

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

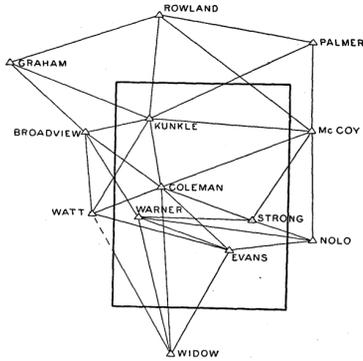


FIG. 1.—Diagram showing triangulation stations on which the survey of the quadrangle is based.

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

¹The 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.

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 Ebsenburg 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 1½ 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 Turner station, top of west rail at.....	1,010
Tunnel station, 900 feet north of; in a cut, stone, chiseled mark.....	1,000.98
Smiths station, road crossing; top of west rail at 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... Blacklick station, 900 feet north of; west side of railroad, rock, chiseled mark.....	967
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".....	972.05
Blacklick station, 1 mile north of; at road crossing, top of east rail.....	980.509
Penn Run, 1 mile west of post-office; on rock under wild cherry tree, chiseled mark.....	1,009
Penn Run, Presbyterian Church, on lower stone step of; bronze tablet, marked "1475 PITTSBURG".....	1,028.5
Pikes Peak, 1.5 miles southwest of; north side of road, rock, chiseled mark.....	1,019
Pikes Peak, 2.2 miles southwest; bridge over Yellow Creek.....	1,020.37
Brush Valley, 2.5 miles northeast of post-office; south side of road, by red house, stone, chiseled mark.....	1,063.0
Brush Valley, 300 feet northeast of post-office; nail in root of oak tree.....	1,060
Brush Valley, Union House, entrance to; in south end of top stone step of, bronze tablet, marked "1448 PITTSBURG".....	1,042.20
Brush Valley, 1.5 miles west of; nearly opposite chestnut tree on north side of road; south side of road, rock, chiseled mark.....	1,014.36
Brush Valley, 8 miles west of; south side of road, by log house, rock, chiseled mark.....	1,019.092
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

	Feet.
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 "1399 PITTSBURG 1900".....	1,299.023

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....	1,307.3
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.....	1,180.15
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 "1084 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, 800 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".....	1,182.225
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, 8 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.....	1,396.60
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.....	1,030.80
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 Plateau.—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 Plateau. 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 Horse-shoe 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 Plateau, 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 Plateau 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.

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

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

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.....	230	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

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 Getys-

Indiana.

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

¹I 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.

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

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:

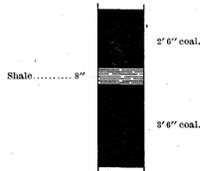


FIG. 2.—Section of the Upper Freeport coal in McCreary mine No. 1, Graceton.

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.

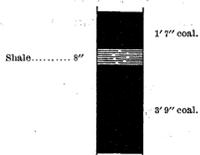


FIG. 3.—Section of the Upper Freeport coal in the Glenmore mine, near the mouth of Tearing Run.

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

Indiana.

farm of John L. Henry, on the road between Homer and Heshbon, 1½ miles east of Graceton, the coal underlies the Mahoning sandstone and shows the following section (fig. 4):

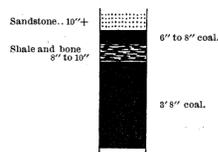


FIG. 4.—Section of the Upper Freeport coal in the Henry coal bank, 1½ miles east of Graceton.

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

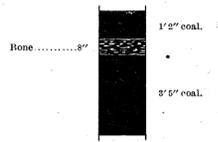


FIG. 5.—Section of the Upper Freeport coal in the Gamble mine.

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.

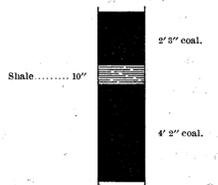


FIG. 6.—Section of the Upper Freeport coal in McHenry and Agey coal banks, on Two Lick Creek, southeast of Indiana.

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 Barnett and J. S. Ralston showed the following section (fig. 7):

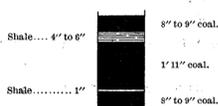


FIG. 7.—Section of the Upper Freeport coal in Barnett and Ralston coal banks, between Indiana and Greenville.

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):

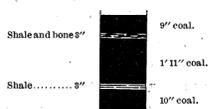


FIG. 8.—Section of the Upper Freeport coal in coal banks near Greenville.

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.

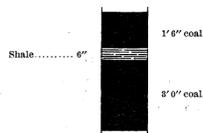


FIG. 9.—Section of the Upper Freeport coal at Simon Fisher's coal bank, opposite Chambersville.

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):

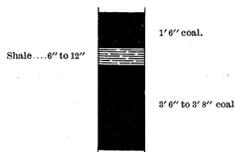


FIG. 10.—Section of the Upper Freeport coal at the Spence Brothers' mine, on McKee Run.

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 Woodson 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 Furrriers 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

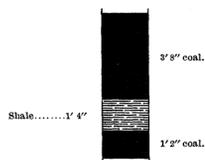


Fig. 11.—Section of the Lower Kittanning coal in coal banks above Ramsey Run.

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

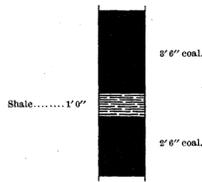


Fig. 12.—Section of the Lower Kittanning coal at Lydick's coal bank, above the mouth of Allen Run.

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 5½-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 6½-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.

Indiana.

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.

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