet deep. This is illustrated in the following figure:

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

The section in fig. 3 shows three sets of formations distinguished by their underground relations.

*Fig. 3.—Sketch of a vertical section through a bed formed by a stream.*

The uppermost of these, seen at the left of the section, is a set of amylolites and shales, which lie in a horizontal position. Three sedimentary strata are high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's crust 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 dip to the left, and show no change of elevation. The strata, beds, and one of the first set, are conformable. The horizontal strata of the plateau rest upon an inclined bed, and 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 horizontal strata and degradation of the older strata must have occurred between the deposition of the older beds above and after the appearance of the younger. When younger strata rest upon an inclined surface of older rocks the relation between the two is an unconformable one, and their surface of contact is a nonconformity.

The third set of formations consists of crystalline rocks and igneous rocks. At some period of their history the schists were subjected to pressure and traversed by emulsions 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 epiclastic 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 slope of the ground along the line of the sections, and the depth from the surface of the map is measured by the scale of the map.

*Fig. 3.—Sketches used in sections to represent different kinds of rock.*

The figure in fig. 2 presents toward the lower left side of the landscape, and the bedrock upon which the strata are built up. The bedrock is shown on the map by a distinctive combination of color and pattern, and is labeled with a special letter symbol.

**Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea or lakes.** Patterns of data and circles represent either glacial or fluvial origin. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by inclusions or irregular patterns, if the rock is schist or the dikes may be arranged in wavy lines parallel to the structure.
<table>
<thead>
<tr>
<th>No.</th>
<th>Name of folio</th>
<th>State</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Livingston</td>
<td>Montana</td>
<td>$5</td>
</tr>
<tr>
<td>2</td>
<td>Riegelsdorf</td>
<td>Georgia-Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>3</td>
<td>Placerette</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>4</td>
<td>14th Street</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>5</td>
<td>Sacramento</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>6</td>
<td>Chatsworth</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>7</td>
<td>Pine Peak</td>
<td>Colorado</td>
<td>$5</td>
</tr>
<tr>
<td>8</td>
<td>Seneca</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>9</td>
<td>Antelope-Crested Butte</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>10</td>
<td>Harpers Ferry</td>
<td>Va., Va.-Md.</td>
<td>$5</td>
</tr>
<tr>
<td>11</td>
<td>Jackson</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>12</td>
<td>Estillville</td>
<td>Va.-Ky.-Tenn.</td>
<td>$5</td>
</tr>
<tr>
<td>13</td>
<td>Fredericktown</td>
<td>Maryland-Virginia</td>
<td>$5</td>
</tr>
<tr>
<td>14</td>
<td>Stuartsburg</td>
<td>Virginia-West Virginia</td>
<td>$5</td>
</tr>
<tr>
<td>15</td>
<td>Lassen Peak</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>16</td>
<td>Knoxville</td>
<td>Tennessee-North Carolina</td>
<td>$5</td>
</tr>
<tr>
<td>17</td>
<td>Maryville</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>18</td>
<td>Smartsville</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>19</td>
<td>Stevensville</td>
<td>Ala.-Ok.-Tenn.</td>
<td>$5</td>
</tr>
<tr>
<td>20</td>
<td>Cleveland</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>21</td>
<td>Pekin</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>22</td>
<td>McMinnville</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>23</td>
<td>Nolensville</td>
<td>Maryland-Virginia</td>
<td>$5</td>
</tr>
<tr>
<td>24</td>
<td>Three Forks</td>
<td>Montana</td>
<td>$5</td>
</tr>
<tr>
<td>25</td>
<td>London</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>26</td>
<td>Pocahontas</td>
<td>Virginia-West Virginia</td>
<td>$5</td>
</tr>
<tr>
<td>27</td>
<td>McMainville</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>28</td>
<td>Piedmont</td>
<td>Maryland-Est-W Va.</td>
<td>$5</td>
</tr>
<tr>
<td>29</td>
<td>Nevada City Special</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>30</td>
<td>Yellowstone National Park</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>31</td>
<td>Pyramid Peak</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>32</td>
<td>Franklin</td>
<td>Virginia-West Virginia</td>
<td>$5</td>
</tr>
<tr>
<td>33</td>
<td>Bichowsky</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>34</td>
<td>Cookman</td>
<td>Alabama</td>
<td>$5</td>
</tr>
<tr>
<td>35</td>
<td>Pocahontas</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>36</td>
<td>Des Moines</td>
<td>Colorado</td>
<td>$5</td>
</tr>
<tr>
<td>37</td>
<td>Grandton</td>
<td>Montana</td>
<td>$5</td>
</tr>
<tr>
<td>38</td>
<td>Virginia</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>39</td>
<td>Bismarck Bar</td>
<td>Idaho</td>
<td>$5</td>
</tr>
<tr>
<td>40</td>
<td>Beige</td>
<td>Kentucky</td>
<td>$5</td>
</tr>
<tr>
<td>41</td>
<td>Bismarck County</td>
<td>North Dakota</td>
<td>$5</td>
</tr>
<tr>
<td>42</td>
<td>Roosevelt</td>
<td>Oregon</td>
<td>$5</td>
</tr>
<tr>
<td>43</td>
<td>Bismarck-Tatum</td>
<td>Oregon</td>
<td>$5</td>
</tr>
<tr>
<td>44</td>
<td>Brownsville-Greenbushville</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>45</td>
<td>Virginia-West Virginia</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>46</td>
<td>Bloomfield</td>
<td>Pennsylvania-New York</td>
<td>$5</td>
</tr>
<tr>
<td>47</td>
<td>Trenton</td>
<td>New York</td>
<td>$5</td>
</tr>
<tr>
<td>48</td>
<td>Big Trees</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
</tbody>
</table>

PUBLISHED GEOLOGIC FOLIOS

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of folio</th>
<th>State</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>Nevada City Special</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>30</td>
<td>Yellowstone National Park</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>31</td>
<td>Pyramid Peak</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>32</td>
<td>Franklin</td>
<td>Virginia-West Virginia</td>
<td>$5</td>
</tr>
<tr>
<td>33</td>
<td>Bichowsky</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>34</td>
<td>Cookman</td>
<td>Alabama</td>
<td>$5</td>
</tr>
<tr>
<td>35</td>
<td>Pocahontas</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
<tr>
<td>36</td>
<td>Des Moines</td>
<td>Colorado</td>
<td>$5</td>
</tr>
<tr>
<td>37</td>
<td>Grandton</td>
<td>Montana</td>
<td>$5</td>
</tr>
<tr>
<td>38</td>
<td>Virginia</td>
<td>California</td>
<td>$5</td>
</tr>
<tr>
<td>39</td>
<td>Bismarck Bar</td>
<td>Idaho</td>
<td>$5</td>
</tr>
<tr>
<td>40</td>
<td>Beige</td>
<td>Kentucky</td>
<td>$5</td>
</tr>
<tr>
<td>41</td>
<td>Bismarck County</td>
<td>North Dakota</td>
<td>$5</td>
</tr>
<tr>
<td>42</td>
<td>Roosevelt</td>
<td>Oregon</td>
<td>$5</td>
</tr>
<tr>
<td>43</td>
<td>Bismarck-Tatum</td>
<td>Oregon</td>
<td>$5</td>
</tr>
<tr>
<td>44</td>
<td>Brownsville-Greenbushville</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>45</td>
<td>Virginia-West Virginia</td>
<td></td>
<td>$5</td>
</tr>
<tr>
<td>46</td>
<td>Trenton</td>
<td>Pennsylvania-New York</td>
<td>$5</td>
</tr>
<tr>
<td>47</td>
<td>Trenton</td>
<td>New York</td>
<td>$5</td>
</tr>
<tr>
<td>48</td>
<td>Big Trees</td>
<td>Tennessee</td>
<td>$5</td>
</tr>
</tbody>
</table>