Bulletin No. 256

Series {A, Economic Geology, 51
{B, Descriptive Geology, 63

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

MINERAL RESOURCES OF THE ELDERS RIDGE QUADRANGLE, PENNSYLVANIA

RALPH W. STONE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., July 21, 1904.

SIR: I transmit herewith the manuscript and illustrations for a bulletin entitled "Mineral Resources of the Elders Ridge Quadrangle, Pennsylvania," by Ralph W. Stone.

This report describes an important coal and gas field, and particular attention is consequently devoted to those products, but the minor economic products of the area also are discussed in some detail.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

MINERAL RESOURCES OF THE ELDERS RIDGE QUADRANGLE, PENNSYLVANIA.[a]

By RALPH W. STONE.

INTRODUCTION.

LOCATION AND AREA.

The Elders Ridge quadrangle is located in central-western Pennsylvania. It extends from latitude 40° 30′ on the south to 40° 45′ on the north, and from longitude 75° 15′ on the east to 75° 30′ on the west. It includes, therefore, one-sixteenth of a square degree of the earth's surface, and covers an area of 227 square miles. It takes its name from a small village in its southern-central part, in Indiana County, almost on the Armstrong-Indiana county line.

About half of the quadrangle is in Armstrong County and half in Indiana County. The N. 36° E. line, which forms a portion of the boundary between the two counties, extends from the upper right-hand corner of the quadrangle to Kiskiminitas River in the lower left-hand corner. The portion of the quadrangle lying south of the river, about 5 square miles in all, is a part of Westmoreland County.

TRIANGULATION POINTS.

The exact location of the Elders Ridge quadrangle with reference to latitude and longitude is determined from certain high points, the position of which has been ascertained accurately by triangulation. There are four triangulation stations within the boundaries, and five near by, which give complete control of the quadrangle. The locations of the stations within the quadrangle are shown on the topographic map by small triangles. Fig. 1 (p. 10) shows the relations of the nine controlling points.

These stations are marked by stone posts, 6 by 6 or 8 by 8 inches in cross section, set about 3 feet in the ground. In the center of the top

[a] The author desires to acknowledge his indebtedness to Charles Butts and L. H. Woolsey, who did part of the geologic mapping of the quadrangle, and to M. R. Campbell, all of the United States Geological Survey, for advice and assistance; also to the gas companies for the use of their records, and to the superintendents of the several coal companies for valuable information.

of each post is cemented a bronze tablet marked "U. S. Geological Survey—Pennsylvania." For the convenience of engineers making surface surveys the following descriptions of these stations are given. Full details regarding the angles by which their positions have been determined can be found in Bulletin No. 181 of the United States Geological Survey, which can be obtained on application to the Director at Washington.

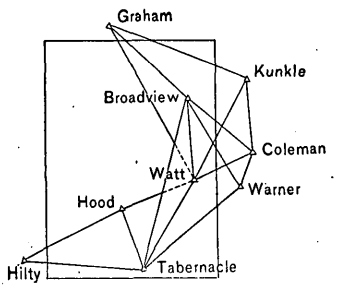


FIG. 1.—Diagram showing locations of triangulation stations on which the survey of the Elders Ridge quadrangle is based.

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. Latitude, 40° 46′ 17.28″. Longitude, 79° 24′ 50.74″.

KUNKLE, INDIANA COUNTY.

On land owned by Philip Kunkle, about 2 miles north of Creekside post-office, near western end of a high ridge having scattering trees on the eastern end. Latitude, 40° 42′ 28.78″. Longitude, 79° 12′ 14.09″.

BROADVIEW, INDIANA COUNTY.

About 2½ miles north of Shelocta and a few rods east of the Armstrong-Indiana county line; 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″.

COLEMAN, INDIANA COUNTY.

In White Township, about 2 miles northwest of Indiana, on high hilltop, on land owned by D. Coleman. Latitude, 40° 38′ 09.95″. Longitude, 79° 11′ 02.71″.

WARNER, INDIANA COUNTY.

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

WATT, INDIANA COUNTY.

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

HOOD, INDIANA COUNTY.

In Young Township, about 1 mile east of Elders Ridge post-office, on the highest point of a bare roundtop hill owned by Calvin Hood. Latitude, 40° 34′ 38.44″. Longitude, 79° 23′ 25.45″.

TABERNACLE, INDIANA COUNTY.

About 1½ miles southeast of Clarksburg post-office and about 6 miles by road northeast of Saltsburg, on the highest part of a bare, cultivated, roundtop hill owned by the heirs of S. W. Coleman. Latitude, 40° 30′ 54.57″. Longitude, 79° 21′ 49.71″.

HILTY, WESTMORELAND COUNTY.

In Bell Township, about 1½ miles north of Perrysville post-office, on the eastern part of a bare knob, and about 3 feet lower than the highest part of the hill, on land owned by S. McCauley. Latitude, 40° 31′ 28.40″. Longitude, 79° 31′ 59.01″.

BENCH MARKS.

Precise-level lines have been run over the Elders Ridge quadrangle, and elevations are based on and adjusted between bench marks established by spirit leveling. All bench marks are referred to an aluminum tablet in the foundation of the Seventh Avenue Hotel at Pittsburg marked "738 Pittsburg 1899," the elevation of which is accepted as 738.384 feet above mean sea level, and are stamped with the letters "Pittsburg" in addition to their figures of elevation. A list and description of the bench marks established in this quadrangle for the preservation of altitudes, with their precise elevations, as finally adjusted in 1903, follows. Where a whole number is given without decimals the altitude is not exact, being given only to the nearest foot.

Elevation of bench marks in Elders Ridge quadrangle.

SHELOCTA, PARKWOOD, AND KENT.

	Feet.
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
Shelocta, 1.2 miles southwest of; south side of road, rock, chiseled mark.	1,046.42
Shelocta, 2.5 miles south of; opposite white house, under clump of locust trees, rock, chiseled mark	1,125.05
Shelocta, 2.75 miles south of; west side of road, opposite hickory tree, rock, chiseled mark	1,165.28
Parkwood, 1,000 feet north of; west side of road, rock, chiseled mark	1,331.42
Parkwood, 1.75 miles south of; bridge over Blacklegs Creek	1,082.00
Kent, 3 miles north of post-office; W. L. Neal's brick residence, on upper foundation stone, aluminum tablet, marked "1167 Pittsburg"	1,167.098
Kent, 2 miles north of post-office; Clark Neal's residence, in front of, on top of stepping block, chiseled mark	1,138.98
Kent, 0.25 mile north of post-office; by old barn, rock, chiseled mark	1,071.43
Kent, at intersection of roads at west end of; opposite blacksmith shop, rock, chiseled mark	1,055.49
Kent, 0.8 mile south of post-office; on east side of road, opposite sawmill, rock, chiseled mark	1,038.86
Kent, 2 miles south of post-office; James M. Jack's brick residence, on stone doorstep, bronze tablet, marked "1029 Pittsburg"	1,028.344
Kent, 3.5 miles south of post-office; bridge over Aultmans Run	982.00

SHELOCTA, ALONG HIGHWAY VIA ELDERTON, COCHRAN MILLS, AND ELDERS RIDGE TO JACKSONVILLE (KENT POST-OFFICE).

Shelocta, covered bridge over Crooked Creek; in wing wall of, bronze tablet, marked "992 Pittsburg"	991.414
Shelocta, 1.5 miles northwest of; large white house and barn, on gate in front of	1,004.00
Elderton, 2 miles east of; at road intersection, iron bridge over Plum Creek, floor of	985.00

	Feet.
Elderton, opposite hotel, on street corner; in west side of square stone hitching post, aluminum tablet, marked "1265 Pittsburg"	1,264.51
Elderton, 3 miles from; 0.5 mile east of Cherry Run, tree, nail in root of	1,124.55
Elderton, 3.5 miles from; bridge over Cherry Run, floor of	1,002.60
Cochran Mills, 3.1 miles northeast of; at fork of road, bridge, floor of	946.00
Cochran Mills, 1.5 miles northeast of; at road to east, bridge, floor of	917.00
Cochran Mills, iron bridge over Cherry Run; floor of	868.00
Cochran Mills, old covered wooden bridge over Crooked Creek; east abutment of, in northwest wing wall of, bronze tablet marked "871 Pittsburg"	870.429
Cochran Mills, 1 mile east of; near crest of hill, on rock, chisel mark projection	1,227.36
Cochran Mills, 2 miles east of; signboard tree, nail in root of	1,261.72
Girty, at road intersection, ground	1,003.00
Girty, 0.2 mile southwest of; bridge over Crooked Creek, on wing wall of, paint spot	945.97
Shady Plain, 0.5 mile north of; at road fork to west	1,393.00
Elders Ridge, 2 miles north of; 0.25 mile above schoolhouse, on left of road, rock	1,139.50
Olivet, at sign "West Lebanon 4 m.," road fork	1,079.00
Elders Ridge, Presbyterian Church, in southeast corner of, foundation stone, aluminum tablet marked "1226 Pittsburg"	1,225.639
Clarksburg, 1 mile west of; 300 feet west of coal pit, by side of road, log, nail in end of	1,137.89
Clarksburg, 1,000 feet west of Main street, large oak tree, nail in root of	925.08
Clarksburg, front of hotel, at corner of, on stone, chiseled square	917.85
Clarksburg, 0.75 mile east of; Blacklegs Creek, covered bridge over floor of	931.00
Clarksburg, about 2.5 miles east of; at left of road and above white house, white-oak tree, tack in root of	1,071.65
Clarksburg, about 3.5 miles east of; signboard tree, nail in root of	1,256.23
Jacksonville, Kent post-office, 1 mile west of; summit of road, ground	1,335.00
Jacksonville, Kent post-office, blacksmith shop near road intersection, on stone, chisel mark	1,055.49

AT EDRI.

Edri, 0.1 mile west of station; railroad bridge, on west abutment of, on south end of bridge seat, copper bolt, Pennsylvania Railroad bench mark	834.55
Edri, 0.1 mile west of station; railroad bridge, in northwest corner of bridge seat, bronze tablet marked "834 Pittsburg"	833.732

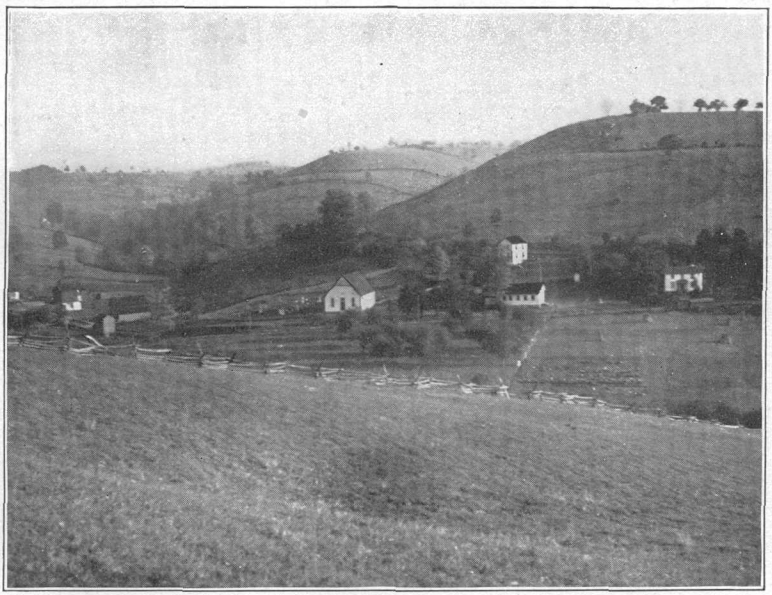
TOPOGRAPHY.

SURFACE RELIEF.

The highest point in this quadrangle is Watt Hill, in Armstrong Township, Indiana County. Its top is 1,620 feet above sea level, or nearly 300 feet higher than the road corners at Parkwood. The point of least elevation is on Kiskiminitas River below Salina, where the level of the water is about 800 feet above tide. Crooked Creek has nearly the same elevation where it leaves the quadrangle a few miles to the north.

A. VIEW OF GENERAL TOPOGRAPHY.

Elderton in middle distance.



B. VIEW OF CONEMAUGH FORMATION TOPOGRAPHY, ROCKVILLE.

Throughout this quadrangle the surface is hilly. For this reason roads find better grades along the valleys than on the higher land, although some highways on the divides have easy grades for several miles. Pl. II, *A*, gives a broad view of the general topography, with Elderton in the middle distance, and Pl. II, *B*, shows in greater detail the character of topography developed on the Conemaugh formation. Rockville is in the foreground of the view. Because a large portion of the surface of the region is underlain by the rocks of one formation—and they vary but little from place to place—there is not much change in the character of the surface relief.

DRAINAGE.

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

All of the drainage is tributary to Allegheny River. The streams are so small that none is navigable, even for rowboats, except on short stretches. The largest is Kiskiminitas River, which is formed by the junction of the Conemaugh and Loyalhanna at Saltsburg, about 3 miles south of the border of the quadrangle. The Kiskiminitas crosses the southwest corner, flowing due north for 2 miles, and then west at a right angle past Avonmore and Salina, about 5½ miles in all. It empties into the Allegheny near Freeport.

The main tributary of the Kiskiminitas in the region under discussion is Blacklegs Creek, which has its rise in the country about West Lebanon and Parkwood, and flows in a direct course to its mouth, 1¾ miles south of Edri, near the American Sheet Steel Company's plant. Big, Marshall, Hooper, Whisky, and Harper runs are the principal branches of Blacklegs Creek.

Crooked Creek is the second largest stream (Pl. III, *A*). It flows west across the northern half of the quadrangle in a course which its name describes. From Shelocta to Southbend, a village located almost in the center of the quadrangle, the stream flows through an open valley; but from Southbend to the western border it cuts a good-sized gorge, making steep rocky bluffs, in some places over 250 feet high.

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

RELATION OF TOPOGRAPHY TO MAN'S ACTIVITIES.

Of the thirty or more hamlets in the Elders Ridge quadrangle, only a little more than half are on the banks of streams in the valleys; the others are on the uplands. The reason for the location of some of these settlements is apparent. Cochran Mills, for instance, is at the confluence of two streams, along which are main lines of travel, and is also the site of excellent water power. It is in a deep gorge, however, where there is room for only a few houses. The location of West Lebanon on the top of a hill 1,300 feet above sea level may have had its origin in the opening of a 7-foot bed of coal (Pittsburg) in the ravines which head around the hill. The principal occupation in this quadrangle is agriculture and grazing.

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

Crooked Creek carries a sufficient volume of water to furnish power for a number of mills. It falls 130 feet from Shelocta to Cochran Mills, a distance of nearly 18 miles as the stream flows; this furnishes enough head for water power at frequent intervals. Dams have been built at Cochran Mills, South Bend, and Idaho to run gristmills. Blacklegs Creek has been dammed near its mouth, where the grade is so low that the stream is ponded for some distance. Plum Creek and Cherry Run also are used for water power for small mills.

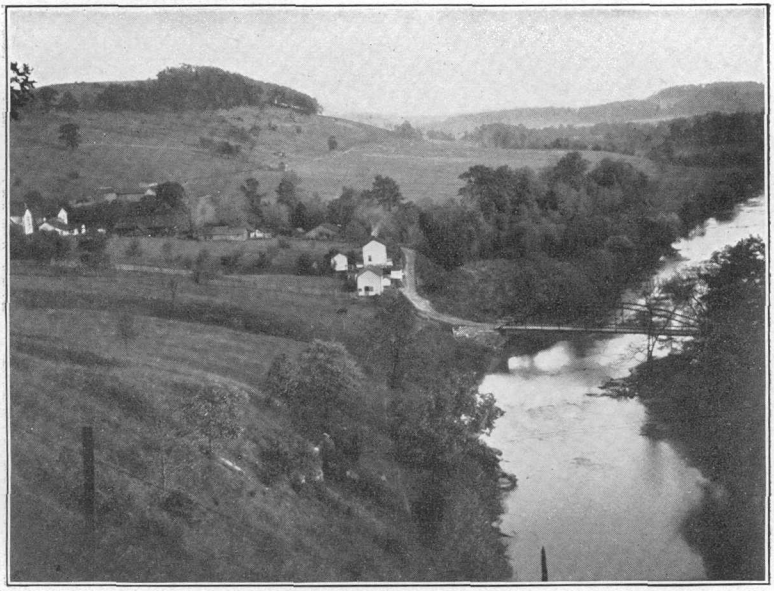
GEOLOGY.

STRUCTURE.

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

METHOD OF REPRESENTING GEOLOGIC STRUCTURE.

There are in current use two methods of representing geologic structure. The first and most obvious method is by means of cross sections which show the various strata as they would appear if cut by vertical planes entirely across the quadrangle. This method is effective only where the dip of the rocks is perceptible to the eye. In the



A. CROOKED CREEK AT GIRTY.

B. MAHONING SANDSTONE NEAR SCHOOLHOUSE, JACKSONVILLE.

Elders Ridge quadrangle the rocks dip so gently that the anticlines and synclines would not be very apparent on such sections; besides, the sections illustrate the structure only along certain lines and do not give the shape of the arches and basins, and these are of the greatest importance in the commercial development of the field, as regards both the mining of coal and the exploitation for oil and gas.

The second method has been used in adjacent folios in the bituminous coal field of western Pennsylvania. It consists in the representation of the surface of some particular stratum which is known through its wide exposure in outcrop, its exploitation by mines, its relation to some other bed above it, or the records of wells drilled for oil and gas. The deformed surface of the key stratum is then represented by means of contour lines which show the form and size of the folds into which it has been thrown and its altitude above sea level at practically all points within the quadrangle.

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

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

The depth of the reference stratum below the surface at any point is obtained by subtracting its elevation, as shown by the structure contour lines, from the elevation of the surface at the same point. Suppose, for instance, the position of the Upper Freeport coal is desired at Parkwood. It will be seen by the map that the elevation of the surface at the road corners is 1,325 feet, and that the 800-foot structure contour line passes through the place. The Upper Freeport coal, therefore, is here about 1,325 minus 800 feet, or about 525 feet below the surface.

As a rule these structure contours are generalized, and are only approximately correct. They are liable to error from several condi-

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

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

DETAILED GEOLOGIC STRUCTURE.

The general structural features of the Elders Ridge quadrangle have the same southwest-northeast strike that characterizes the whole Appalachian province. The folds in the rocks underlying this part of Indiana and Armstrong counties were recognized by Platt and described by him in Reports H4 and H5 of the Pennsylvania Second Geological Survey. The strongest features are three anticlines and two synclines. These axes are named from localities where they are strongly developed, or from places near which they pass. The first of these in this quadrangle, taking them in the order in which they occur from east to west, is the Jacksonville anticline, which passes near Lewisville and Jacksonville (Kent post-office). The next is the Elders Ridge syncline, which brings the Pittsburg coal down so that it lies in the hills under several square miles of this territory. The Roaring Run anticline parallels this syncline on the west for a short distance, but is broken up in the middle of the quadrangle. On the west of the Roaring

Run anticline is a basin which is not strongly developed on Crooked Creek, but becomes more pronounced to the north and may be known as the Apollo syncline. The lower end of the strong anticline which has been mapped across the Rural Valley quadrangle and is known there as the Greendale anticline crosses the northwest corner of this quadrangle.

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

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

Jacksonville anticline.—The structural fold, which is a strong feature in the southeast corner of this quadrangle, reaches its greatest

elevation in the vicinity of the village of Jacksonville and takes its name from that place. To the south it crosses Conemaugh River about 2 miles east of Saltsburg and maintains a southwest course for some miles, gradually losing strength as it continues into Westmoreland County. To the north the crest of this anticline can be traced but a short distance beyond the boundary of this quadrangle; in fact, it is very inconspicuous on Curry Run and gives place to the McKee Run anticline, which is offset a short distance to the east. The Freeport coal on the crest of this anticline in the vicinity of Jacksonville is about 1,280 feet above sea level. From here it falls rapidly to the west, so that the Pittsburg coal, which is stratigraphically from 600 to 700 feet above it, is found at the same elevation above tide on the west side of the valley of Blacklegs Creek.

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

Dutch Run anticline.—North of the Elders Ridge syncline and east of the Roaring Run anticline in Indiana County there is a low structural fold which has enough strength to raise the Upper Freeport coal just above water level along the lower courses of Dutch Run and Plum Creek. The axis of this fold crosses the south branch of Plum Creek three-fourths of a mile east of the Armstrong-Indiana county line and crosses Dutch Run about the same distance west of Advance. It pursues a direct course to Plum Creek, paralleling Dutch Run for 3 miles, and crosses the former stream a mile above its mouth.

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

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

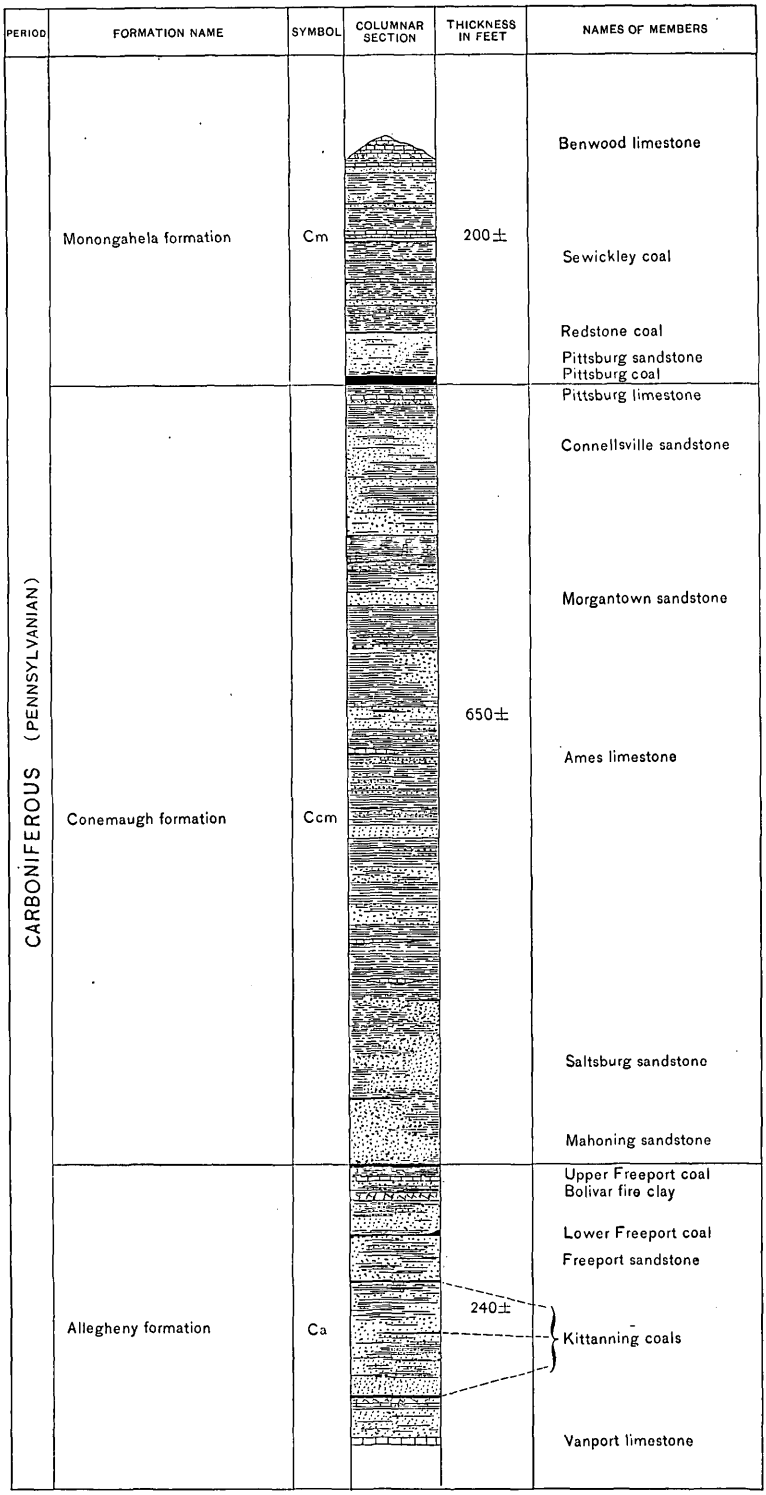
There is a synclinal basin north of Elderton and Gastown which is not considered to be a sufficiently important feature to receive a name. It assumes a very irregular shape in the Rural Valley quadrangle and is nameless there.

Roaring Run anticline.—In the Pennsylvania Second Geological Survey report on Armstrong County Mr. Platt describes an anticlinal axis which crosses Kiskiminitas River at the mouth of Roaring Run, and follows the course of that stream northeastward to Shady Plain and Elderton. He maintained that it was the Waynesburg (Bellevernon) anticline of Greene County, and described it as a continuation of the same, although he used the local term in his report. The present writer does not feel justified in correlating these axes before the intervening territory is mapped. This axis, as traced by the present writer, enters the quadrangle a little to the east of Roaring Run, but strikes into the stream toward its headwaters and passes directly through Shady Plain. On Crooked Creek in the vicinity of Girty there are two axes of about equal strength, and they seem to indicate that the Roaring Run anticline has a slight wrinkle on its crest for a short distance north of Shady Plain. The anticline decreases somewhat in height toward the north. The easternmost axis brings the Vanport limestone above water level about three-fourths of a mile east of Girty, and the westernmost crosses Crooked Creek near the neck of the "Loop," and also brings the limestone to daylight. Since the depth of the syncline between these two axes probably is less than 50 feet, and the Roaring Run anticline as a whole continues northward beyond the boundary of the quadrangle, it is not deemed necessary to apply a new name in Plum Creek Township, although Platt did so, calling the western axis the Fagley Run anticline. The numerous openings on the Upper Freeport coal in this vicinity give frequent elevations on the reference stratum, and also the dip of the rocks, and from this it has been determined that the western axis is the stronger in the highlands between Elderton and Cherry Run. At this point

the crest of the anticline rises again slightly, but falls off to the north and reaches its lowest point in the vicinity of the Say farm, 3 miles northwest of Elderton. The Roaring Run anticline continues a northeast course, and on the northern boundary of this quadrangle changes abruptly to a marked dome, the southern half of which is shown on Pl. I. This dome marks the extreme northern development of this anticline and terminates it 2 miles north of the boundary line of this quadrangle and about 2 miles east of Blanco in Cowanshannock Township. The position of the Upper Freeport coal in the northern part of the quadrangle, where the seam is below the surface, is determined by a number of deep-well records, and is probably accurate within a contour interval.

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

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



GEOLOGIC SECTION IN ELDERS RIDGE QUADRANGLE.

STRATIGRAPHY.

CARBONIFEROUS SYSTEM.

All of the rocks seen at the surface in this quadrangle belong to the Pennsylvanian series of the Carboniferous system. Three formations are present—the Allegheny, Conemaugh, and Monongahela. These are, respectively, the Lower Productive, Lower Barren, and Upper Productive measures. The Allegheny formation is exposed along Roaring Run, Crooked Creek, Plum Creek, Dutch Run, and Aultmans Run—a small portion of the whole surface. The Monongahela formation underlies a belt of country about 9 miles long and 3 miles wide between Kiskiminitas River and West Lebanon. The rocks underlying the remainder and by far the largest portion of the surface belong to the Conemaugh formation (Pl. I). More than 1,100 feet of stratified rocks are exposed at the surface in this quadrangle. They are divided among the formations as follows: Allegheny, 240; Conemaugh, 650; Monongahela, 216. A graphic representation of the section exposed in this quadrangle is given on Pl. IV.

ALLEGHENY FORMATION.

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

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

Partial section of Allegheny formation.

	Feet.
Upper Freeport coal	4
Shale	8
Limestone	3
Sandstone	4
Shale	5
Fire clay	8
Sandstone and shale	30
Lower Freeport coal	2
Shale and sandstone	18
Freeport sandstone	25
Upper Kittanning coal	1

	Feet.
Sandstone and shale	70
Sandstone	25
Lower Kittanning coal	3
Fire clay	8
Shale, iron nodules, and sandstone	22
Vanport limestone	10
Total	246

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

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

Upper Kittanning coal.—This bed caps the series of soft rocks and is usually present at its proper horizon. It has a thickness of scarcely more than a foot, and is therefore of little value. A few inches or feet of shales separate it from the Freeport sandstone, which in this region has a thickness of 25 feet. It is often massive, coarse grained,

and mottled with iron stains, but in places becomes shaly. A typical section of this sandstone in its massive condition and of the underlying Upper Kittanning coal with the Johnstown limestone is seen at Cochran Mills, in the bluff opposite the mill, and also at the road corner, three-quarters of a mile southeast of Girty.

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

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

Upper Freeport coal.—A coal bed of workable thickness which outcrops in many places in this quadrangle is known as the Upper Freeport. Its outcrop in the hills and valleys on three sides of the territory is long and irregular, as it is brought to light in the many side valleys which branch off from the main streams. This coal bed persists throughout a large area in western Pennsylvania and maintains a fairly constant thickness of 4 feet. Along Roaring Run and its branches the coal has been opened on almost every farm. A section measured in the Hilty mine a mile south of Equitable and on the axis of the anticline is as follows:

Section on Roaring Run.

	Ft.	in.
Coal	3	7
Shale	0	1
Coal	0	11
Total	4	7

This section is an average one of the region and shows the thin parting shale which is characteristic of the seam on Roaring Run. This seam is thicker in the western part of the quadrangle and at the openings on the Grey farm near Long Run than it is elsewhere within the boundaries of the district. Sections measuring little more than 3 feet are common, and where a thickness of 5 feet or more is found the seam is much broken by partings, or the lower benches are so small and separated from the upper bench by so much shale, that it does not pay to remove the burden in order to get the coal.

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

CONEMAUGH FORMATION.

The Conemaugh formation includes the rocks from the roof of the Upper Freeport coal to the floor of the Pittsburg coal. The Mahoning, Saltsburg, Morgantown, and Connellsville sandstones are the prominent members of the formation, and their presence is often shown by the number of large blocks of sandstone scattered over the surface. All of these sandstones when well developed and massive have much the same appearance. They weather grayish-white, are sometimes iron stained, vary from coarse to fine grain, and are best recognized by their position in the geologic section. The formation is composed largely of shales. These are variegated and show green, gray, and red tints. There are several insignificant beds of limestone, none of which are valuable as key rocks in this quadrangle.

The frequent changes and modifications which these strata undergo are shown by exposures, natural and artificial, found on the highways and along stream courses, the thickness and character of the members often changing so completely in a short distance that sections only a few hundred feet apart may have little resemblance.

The entire Conemaugh formation is present only in the region of the Pittsburg coal, between Long Run and Blacklegs Creek. It forms the upland of the quadrangle, except in the above-mentioned belt, where the Monongahela formation is present.

The thickness of the formation is over 600 feet, and yet there is nothing in it of particular economic interest except the massive sandstones. A generalized section is as follows:

Generalized section of Conemaugh formation.

	Feet.
Shale	8
Pittsburg limestone	5
Fire clay	3
Shale	24
Connellsville sandstone	30

Generalized section of Conemaugh formation—Continued.

	Feet.
Sandstone, shale, and thin limestones	100
Morgantown sandstone	20
Shale, sandstone, and thin limestones	320
Saltsburg sandstone	45
Sandy shale	40
Mahoning sandstone	50
Shale	5
Total	650

Mahoning sandstone.—The roof of the Upper Freeport coal, which is the bottom of the Conemaugh formation, is usually a bed of shale varying in thickness from nothing to 10 feet. Over this is a heavy bed of massive sandstone, which rests on the shale; or in places the shale is cut out and the sandstone rests directly on the coal. This sandstone, commonly called the Mahoning, has a thickness of 50 feet or more, and often stands out in bluffs, or strews the surface with large blocks. The blocks are particularly conspicuous about Jacksonville (Pl. III, *B*, p. 14), and the massive sandstone is well exposed on Roaring Run and about Salina. In the northern part of the quadrangle, beyond Crooked Creek, this member loses something of its massive character and is less conspicuous for that reason, although it is seen frequently between Elderton and Cherry Run. It is recognized largely by its thickness and position immediately above the Upper Freeport coal, for its grayish-white color, its hardness, and grain are equally characteristic of other sandstones in the formation. In the northeast corner of the quadrangle the Mahoning sandstone horizon is occupied by shale.

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

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

From the top of the Saltsburg sandstone for 320 feet is a monotonous series of thin sandstones, shaly sandstones, and shales which present no conspicuous or traceable members. The interval contains several very thin intermittent layers of limestone. One of these, which is probably not far above the top of the Saltsburg, is 8 inches thick, black, and contains many fossils. The black shale immediately underlying the limestone contains even more animal remains, the most numerous being an elongated spiral gasteropod of the genus *Bulimorpha*. Bellerophons also are numerous. There is a good exposure of this black fossiliferous limestone in the creek bank beside the road three-quarters of a mile west of Shelocta. A green limestone about 1 foot thick is sometimes found near the middle of the formation, about 340 feet above the Upper Freeport coal. It carries abundant brachiopods and crinoid stems, and can be seen on Walford Run 1½ miles southwest from Avonmore. According to I. C. White this would be the Ames limestone, which he describes[a] as occurring throughout Pennsylvania about 275 to 300 feet below the Pittsburg coal and the same distance above the Upper Freeport coal, increasing in places to 350 feet. The position of this limestone also agrees with White's section[b] in Beaver County, south of Ohio River. In his section of the Lower Barren measures in Armstrong County[c] Platt places the green Fossiliferous limestone, which is another name for the Ames limestone, 212 feet below the Pittsburg coal. Some thin limestone was noted at this horizon by the writer, but not recognized as described. Furthermore, Platt's section is 100 feet shorter than the thickness of the formation determined in this quadrangle. Whether either of these limestones can be correlated with the type is an open question.

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

Connellsville sandstone.—There is generally present in this quadrangle, at a distance of 40 feet below the Pittsburg coal, a coarse sand-

[a] Bull. U. S. Geol. Survey No. 65.
[b] Second Geol. Survey of Pennsylvania, Rept. K, p. 334.
[c] Platt, W. G., Second Geol. Survey of Pennsylvania, Rept. H5, p. 5.

stone which has received its name from the city of Connellsville, where it outcrops conspicuously. The bed is usually 30 feet thick. It is massive or slightly shaly, and underlain by red shales and shaly sandstone. The Connellsville in its massive condition is a grayish quartzose sandstone, sometimes iron stained, and in no way different from other sandstones in the formation. It is recognized solely by its geologic position. It lies so near the Pittsburg coal that its importance as a key rock is overshadowed by the coal, which is better known in its outcrop and in its underground extension than any other member of the series.

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

MONONGAHELA FORMATION.

The Monongahela formation consists for the most part of shale, sandstone, and limestone. The Pittsburg coal, the most important seam in the region, is found at the base and other less important beds above. The usual thickness of the Monongahela formation is about 375 feet, extending from the Pittsburg coal at the base to the Waynesburg coal at the top. About 216 feet of the formation is present in this quadrangle, the upper portion having been removed by the general degradation of the land surface. The average thickness of the rocks above the Pittsburg coal is about 100 feet in this region; the 200-foot intervals occur but rarely. The area to which the Monongahela formation is confined in this quadrangle is about 12 miles long by 3 miles wide. Its limits are defined on the north by Gobblers Run, on the east by Blacklegs Creek, on the south by the quadrangle boundary, and on the west by Long Run (Pl. I).

The highest rocks in this quadrangle, in a geologic sense, are found in the vicinity of Elders Ridge and West Lebanon, where the Benwood limestone caps several hills in the basin of the Elders Ridge syncline.

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

Partial section of Monongahela formation.

	Feet.
Benwood limestone	25
Sandstone	7
Sandy shale, sandstone, and limestone	76
Sewickley coal	2

	Feet.
Shale	12
Limestone	6
Shale	15
Sandstone	5
Shale	25
Redstone coal	1
Sandstone	30
Shale	5
Pittsburg coal	7
Total	216

Pittsburg coal.—The basal member of the Monongahela formation is the Pittsburg coal. The bed has hundreds of miles of outcrop in western Pennsylvania, and is well and favorably known for its coking and steaming qualities. It is usually from 7 to 10 feet thick, with thin shale partings, and can be traced easily by the numerous springs, coal blooms, and openings on the outcrop and by the broad bench on the slopes over which it runs.

The Pittsburg seam reaches its most northern development in this quadrangle (fig. 3, p. 43). It exists in three irregular areas of nearly equal size which lie along the Armstrong-Indiana county line. The boundaries of the coal area are the same as those of the Monongahela formation. It does not extend east of Blacklegs Creek or west of Long Run, and the most northern occurrence is in the hills just north of West Lebanon. On the south side of the river, in Westmoreland County, the coal has a more extensive development, only a small area of which is included in this quadrangle. The deep ravines, which cut entirely through the coal seam and divide the belt into separate areas, together with notches made on all sides by small streams, furnish long and irregular lines of outcrop and ready access to the coal in the basin. The bed dips gently from all directions toward the lowest point on the synclinal axis, which is between Elders Ridge and Big Run.

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

Pittsburg sandstone.—The sandstone which begins a few feet above the Pittsburg coal is known by the same name. It is 30 to 40 feet thick near the river and forms cliffs in the hilltops overlooking Avonmore. Its character is generally massive and the bowlders that break off from the outcrop are large. Toward the northeast this massiveness becomes less pronounced and the thickness decreases. South of Olivet it is current bedded, making it suitable for flagging. The sand-

stone, which is directly above the Pittsburg coal near West Lebanon, is only 25 feet thick and so thin bedded that it weathers off into thin, soft fragments. This extreme variation from massive and compact to loose and shaly carries with it a change from quartzose to clayey and from gray to dark colored.

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

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

Sewickley coal.—The extent of this coal throughout the basin is much less than that of the Pittsburg, for it is 100 feet higher in the hills. It has a thickness of 2 to 5 feet and is found frequently with strong bloom, showing a persistence in its occurrence. So long as the Pittsburg coal bed is near by, this coal seam can not be worked with profit, and it is not mined at present within the boundaries of the quadrangle. This coal shows at the extreme hilltops in the northern bluffs below Hicksville and is seen frequently in the roadside ditches near Elders Ridge. Above the Sewickley coal is an interval of about 80 feet which consists mainly of argillaceous shale. These rocks weather easily and produce good soil.

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

QUATERNARY SYSTEM.

Carnichaels clay.—Deposits of gravel, sand, and clay are found at a number of places high above the present flood plains of Kiskiminitas

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

The occurrence of these terrace deposits and their elevation above the present streams is shown on the economic geology map (Pl. I). In the vicinity of Shelocta the terrace deposits are only a few feet above the reach of the highest floods on Crooked Creek and the slopes away from the stream are so gentle that it is difficult to determine where the recent alluvium stops and the terrace deposits begin. In fact it is quite probable that the gravels and sands of the older river stages have washed down upon and merge with the present flood-plain deposits. On the same stream below Girty well-rounded pebbles and river silts have been found in a number of places at an elevation of 100 feet or more above the creek. Back of the village of Avonmore on Kiskiminitas River there are well-developed terrace deposits at an elevation of 80 feet above the river, and also on the broad upland above the village 100 feet higher than the first bench, at an elevation of about 1,000 feet above tide. The character of the deposits as shown in street cuttings in the southeastern part of the village and in tilled land on the upper flat is interstratified gravel, sand, and clay. These were laid down during the periods of no crustal movement in which the valley floors were broadened.

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

Blacklegs Creek has built a narrow flood plain along several miles of its course. It is nowhere more than a few hundred yards wide, and is only a minor feature of the geology. Cherry Run has no alluvium broad enough to be represented on the map, and Aultmans Run shows only a small amount.

Crooked Creek is in a narrow gorge below Girty, but has some wide flood plains along its course east of that village and on its tributaries. Plum Creek, in particular, has a broad, flat, valley bottom, and is conspicuous on the maps for its wide floor. Dutch Run, which empties

into Plum Creek, also has a flood plain broad enough to be represented on the map along several miles of its course.

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

MINERAL RESOURCES.

COAL.

Coal is the most important of the mineral resources of the Elders Ridge quadrangle. Two beds of workable thickness are extensively exposed. These are the Upper Freeport and the Pittsburg. A third bed, the Lower Freeport, which is usually thin, has a local importance in some places where it thickens considerably. Several other beds too thin to be of economic importance are present. These coals are in the Allegheny and Monongahela formations, and lie between the Vanport and Benwood limestones. Although eight or nine seams occur in this interval, it must not be assumed that they are everywhere present or are always of the same thickness. The generalized sections so often published are meant to show only their relative positions. It should be understood that these beds vary in position with relation to other beds and that their thicknesses are not constant. The description will begin with the lowest coal exposed in the area and end with the highest. No mention will be made of the Gallitzin and Redstone coals, which are mere streaks where seen and undoubtedly are small throughout the quadrangle.

It may be well here to define certain terms in common use. An opening is a small excavation which reveals the coal in place and the thickness of the bed. A coal bank is a small mine in which a few men, from 1 to 10, are employed, and in which the coal is mined and brought out to the scaffold without the use of machinery. A coal mine employs enough men to require a mine boss, probably uses machines for undercutting the coal, and hauls by means other than hand. Coalpit is a term applied without discrimination to openings, banks, and mines.

LOWER KITTANNING COAL.

The horizon of the Lower Kittanning coal is seen above water level on Crooked Creek for some distance between South Bend and Cochran Mills. It is in no place more than 50 or 60 feet above the stream and its outcrop line coincides closely with that of the Vanport limestone shown on Pl. I, because both are in the deep gorge of the creek. This is the only place where this coal is seen in the Elders Ridge

quadrangle. It is not being worked anywhere on the creek at present and never has been mined to more than a very small extent. It had been opened previous to the Second Geological Survey of Pennsylvania, and the reports of the Survey state that the coal averaged about 3 feet where seen at the old salt works below the "Loop" (fig. 2, *A*). A section measured by the writer in a small ravine two-thirds of a mile below the "Loop" is as follows:

Section on Crooked Creek below Girty.

	Ft.	in.
Sandstone	10	0
Lower Kittanning coal	2	7
Clay	6	0
Sandy shale	30	0
Vanport limestone	8	0
Creek level		

This coal was also mined at one time near the bridge at Girty. It is highly pyritous, and is so much broken by parting slates that the seam is nearly worthless for practical purposes. In a detailed section measured by the Second Geological Survey of Pennsylvania the bed is subdivided (fig. 2, *B*):

Section of Lower Kittanning coal at Girty.

	Ft.	in.
Slaty clay		
Coal	0	6½
Slate	0	1
Coal	1	6
Slate	0	½
Coal	0	3
Total	2	5

MIDDLE KITTANNING COAL.

If this coal bed is present in the Elders Ridge quadrangle it can outcrop only in the region described for the Upper Kittanning coal. Its blossom was nowhere recognized, and it is presumed that the bed is extremely thin. The report of the Second Survey gives it a thickness of 6 inches.

UPPER KITTANNING COAL.

This coal bed also is seen only in the valley of Crooked Creek below South Bend. It is nowhere of practical importance, although it was at one time developed to a small extent at the mouth of Cherry Run for household use. The first occurrence of this coal noted in going downstream is a blossom in the highway at the mouth of Sugar Run. The bed appears to be about a foot thick at this point and is underlain by Johnstown cement limestone. The coal has been stripped farther up Sugar Run from the bed of the stream, and is reported to be 2 feet thick. At Cochran Mills the Upper Kittanning coal has been opened

at the bluff on Crooked Creek and at the mouth of Cherry Run opposite Mr. Kinnard's house. There are also several old openings on Cherry Run along which the coal outcrops for some distance. The bed is about 2 feet thick (fig. 2, *C*) in this locality, and was mined

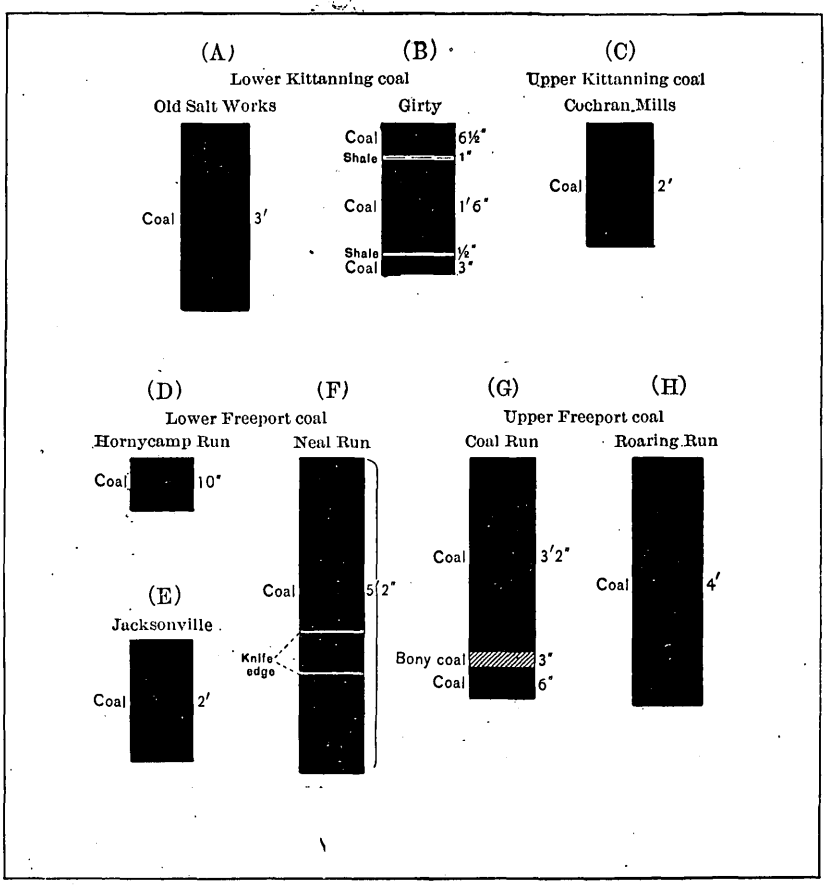


FIG. 2.—Sections of Kittanning and Freeport coals.

because its location was more convenient than that of the Upper Freeport coal, which is in the top of the bluff. A section measured at Cochran Mills is as follows:

Section at Cochran Mills.

	Feet.
Freeport sandstone	45
Sandy shales	30
Upper Kittanning coal	2
Fire clay (impure)	2
Johnstown cement limestone	3
Clay and shales	5
Slates, dark	20
Creek level	
Total	107

Farther down Crooked Creek the thickness of this seam diminishes to a mere streak, and its blossom is seen very infrequently. It is nowhere of practical importance in this region.

LOWER FREEPORT COAL.

Whether this seam is present throughout the Elders Ridge quadrangle is questionable. The horizon is well exposed in the ravine at Cochran Mills, but no trace of the coal was seen there, and in fact it was not recognized more than two or three times in the valley of Crooked Creek. A small coal blossom was seen on the township road 1 mile east of Girty at the end of Mr. Barr's lane, and in a small ravine south of the "Loop" on Crooked Creek another exposure was seen in which the coal is reported to be about 18 inches thick. On Hornycamp Run, which is 1 mile south of Elbow Run, a 10-inch coal, believed to be the Lower Freeport, shows at the roadside south of the schoolhouse (fig. 2, *D*). It is commonly reported at Rockville that there is a coal bed a few feet below the surface of the run, and two or three wells which have been drilled at water level have found coal at a depth of 15 or 20 feet. If this is the case, it is probably the Lower Freeport seam, and although the drillers say that it is several feet thick their statement has not been proved. It is probable that the seam will not measure more than 2 feet thick wherever it is found in this part of the quadrangle.

In the vicinity of Jacksonville, Conemaugh Township, the Jacksonville anticline raises the Allegheny formation high above water level, so that the horizon of the Lower Freeport coal is exposed for a number of miles. The coal is not more than 20 inches thick on Reeds Run, and it is probably less than 2 feet thick at the head of Neal Run. The bed has been opened on the east hillside three-fourths of a mile north of Jacksonville and found to be only 2 feet thick (fig. 2, *E*). This is probably the normal occurrence for this part of the county. Near the mouth of Neal Run, however, the Lower Freeport has an unusual development. It is mined near the schoolhouse 2 miles north of Jacksonville by Mr. Clark Neal and Mr. William H. Martin. In both these banks, which are nearly opposite each other on the same run, the Lower Freeport coal measures 5 feet 2 inches (fig. 2, *F*). The bed is very even and does not carry a large per cent of sulphur, but is considerably intermixed with thin bands of earthy material which in places gives it a large percentage of ash. It is the presence of this impurity that gives it its great firmness, causing it to come from the mine in large blocks. The coal has a dull luster generally, but shows numerous bright pitchy bands. The lower bench, which is 20 inches thick, is harder than the rest. It is overlain by 8 inches of a softer coal which is excellent for blacksmithing purposes. Mr. Neal produces from 20,000 to 30,000 bushels annually, and Mr. Martin from

10,000 to 15,000 annually. The coal has been mined on this run continuously for nearly sixty years. In the first hollow south of Neal Run the same bed has been mined on the Marshall farm close to the axis of the Jacksonville anticline, the seam measuring 4 feet 6 inches thick.

It is believed by some people in the vicinity that the Lower Freeport seam maintains a thickness of from 4 to 5 feet throughout a considerable area in this part of Indiana County, but this is readily disproved by an examination of the outcrops in the immediate vicinity of the coal banks above mentioned. It is possible that the bed attains the same thickness at other points where it is hidden beneath the surface, but it is quite certain that the development on Neal Run is very local, and will extend less than a mile in any direction.

A coal reported to be 5 feet thick in the Stahl well (261) is at the proper horizon for the Lower Freeport. It is a churn-drill measurement, however, and therefore unreliable. The bed is not known on Conemaugh River a few miles south of this well.

An average specimen of this coal, analyzed by Mr. A. S. McCreath for the Second Geological Survey of Pennsylvania (Rept. HHHH, p. 251), is as follows:

Analysis of Lower Freeport coal on Neal Run.

	Per cent.
Fixed carbon	55.380
Volatile matter	28.505
Moisture	1.010
Ash	14.405
Sulphur	.700
Total	100.000
Coke	70.485

An analysis made from a sample of this coal, collected by the writer at the Clark Neal bank and analyzed by Mr. W. T. Schaller of the United States Geological Survey, is as follows:

Analysis of Lower Freeport coal on Neal Run.

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

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

UPPER FREEPORT COAL.

The "four-foot coal," as it is called, has an extensive exposure in this quadrangle. Its outcrop is to be found in all four corners and well in toward the middle of the area. By far the longest line of out-

crop is in the northwest quarter of the quadrangle, where the coal is above water level on every tributary of Crooked Creek. The average thickness of the bed is probably a little under 4 feet, and the coal is everywhere somewhat slaty and sulphurous. The areas in which the coal outcrops are so detached that they may well be described separately.

Southeast quarter.—The Upper Freeport coal is brought to the surface in the southeast corner of the quadrangle by the Jacksonville anticline. The axis of this fold in the geologic structure crosses Conemaugh River half way between Saltsburg and Tunnelton with a strong northeast trend. It turns northward near Lewisville and passes 1 mile west of Jacksonville, pursuing a course nearly parallel with Reeds Run, and disappearing soon after entering the Indiana quadrangle near Tannery. The coal is exposed along the whole length of Coal Run, and on Aultmans Run northward from the mouth of Coal Run to the headwaters of Neal and Reeds runs. The bed has been opened at short intervals north and south of Jacksonville and shows a thickness ranging from 3 feet 6 inches to 4 feet 7 inches. An average thickness for the coal in this vicinity is 4 feet, the typical section, measured on Coal Run by the Second Survey,[a] being as follows (fig. 2, *G*):

Section at Kennedy's mine on Coal Run.

	Ft.	in.
Coal	3	2
Bony coal and slate	0	3
Coal	0	6
Total	3	11

In an opening at the western head of Coal Run the bed was seen 4 feet 7 inches thick, while on the northern branch of the same stream near the road forks, 1 mile due west from Jacksonville, the coal seen in a new test pit measured 3 feet 6 inches. On Aultmans Run the bed is 4 feet thick on the following farms: McKee, Fails, Jacks, Means, McFarland, Evans, and McIntyre. It measures 3 feet 11 inches on the Clawson farm and at a point 2 miles northeast of Jacksonville on a tributary of Aultmans Run; 3 feet 10 inches at George Dickey's; and 3 feet 10 inches to 4 feet in the A. W. Robinson bank and the abandoned workings near the head of Reeds Run. Near the mouth of Reeds Run, where the Lower Freeport coal has an unusual development, the Upper Freeport, 60 feet above it, is from 4 feet to 4 feet 3 inches thick.

The Upper Freeport coal with its underlying limestone is also exposed for more than a mile at the upper end of Marshall Run, in which distance it rises 170 feet on the flank of the Jacksonville anti-

[a] Second Geol. Survey of Pennsylvania, Rept. HHHH, p. 248.

cline. There are a number of openings on the coal in this ravine, but they were so badly caved that no measurements of the coal could be made.

It is known that the Upper Freeport coal is thin in the southern central part of Young Township, where it lies deep below the surface.

Southwest quarter.—The Elders Ridge syncline carries the Upper Freeport coal several hundred feet below the surface. Well records show that at the mouth of Blacklegs Creek it is 320 feet and at the mouth of Long Run 250 feet below water level. If the interval between the Pittsburg and Upper Freeport coals remains the same as on the river, the latter coal should be about 800 feet below the village of Elders Ridge.

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

In the valley of Roaring Run the bed has a thickness of 4 feet (fig. 2, *H*), which it maintains with great persistency. It carries a small parting, which usually is not more than 1 inch thick. The outcrop extends to the head of the run near Shady Plain and shows numerous openings along the entire length of the stream in this quadrangle. Many of these were abandoned, however, because the coal dips into the hills on both sides of the valley and is difficult to drain.

In the bank on the Hilty Brothers' farm, near the mouth of a small run three-fourths of a mile south of Equitable, the bed is 4 feet 5 inches thick at the entrance, but diminishes to a little less than 4 feet at the breasts farther up on the anticline. In one or two banks on the west side of the run the coal was seen 3 feet 10 inches thick, and it is reported to be a little over 4 feet thick in the pits near the head of the run, but these have been abandoned and the statement could not be verified. An abundance of natural gas in this region may account in part for the abandonment of some of the coal pits.

There is a very limited outcrop of the Upper Freeport coal in a small ravine on the Grey farm 1 mile northwest of Long Run. The stream has cut into the flank of the Roaring Run anticline just deep enough to reveal the coal for a few rods. The dip is nearly 6 degrees and carries the bed under water level before reaching the mouth of the little branch. Up the ravine it disappears under the hill no less quickly. Two sections are given, the first of which was measured by the writer at the lowest opening, and the second was published by the Second Survey in the report on Armstrong County.[b] (Pl. V, *A*, *B*.)

[b] Second Geol. Survey of Pennsylvania, Rept. H5, p. 38.

Sections on Grey farm.

	Section 1.	Section 2.
	Ft. in.	*Ft. in.*
Coal	1 3	.....
Parting (bony coal)	0 2	0 3
Coal	0 10	3 3
Parting	1 3	2 4
Coal	3 8	2 0
Total	7 2	7 10

The arrangement in the sections given above is not intended to represent correlations. It is possible that the lowest coal bench is the same and that the heavy parting above it may be correlated, but it does not seem probable that the middle coal in the first section represents the heavy bench in the second section. It is more likely that the 2-inch parting in the first section did not occur in the opening where the second section was measured and that the upper and middle benches of coal, with this thin parting—in all, 2 feet 3 inches thick—are to be correlated with the 3 foot 3 inch bench. The thickness of the main parting makes recovery of all the coal expensive by reason of the large amount of waste which must be handled.

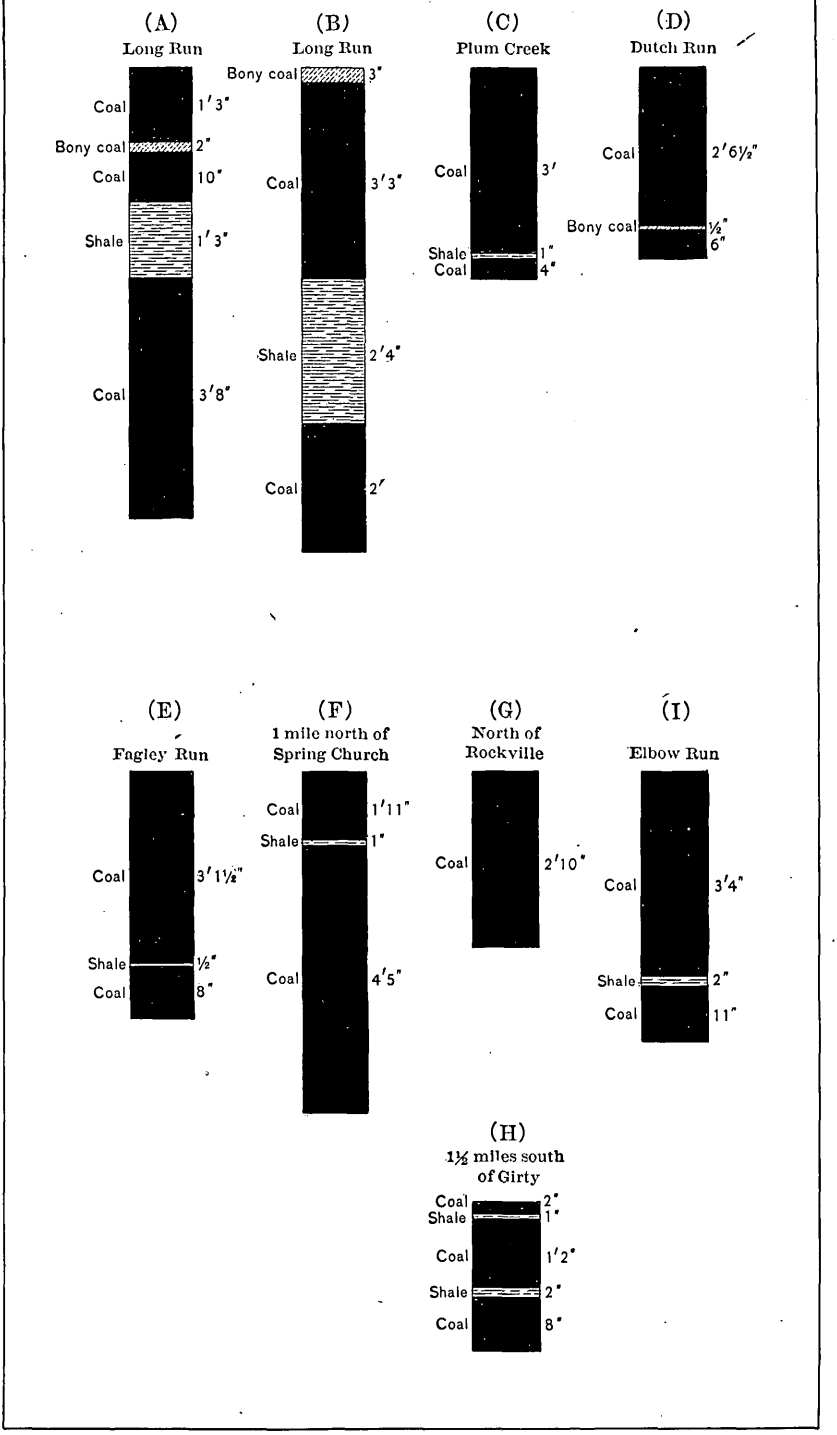
Northeast quarter.—On the South Branch of Plum Creek the Upper Freeport coal is exposed just above water level for 3 miles by the uplift of the Dutch Run anticline. One mile of this outcrop is on the Elders Ridge quadrangle and the other two extend up to Willet, on the Indiana quadrangle. The coal on this stream measures from 2 feet 10 inches to 3 feet 6 inches in thickness. The following section shows the condition of the bed in the Parke and Trusal mines on Sugarcamp Run, 2 miles east of the boundary of this quadrangle, and so closely resembles the section in the Marlin bank at Willet, published by the Second Survey, that it may be considered fairly typical for the occurrence in this corner of the quadrangle (Pl. V, *C*):

Section on Sugarcamp Run.

	Ft.	in.
Coal	3	0
Shale	0	1
Coal	0	4
Total	3	5

A sample from the upper or main bench of the bed in the Marlin pit was analyzed by Mr. McCreath,[a] with the following results:

[a] McCreath, A. S., Second Geol. Survey of Pennsylvania, Rept. HHHH, p. 281.



SECTIONS OF UPPER FREEPORT COAL.

Analysis of Upper Freeport coal on Sugarcamp Run.

	Per cent.
Fixed carbon	60.736
Volatile matter	31.890
Moisture	1.100
Ash	4.995
Sulphur	1.279
Total	100.000
Coke	67.01

The Upper Freeport coal is also exposed for 1½ miles on Dutch Run, and on Plum Creek to its mouth, with an average thickness of little more than 3 feet. There is a coal bank on the Ramsey farm on Dutch Run which is operated by Mr. Jacob Miller. The bed varies in thickness from 2 feet 9 inches to 3 feet 1 inch, including one half-inch bony parting about 6 inches from the floor (Pl. V, *D*). It is reported that the coal is 4 feet thick in some parts of the old workings. In the winter of 1902–3 the bank was operated by three men from fall to spring, and from 25,000 to 28,000 bushels of coal were sold at 4 cents a bushel on the scaffold.

The coal pits on Plum Creek below Elderton are mostly closed. The most extensive mining seems to have been done on the Clark and Ralston farms, where there are several old pits near each other. In a coal bank at the bend on Crooked Creek, a half mile above the mouth of Plum Creek, the bed was seen 2 feet 6 inches thick. The coal is carried below water level at this point by the Elders Ridge syncline and reappears 8 or 9 miles east of here at Chambersville on Crooked Creek and at Ernest on McKee Run.

The horizon of the Upper Freeport is just above water level at the big bend of Crooked Creek, a half mile below Idaho, and several openings were once made on the coal at the base of a conical hill which stands between the present and the former course of the creek. The thickness of the coal or the extent of the workings could not be determined because the pits had all fallen in.

Northwest quarter.—The Upper Freeport coal is widely exposed in this quarter of the quadrangle. It is raised above water level a half mile below South Bend by the Roaring Run anticline and continues in sight to Allegheny River. The elevation of the formation is sufficient to carry the outcrop of the coal up the tributaries of the creek for long distances. In the vicinity of Girty, on the north side of Crooked Creek, the bed measures from 3 feet 4 inches to 3 feet 6 inches in a number of banks. On Fagley Run, in the George Altman bank (Pl. VI, *A*), the coal is 3 feet 10 inches thick with ½-inch bearing-in slate 8 inches above the floor (Pl. V, *E*). At the present breast, which is 500 feet from the entry, the face is 3 feet 7 inches high.

On the south side of Crooked Creek there is an area near Girty in which the Upper Freeport coal is thinner than usual. On Barrel Valley Run, which has its mouth just above Girty, the bed is reported to be 2 feet 6 inches thick on the Watson and Painter farms. In a little pit back of the schoolhouse and church on this run 1½ miles south of Girty the following section was measured (Pl. V, *H*):

Section south of Girty.

	Ft.	in.
Coal	0	2
Shale	0	1
Coal	1	2
Shale	0	2
Coal	0	8
Total	2	3

This condition seems to be local, however, for the coal is 3½ feet thick on the Marshall farm 1 mile northeast of Shady Plain, and 4 feet 8 inches at James Clark's above Mateer. There are a number of pits near Mateer in which the bed is from 3½ to 4½ feet thick.

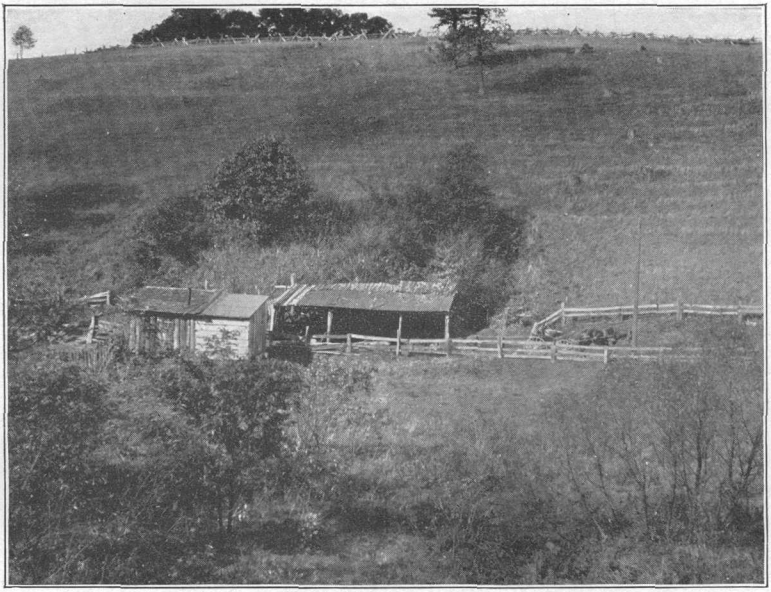
On Carnahan Run, 1½ miles north of Spring Church, this coal has been mined extensively on the farm of the Clark heirs and adjoining farms a half mile east of the schoolhouse, and shows a considerable thickness (Pl. V, *F*):

Section 1½ miles north of Spring Church.

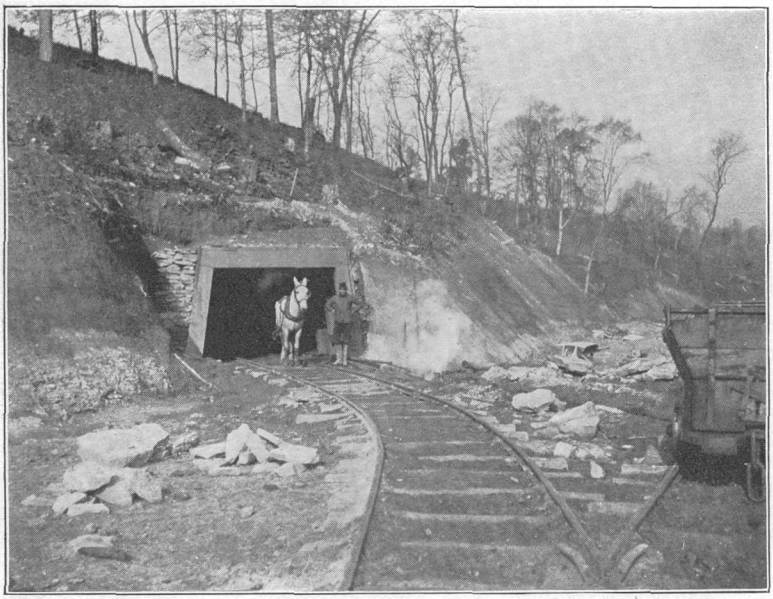
	Ft.	in.
Coal	1	1
Shale	0	1
Coal	4	5
Total	5	7

At Cochran Mills the Upper Freeport coal is near the top of the bluff and has been opened in only a few places. The bank on the Samuel Fiscus farm is worked every winter. The product in the winter of 1902–3 amounted to 9,000 bushels, which was sold on the scaffold at 3½ cents a bushel. The coal is 3½ feet thick in this bank and rises both to the right and left of the entry. On Cherry Run there are a number of openings in which the coal measures 4 feet. Near Adam Cessna's it is about 3 feet 9 inches and at Joe McKee's 4 feet 2 inches.

It will be seen by the economic geology map that the Upper Freeport coal is above water level on the North Branch of Cherry Run in the vicinity of Rockville. Mr. Platt stated in the Second Survey report on Armstrong County that the coal goes under the run at Heilman schoolhouse, Rockville, and that the Gallitzin seam is opened at Remaley's mill, between Rockville and Shay. He describes the Gallitzin seam as being 2 feet 7 inches thick 50 feet above the Upper Freeport coal and resting on massive Mahoning sandstone. The pres-



A. TYPICAL COAL BANK ON FAGLEY RUN.



B. PITTSBURG GAS COAL COMPANY'S HEADING NO. 2, HARPER RUN.

ent writer came to the conclusion that the Upper Freeport coal continues above water level at Rockville and decreases in thickness from 42 inches near Pyrra to 22 inches or less at Remaley's mill. The heavy sandstone which outcrops at Rockville is believed to be the Butler sandstone. The Mahoning sandstone may be seen above the Upper Freeport coal at Remaley's mill. This mill is now owned by Mr. Heffelfinger.

It is generally admitted that the coal which outcrops just above water level at Pyrra is the Upper Freeport. The rocks rise to the northwest on the Greendale anticline, and the coal keeps above the stream to Remaley's mill, as shown by the following occurrences, with their approximate elevations above sea level:

Elevations of Upper Freeport coal above sea level.

	Feet.
Abandoned coal bank near Pyrra	1,045
Van Schall coal bank (coal 42 inches)	1,050
Coal blossom reported plowed up on hillside	1,070
Wet spring spots opposite Reuben Schall's	1,085
Old opening below Crim's house	1,110
Old opening below Crim gas well	1,120
New opening below Remaley's mill (coal 22 inches)	1,130
Old opening above Remaley's mill (coal 18 inches to 3 feet)	1,150

The coal bed which has been opened at Remaley's mill has been mined in several places on Cherry Run north of Rockville. On the Harry Faith farm four pits have been dug, only one of which is accessible. This shows 2 feet 10 inches of clean coal (Pl. V, *G*). A half acre of coal is said to have been mined on the Schall and Heilman farms in a period of thirty years. The bed is said to have averaged 2 feet 4 inches of clean coal, but as the bank was abandoned ten or twelve years ago this statement could not be verified. If the coal above the run at Rockville is Upper Freeport this also is. The writer believes that the coal bed reported at a depth of 15 to 20 feet below the run in wells drilled at Rockville is the Lower Freeport. Its thickness is not known.

On Elbow Run, 1½ miles from Crooked Creek, both the Upper and Lower Freeport coals are reported to have been opened or stripped many years ago and found to be 3½ feet thick. There was no opportunity to verify this statement. In the Robert Walker bank near the mouth of Elbow Run this section was measured (Pl. V, *I*):

Section on Elbow Run.

	Ft.	*in.*
Coal	3	4
Shale	0	2
Coal	0	11
Total	4	5

On Big Run, which is in the northwest corner of the Elders Ridge quadrangle and heads near Shay, the Upper Freeport has been opened in a number of places on the Daniel Campbell and Samuel McClune farms. Thousands of bushels of coal have been taken out, but the industry was given up about 1893 on account of trouble with miners and because gas was discovered in the neighborhood about that time. Mr. McClune says that the coal measures from 4 feet to 4 feet 9 inches and carries very little shale parting.

The composition of the Upper Freeport coal is shown by the following analyses. The first was made by A. S. McCreath for the report of the Second Survey on Indiana County. The sample was taken from the upper bench in the Hazlett mine near Jacksonville. The second analysis was made by E. C. Sullivan, of the United States Geological Survey, from a sample of marketable coal in the Walker mine on Crooked Creek near the mouth of Elbow Run. The third and fourth analyses were made by W. T. Schaller, of the United States Geological Survey, from samples of marketable coal taken by the writer in the George Altman bank on Fagley Run north of Girty and the A. W. Robinson bank at the head of Reeds Run north of Jacksonville.

Analyses of Upper Freeport coal.

	Hazlett.	Walker.	Altman.	Robinson.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Fixed carbon	56.679	51.23	59.57	58.94
Volatile hydrocarbons	26.500	37.76	29.43	29.26
Moisture	1.180	1.23	2.43	1.47
Ash	14.970	9.78	8.57	9.63
Sulphur	.671	3.94	.80	2.25

PITTSBURG COAL.

OCCURRENCE.

The northernmost remnant of the Pittsburg coal seam, which underlies about 2,000 square miles in the southwestern part of Pennsylvania (fig. 3), is in the Elders Ridge quadrangle. This remnant is a small area which lies along the Armstrong-Indiana county line and is detached from the main body of the seam.

EXTENT.

Geographically the limits of the Elders Ridge coal field are clearly defined. It is bounded on the north by Gobblers Run, on the east by Blacklegs Creek, on the south by Kiskiminitas River, and on the west by Long Run. It is about 10 miles long and 3 miles wide,

with the long axis in a northeast-southwest direction. This belt of coal is divided transversely into three large blocks by the valley of Whisky Run and Big Run, which have cut through the horizon of the coal and expose long lines of outcrop on both sides of the streams. The middle one of these three blocks, which lies between Olivet and Clarksburg, is the largest, and the northernmost is the smallest. All three have irregular outlines. There are a number of outliers of a few

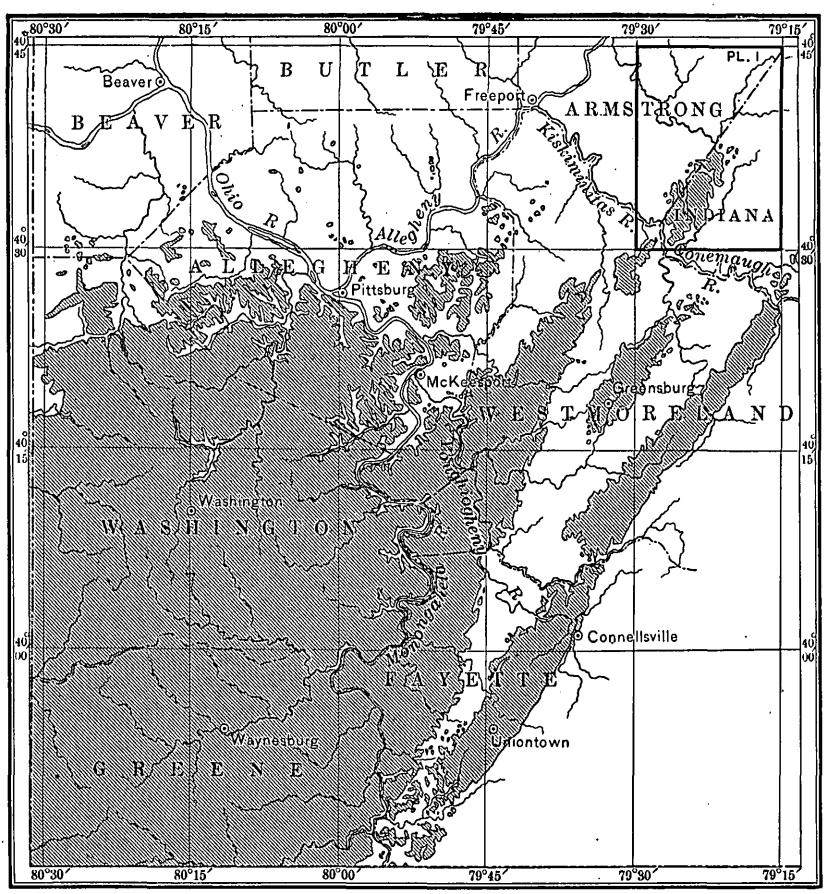


FIG. 3.—Map showing the area of the Pittsburg coal in Pennsylvania (Elders Ridge quadrangle shown by rectangle in upper right corner).

acres in extent on the northern and western sides of the field. Roughly estimated, there are about 14 square miles of coal in this area, or between 8,500 and 9,000 acres. The coal has been mined out from 600 or 700 acres. The thickness of the bed will average close to 7 feet.

STRUCTURE OF THE PITTSBURG COAL.

This coal field lies in a structural basin known as the Elders Ridge syncline. The position of the axis is shown on the accompanying

sketch map (fig. 4). It crosses the river above Edri, passes close to the Foster mine (No. 12), a few rods east of the Robert Fritz bank (No. 8), and through Elders Ridge near the academy. It enters the northern block between the W. B. Davis and John D. Hart heirs banks (No. 6), passes west of West Lebanon, and leaves the field near Holsten Brothers bank (No. 1). The beginning of the sharp deflection to the east, which takes the axis to Crooked Creek, nearly 2 miles east of Shelocta, is shown north of the coal banks on the Hugh Blakley (No. 2) and Madison Craig (No. 3) farms. All of the coal on the east side of this syncline rises toward Blacklegs Creek, and all on the west toward Long Run. The basin is deeper in the vicinity of Elders Ridge than at Edri or West Lebanon, so that the structural shape of the field is a broad canoe-like fold, with the rocks dipping from all sides toward the center. The dip is gentle, being just enough to aid the operations of the miner.

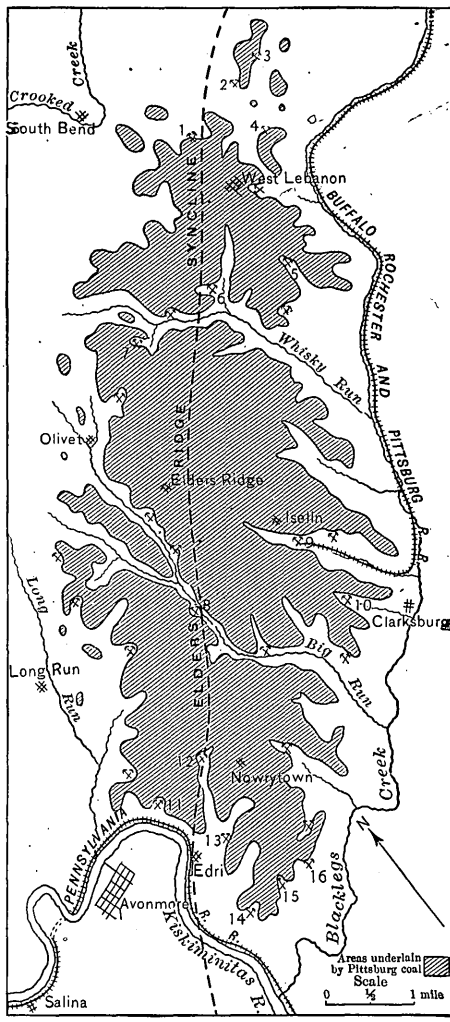


FIG. 4.—Map of the Elders Ridge coal field, Pennsylvania.

The profile of the axis of the basin is shown by the elevations of the Pittsburg coal above mean sea level. From the northeast to the southwest along the bottom of the syncline the elevations at six points are as follows:

Elevations of Pittsburg coal above sea level.

	Feet.
Holsten Brothers, No. 1	1,180
John D. Hart, No. 6	1,112
Elders Ridge, deep well near creamery	1,070
Robert Fritz, No. 8	1,022
Foster, No. 12	1,100
West side of Kiskiminitas River	1,150

This shows that the deepest part of the syncline lies between Elders Ridge and the point where the axis crosses Big Run. The axis rises

slowly from Big Run to the northeast, but more rapidly from the Fritz farm to Foster, the coal rising in this direction about 60 feet in little more than a mile.

DEVELOPMENT OF THE PITTSBURG COAL.

On the accompanying sketch map of the Elders Ridge coal field most of the points where a clean face of the Pittsburg coal may be seen are indicated by crossed hammers, the usual symbol for a mine or quarry. Some of these are numbered, for ready reference, as follows:

List of properties where exposures of Pittsburg coal occur.

1. Holsten Brothers.
2. Hugh Blakley.
3. Madison Craig.
4. Wilson Blakley.
5. Harry Hart.
6. John D. Hart.
7. Simon Townsend.
8. Robert Fritz.
9. Pittsburg Gas Coal Company.
10. Thomas Hart.
11. Avonmore mine.
12. Foster mine.
13. Edri mine.
14. Bowman mine.
15. Conemaugh Coal Company.
16. Mrs. Arnold.

For figures in parentheses in the text see fig. 4.

A large number of openings have been made on the outcrop of the coal. Many of these were abandoned after a small quantity of coal had been taken out, and have been closed for years. Other banks to the number of ten or twelve are kept open and are operated by one or two men throughout the greater part of the year. Among these country banks are those of Holsten Brothers, Madison Craig, Wilson Blakley, John D. Hart, Harry Hart, Robert Fritz, Samuel White, McComb, Thomas Hart, and John Hart. These small banks supply fuel for only a narrow belt of farms, because the Upper Freeport coal is mined on Roaring Run and on Crooked Creek below South Bend less than 2 miles west of this field, and both the Upper and Lower Freeport coals are mined to the east not more than 3 miles from Blacklegs Creek.

Extensive mining has been done only near the river. Between forty and fifty years ago, when there was a canal along the river, a large mine was worked on the Rhea property, near Avonmore, but developments here terminated about 1865, when the Western Pennsylvania division of the Pennsylvania Railroad was built and the canal was abandoned. Coal mining on a large scale began again about fifteen years ago, and at present there are five or six mines which ship their output to distant markets by rail.

The Avonmore mine (No. 11), which is operated by the Avonmore Coal and Coke Company, is situated at Hicksville on the bluff 350 feet above the river. The working faces are from one-half to three-fourths of a mile from the mine mouths. The cars are collected in the mine by mules and hauled out to the top of the bluff by cable; they

are lowered to the tipple on the railroad by a double-track gravity incline. A daily output of 500 tons is made with a force of 150 men. L. W. Hicks, of Leechburg, Pa., is superintendent of the company. This mine has been working continuously since 1889 (Pl. VII, *A*).

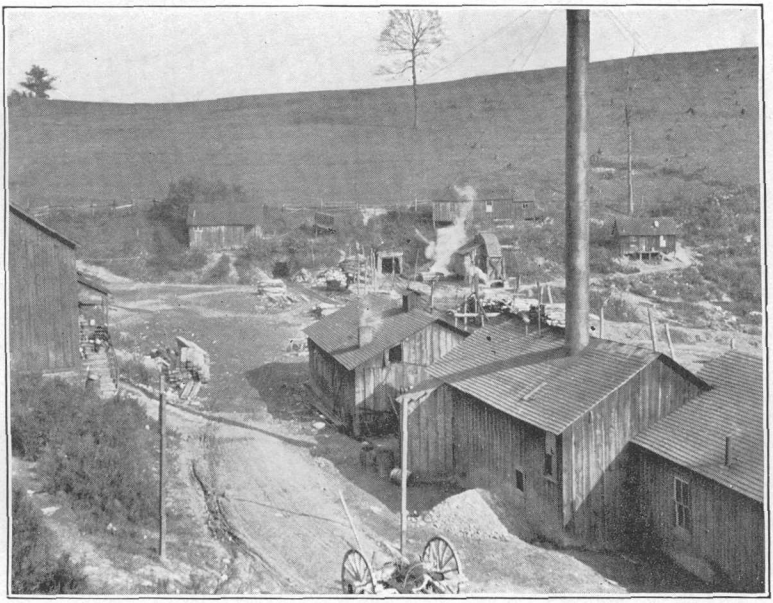
The Foster mine (No. 12) is owned by the Saltsburg Coal Company and was reopened in the fall of 1903 after standing idle a number of years. The coal is hauled down the run and around the face of the river bluff to the tipple on the railroad by a narrow-gage steam locomotive. In December, 1904, this mine was producing 750 tons per day. At the Edri mine (No. 13), which is situated on the hill east of the station of that name, the cars are brought out by mules, and lowered about 200 feet to a tipple on a spur from the railroad. A double-track gravity incline is the method for lowering and raising cars. About 50 men are employed and the daily output is 200 tons. This mine is operated by the Edri Coal Company.

The Bowman Coal Mining Company, S. J. Robinson, superintendent, operates a mine (No. 14) near the southern extremity of the field on the hill about three-fourths of a mile south of Edri. The company employs 60 men and ships from 200 to 250 tons daily. Mules are used for hauling the coal from the breast out to the brow of the hill (Pl. VII, *B*), where it is lowered by an incline to a railroad tipple.

The Conemaugh Coal Company, of Blairsville, Pa., F. M. Graff, superintendent, in 1903 opened a mine (No. 15) a half mile east of the Bowman Company mine. There were 100 men on the pay roll in December, 1904, and they were getting out about 7,000 tons per month. Almost 1,000 feet of heading per month were being driven in the fall of 1904, and it is expected that an additional capacity of 1,000 tons will soon be developed. A large tipple has been built over a railroad spur at the sheet-steel mill and cars are handled on the incline by steam power.

The Pittsburg Gas Coal Company has started a new coal town on Harper Run, about 1½ miles south of Elders Ridge. This company began operations in the summer of 1903 by building a dam across the run, erecting power houses, and starting 6 headings on the coal (Pl. VI, *B*, p. 40). Three of these headings are on the east side of the run and have natural drainage. The other 3, on the west side of the run, are down the dip of the rocks, so a heading is being run almost due west to Big Run to give natural drainage to all the workings in that part of the mine. Electric haulage and all modern improvements, both inside and outside, are used at this mine.

The company expects to erect 350 to 400 houses on its town site, known as Iselin. In March, 1905, according to John Reed, assistant general manager, the town had a population of 2,000, and the company was employing 400 men and producing 1,850 tons of coal daily.



A. AVONMORE MINE, HICKSVILLE.

B. ENTRANCE TO BOWMAN COAL COMPANY'S MINE.

The Buffalo, Rochester and Pittsburg Railway has been extended from Creekside, Indiana County, to Iselin. It began hauling coal from this mine in August, 1904.

THICKNESS OF THE PITTSBURG COAL.

The Pittsburg coal bed in the Elders Ridge field is slaty and much parted in some places; in others it is clean and almost unbroken. It varies in thickness, including its partings and roof coal, from 7 to 10 feet. Generally the roof coal is not taken, being so much parted by thin bands of shale that it has little value. Moreover the shales over the roof coal are so soft and friable that the coal has to be left to support them. The bed has been opened at a great many places in this basin, but there are hardly more than twenty localities where accurate measurements of the seam can easily be made. A few measurements are given in detail to show the character of the seam.

Northern block.—That portion of the Elders Ridge field which lies east of Whisky Run is the smallest of the three blocks into which the field is divided. The small outliers of a few acres in extent which are seen near West Lebanon are the most northern remnants of the great Pittsburg coal bed. Beyond this point the bed would be carried above the present surface by the rising axis of the Elders Ridge syncline if projected beyond the outcrop.

About two-thirds of a mile north of West Lebanon Holsten Brothers own a coal bank (No. 1), which was opened many years ago, but has been worked actively only since about 1900. The coal dips southeast and is practically free from partings and horsebacks. The section is as follows (Pl. VIII, *A*):

Section at Holsten Brothers coal bank.

	Ft.	in.
Coal	2	2
Shale and coal	0	4
Coal	2	5
Shale	0	½
Coal	2	2
Total	7	1½

In a small outlier of the coal, a short distance east of West Lebanon, Wilson Blakley owns a bank (No. 4), which is being worked by H. L. Dillinger. The coal in this bank shows the following thickness (Pl. VIII, *B*):

Section at Wilson Blakley coal bank.

	Ft.	in.
Coal	1	8
Shale	0	11
Coal	3	11
Shale	0	1
Coal (seen)	1	3
Total	7	10

In the fall of 1903 this bank was delivering 2,500 bushels a month to the steam shovels working on the Buffalo, Rochester and Pittsburg Railroad cut near Parkwood, and the Madison Craig bank (No. 2) was working on a similar order.

These northern banks in the Elders Ridge field furnish a large part of the local supply in the Crooked Creek Valley. Being compact and hard, the Pittsburg coal comes out of the mine in firm blocks, which in spite of their impurities are preferred by the farmers for use in stoves and grates to the softer coal from the Upper Freeport seam as mined on Crooked Creek.

At the J. D. Hart bank (No. 6) on Whisky Run, 1 mile southwest of West Lebanon, the entire thickness of the coal was not seen. Two bands of roof coal, 8 and 3 inches thick, are said to be above the draw slate and are not taken down. The main part of the seam comprises 5½ feet of good coal with only two thin partings (Pl. VIII, *C*).

Partial section of J. D. Hart coal bank.

	Ft.	in.
Coal	1	8
Shale	0	½
Coal	1	8
Shale	0	1
Coal	2	1
Total	5	6½

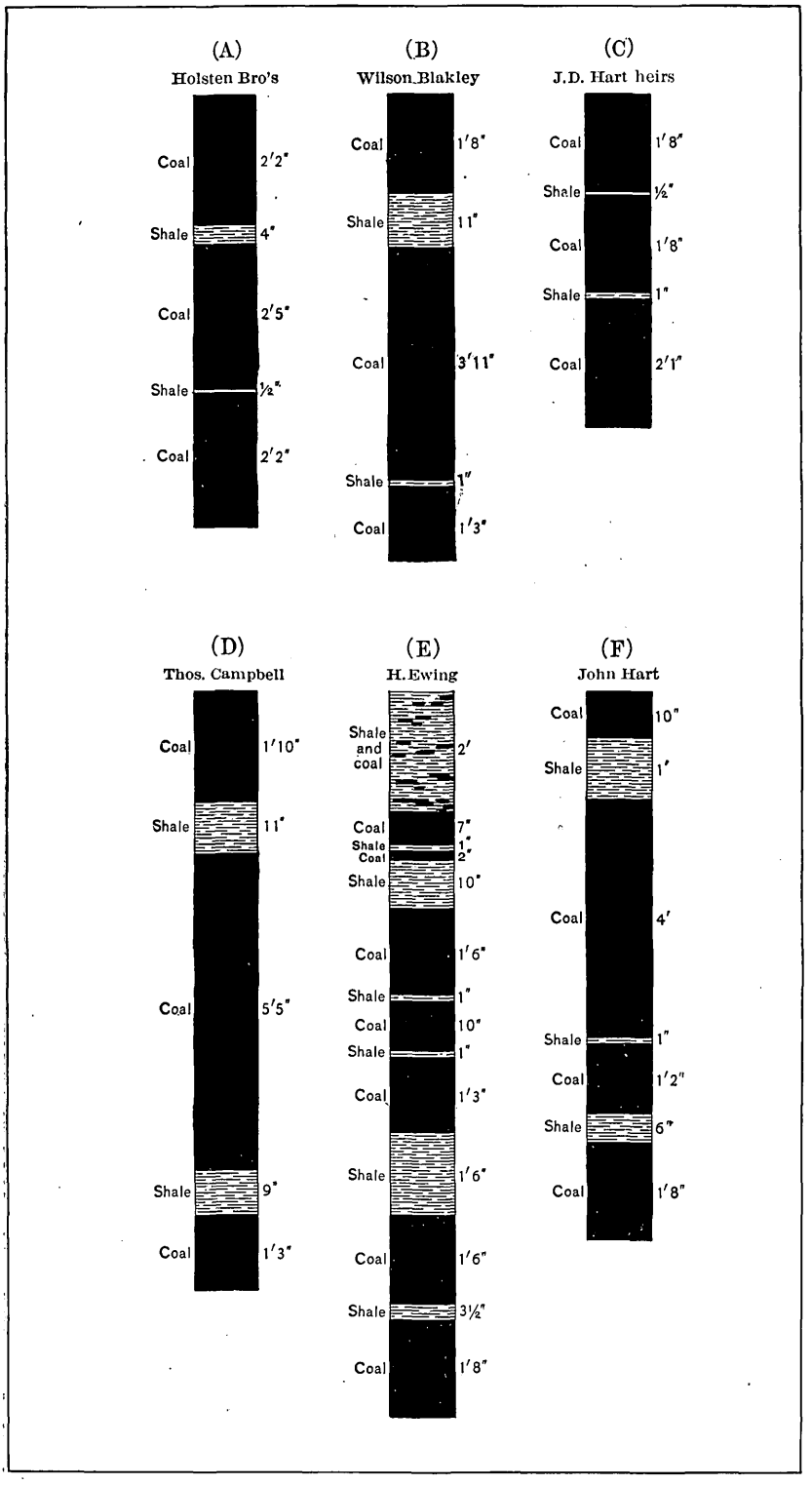
The thickest section of Pittsburg coal measured by the writer is in this northern block, on the farm of Thomas Campbell. Back of his house, which is 1½ miles south of West Lebanon, there is a small ravine in which the coal is well exposed and headings have been driven. The seam is in three benches, the middle one being nearly 5½ feet thick. The section is as follows (Pl. VIII, *D*):

Section on Thomas Campbell farm.

	Ft.	in.
Coal	1	10
Shale	0	11
Coal	5	5
Shale	0	9
Coal	1	3
Total	10	2

Middle block.—Under this heading is included all that portion of the field which lies between Big and Whisky runs. Sections at all of the working banks can not be given, and four or five will be enough to show the variable characters of the bed.

Twenty-five years ago the local trade about Elders Ridge was supplied by a pit on the H. Ewing farm. This coal pit was a short distance east of the Simon Townsend bank (No. 7). Here the bed is at



SECTIONS OF PITTSBURG COAL.

its thickest, and the following detailed section was measured by the Second Geological Survey of Pennsylvania (Pl. VIII, *E*):

Section at the Ewing coal bank.

Roof division:	Ft.	in.
Slate and coal	2	0
Coal	0	7
Slate	0	1
Coal	0	2
Slate and clay, main parting	0	10
Coal	1	6
Slate	0	1
Coal, slaty	0	10
Slate	0	1
Coal	1	3
Slate, 4 inches to	1	6
Coal	1	6
Slate, ½ inch to	0	3½
Coal	1	8
Slate	--	---
Total	12	4½

The seam shows more slate partings than is usual, and the coal in the different benches is said to be slaty and poor. This much-parted condition of the seam may be local, however.

The Pittsburg coal is mined on Harper Run by John Hart. A section obtained there shows all of the bed except perhaps a thin layer in the roof shales. The following measurement was made (Pl. VIII, *F*):

Section at John Hart coal bank.

	Ft.	in.
Coal	0	10
Shale	1	0
Coal	4	0
Shale	0	1
Coal	1	2
Shale	0	6
Coal	1	8
Total	9	3

At the new mine of the Pittsburg Gas Coal Company a measurement was made in heading No. 2. This mine is just across the run from the bank mentioned above, but shows fewer partings. The section is (Pl. IX, *A*):

Section at Pittsburg Gas Coal Company mine.

	Ft.	in.
Coal	6	6
Shale	0	6
Coal	2	0
Total	9	0

The bottom bench, which runs from 20 inches to 2 feet thick, is not being taken out at present. The great thickness of the main bench of coal promises well for the mine if the visible conditions continue. It is overlain by a draw slate which varies from 6 to 12 inches in thickness, but whether there is more coal above this or not has not been ascertained.

Mr. Thomas Hart is operating a bank (No. 10) on a small run near Clarksburg to supply local trade. The main bench of coal is 4 feet 10 inches thick, with one shale parting less than an inch thick a little above the middle (Pl. IX, *B*). The roof coal was not seen, but it is separated from the main bench by 10 inches of shale, and is at least 4 inches thick.

At the southern end of the middle block of coal in this field there is an opening on the James Crawford heirs' farm, which has not been worked for some time, but which was still accessible when seen in 1902. It showed a good body of coal in two benches, but not so thick as in an old opening on the Samuel Gailey farm, a mile farther up Big Run. The sections in these two banks are as follows (Pl. IX, *C*, *D*):

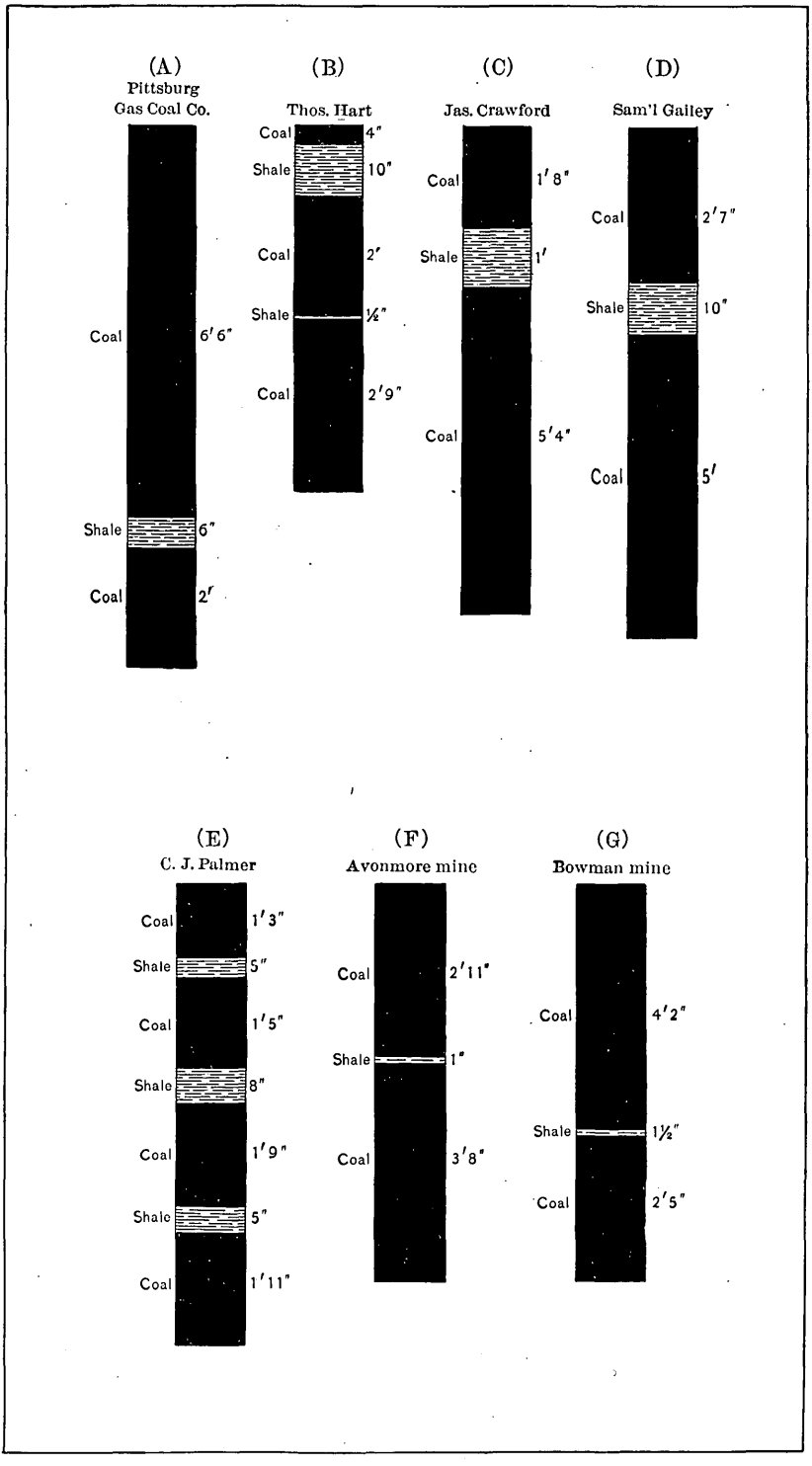
Sections on Crawford and Gailey farms.

	Crawford.	Gailey.
	Ft. In.	*Ft. In.*
Coal	1 8	2 7
Shale	1 0	0 10
Coal	5 4	5 0
Total	8 0	8 5

A detached area of coal containing about 200 acres and lying between the forks of Big Run on the west side of the syncline has been prospected a little, but is not being mined at the present time.

Southern block.—The southern block of the coal field is very irregular in shape. It lies between Big Run and Kiskiminitas River, and by reason of its position has been mined on its river side more than in any other part of the field. The variations in the thickness of coal benches and shale partings are much the same as already described in the northern and middle blocks.

At the northern extremity of the block on the C. J. Palmer farm there is an old pit which was open although not working when seen by the writer. The section at this point is fairly typical of all that portion of the field, and compares very closely with a measurement made at a bank about 1 mile southeast of Long Run, although the latter had a few inches more of coal at the point where the seam was measured. The section at the Palmer bank is as follows (Pl. IX, *E*):



SECTIONS OF PITTSBURG COAL.

Section at Palmer coal bank.

	Ft.	in.
Coal	1	3
Shale	0	5
Coal	1	5
Shale	0	8
Coal	1	9
Shale	0	5
Coal	1	11
Total	7	10

Mr. Samuel White owns and operates for country trade a bank about a mile northeast of Long Run, and Robert Fritz has an opening (No. 8) on Big Run. Complete sections were not obtained at these points, but the bed is known to be over 6 feet thick.

The Avonmore mine (No. 11) is operating on the Pittsburg seam, where the average thickness of merchantable coal is over 6 feet. The usual thickness in this mine, exclusive of the roof coal, is as follows (Pl. IX, *F*):

Partial section at Avonmore mine.

	Ft.	in.
Coal	2	11
Shale	0	1
Coal	3	8
Total	6	8

At the Foster mine (No. 12) the seam carries about the same amount of coal. The parting or "band slate" in all of these mines varies in thickness; near the river it seems usually to be only 1 or 2 inches thick, but increases in places to a foot or more. The total thickness of the bed in the Edri mine (No. 13) changes from 5 feet 9 inches to 8 feet in a few spots, where the parting thickens from 1½ inches to 3 feet.

In the Bowman mine (No. 14), at the southern end of the field, that part of the bed which is taken out is 80 inches high and contains only one noticeable parting. The section is as follows (Pl. IX, *G*):

Partial section at Bowman mine.

	Ft.	in.
Coal	4	2
Shale	0	1½
Coal	2	5
Total	6	8½

The main bench, which is over 4 feet thick, contains a very thin streak of shale, but its exact position was not noted.

Two other mines, also on the southern lobe of this block, are the new one owned by the Conemaugh Coal Company (No. 15) and the mine on the Arnold farm (No. 16), which used to supply the American Sheet

Steel Company mill at the mouth of Blacklegs Creek, but is now operated only for country trade. At the Conemaugh mine the parting or "band slate" is usually from 1 to 2 inches thick, but thickens in places to 1 foot. The "draw slate," from 6 inches to 1 foot thick, is taken down in entry, but can be held in rooms. The total thickness of coal is practically the same as in other mines at this end of the field.

Three small areas of Pittsburg coal are represented in Bell Township, west of Kiskiminitas River. In a coal bank at the road fork, 2 miles south of Avonmore, the following section was measured:

Section 2 miles south of Avonmore.

	Ft.	in.
Coal	0	4
Clay	0	6
Coal	0	3
Draw slate	2	0
Coal	7	10
	10	11

TONNAGE OF THE PITTSBURG COAL.

Allowing 1,560 tons to the acre for each foot, the Pittsburg seam, which averages 7 feet of workable coal in this field, contains 10,920 tons to the acre. There are probably 8,000 acres of merchantable coal remaining in the field, or 87,360,000 tons. If by most advantageous methods of working 70 per cent of this coal can be mined, the total product of the field as it now stands would be 61,152,000 tons.

QUALITY OF THE PITTSBURG COAL.

In the following table nine analyses of the Pittsburg coal in the Elders Ridge field are given. Four of these, made by Mr. A. S. McCreath, were published by the Second Geological Survey of Pennsylvania, in the reports on Armstrong and Indiana counties in 1878. The other five are new, and, so far as known, were published first in Bulletin No. 225, United States Geological Survey, p. 322.

The Avonmore analysis was furnished by the superintendent of the mine, and the method of sampling the coal was not stated.

The Arnold analyses were furnished by the Conemaugh Coal Company, with the statement that the samples "were taken in the usual way in which this work is done, viz, a narrow slip from top to bottom, getting in an equal amount of both bench and breast coal."

The samples for the Iselin and Holsten analyses were collected by the writer. In taking the samples a cut was made at a working face from top to bottom of that portion of the seam which is marketed. The samples were mixed and quartered and sealed in glass fruit jars. The analyses of the Iselin and Holsten coal samples were made in the chemical laboratory of the United States Geological Survey by Mr. George Steiger and Mr. Eugene C. Sullivan, respectively.

Analyses of Pittsburg coal from Elders Ridge field.

Locality.	Fixed carbon.	Volatile Matter.	Moisture.	Ash.	Sulphur.	Fuel ratio.	Coke.	Authority.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Avonmore ...	56.432	35.040	0.720	6.810	0.988	1.61	64.23	L. W. Hicks.
Arnold 1.....	55.17	32.99	.51	10.33	.98	1.67	66.48	C. B. Dudley.
Arnold 2.....	56.47	30.02	.63	11.83	1.02	1.88	69.32	Wuth & Stafford.
Iselin	56.34	31.48	1.76	10.42	1.25	1.79	68.01	Geo. Steiger.
Ashbaugh ...	53.639	37.555	1.110	6.260	1.436	1.43	61.335	A. S. McCreath.
Ewing	50.230	36.900	.800	9.030	3.040	1.36	62.30	Do.
Evans 1.....	50.850	36.940	1.040	9.705	1.465	1.38	62.02	Do.
Evans 2.....	53.788	31.995	1.460	11.760	.997	1.68	66.545	Do.
Holsten	56.25	33.41	1.61	8.73	1.87	1.68	66.85	E. C. Sullivan.

The Avonmore analysis, furnished by Mr. L. W. Hicks, superintendent of the Avonmore Coal and Coke Company, shows that the coal in the Avonmore mine (No. 11) runs high in fixed carbon and low in ash in comparison with that from other parts of the field. Although the fuel ratio is not high, the total amount of combustible matter is the highest of the nine samples. The percentages of sulphur and of ash are both very low, and the amount of phosphorus in this sample was 0.010 per cent. Judging from the above analyses alone, it is evident that the coal in the Avonmore mine is the best in the field for steaming purposes.

The Conemaugh Coal Company has furnished, through Mr. F. M. Graff, superintendent, two analyses of the coal in the Arnold mine (No. 16), one made by C. B. Dudley, of Altoona, the other by Wuth & Stafford, of Pittsburg, Pa. Both analyses run high in ash and low in moisture. Arnold 2 runs higher in fuel ratio than any other sample from this field. This is due to a low percentage of volatile matter. It also shows the highest per cent of coke. The high ash, however, keeps this from being the best sample in the above list. Arnold 2 shows a phosphorus content of 0.028 per cent.

The Arnold mine has about 8 acres of coal, and lies within a few hundred feet of the main entries of the Conemaugh mine. The Conemaugh Coal Company owns the coal all around it, and these Arnold analyses probably represent the character of the immediately surrounding coal.

The Iselin analysis was made from a sample collected by the writer in No. 2 heading of the Pittsburg Gas Coal Company mine (No. 9) at Iselin. It shows the composition of the coal of the main bench, 6½ feet thick, which is now being taken out. The percentage of ash and moisture is high, but the fuel ratio is excellent. The coke per cent and total amount of combustible matter are high. Nine tons of this coal sent to Adrian to be tested made a good coke.

The Ashbaugh analysis, published more than twenty-five years ago, is from a sample of the coal taken at Ashbaugh's steam mill on Har-

per Run, 1 mile above Clarksburg. The lower bench of the bed has a cannel appearance and is very rich in hydrocarbons, which probably accounts for the high percentage of volatile matter. The location is very near the new mine of the Pittsburg Gas Coal Company, but the analyses of the coal at the two points differ considerably. The Ashbaugh analysis shows the next highest amount of combustible matter of any locality in the field.

The coal of the Ewing bank in all the different benches is slaty and poor. Some of it is overloaded with iron pyrites, and none of it in its raw state could be considered marketable fuel, except for local supply. Although not the lowest in total amount of combustible matter, it is the lowest in fuel ratio, and carries such a high percentage of sulphur as to make it unsalable for many purposes.

At the mill of Mr. J. Evans, close to West Lebanon, the Pittsburg coal was mined many years ago. The bed is somewhat slaty and more pyritous than at most other localities. Mr. McCreath analyzed a specimen representing about the average run of the main benches, and the results are given in the table above as Evans 1. One bench (that next to the lowest) in this bank assumes a cannel appearance and Evans 2 is an analysis of the same.

The coal in the Holsten bank (No. 1) takes third place in the list for total amount of combustible matter, stands high in fuel ratio and coke per cent, and it is also high in sulphur. The analysis of the coal at this bank was made by Mr. Eugene C. Sullivan, of the United States Geological Survey, from a sample collected by the writer at a fresh breast.

On the basis of the analyses which give the coal in the Avonmore mine first place, there would be difficulty in making a second choice. The coal at the Holsten and Arnold pits is no better than that on Harper Run.

SEWICKLEY COAL.

The horizon of the Sewickley coal is about 120 feet above the Pittsburg, and its occurrence is limited in this quadrangle to the center of the Elders Ridge syncline. The coal is nowhere worked in this region, but the blossom is seen frequently in ditches along the roadside. It is conspicuous at the road corner above the Thomas Hart bank 1¼ miles northwest of Clarksburg, and also a few rods north of the church at Elders Ridge. An opening on the Smith farm near Elders Ridge, made many years ago, is claimed to have revealed a much-parted seam measuring 5 feet 3 inches. The coal is said to be 3 feet thick in the cliff above Hicksville, but occurrences noted do not indicate more than 2 feet.

COKE.

There are no coke ovens in the Elders Ridge quadrangle at present. It is probable, however, that some time the Pittsburg coal in this area will be coked if it proves to be adapted to the purpose. In the chemical analyses of Pittsburg coal from the Elders Ridge field, given on page 53, the coke percentage, which is the sum of the fixed carbon, ash, and sulphur, is highest in the Arnold and Iselin analyses. The analyses suggest, however, only the strength and purity, and fail to indicate the essential qualities of a good coking coal. The coking and noncoking properties of the soft coals are not yet clearly understood.

The only sure method for determining the adaptability of coal for coking is to have a quantity of it tested in a coke oven and then to make a careful study of the physical and chemical properties of the product.

Comparative analyses of coke.

	Elders Ridge.	Connellsville.
	Per cent.	*Per cent.*
Fixed cabon	90.532	89.509
Volatile hydrocarbons	.....	.880
Moisture	.....	.070
Ash	7.411	8.830
Sulphur	2.057	.711
	100.000	100.000

Two analyses of coke made from Pittsburg coal are given above. The first was made by A. S. McCreath from coke made in the laboratory of the Second Geological Survey of Pennsylvania by coking coal in a platinum crucible. The coal was from the Saltsburg Coal Company mine in the southern block of the Elders Ridge field. The second is the average of a number of analyses of typical Connellsville coke made by the H. C. Frick Coke Company. The amount of sulphur in the Elders Ridge coke is too high for a first-class product, but this might be remedied by washing the coal to get rid of part of the sulphur.

NATURAL GAS.

GENERAL STATEMENT.

More than 260 wells have been drilled for gas and oil in the Elders Ridge quadrangle during the past ten years, drilling having begun about 1894. Many of the wells have produced gas, some have been unproductive, but not one has found a pool of oil. The wells may be

grouped in seven more or less well-defined fields, which are known by local names. These are the Willet, Plum Creek, Say Farm, Girty, Shellhammer, Roaring Run, and Rockville fields.

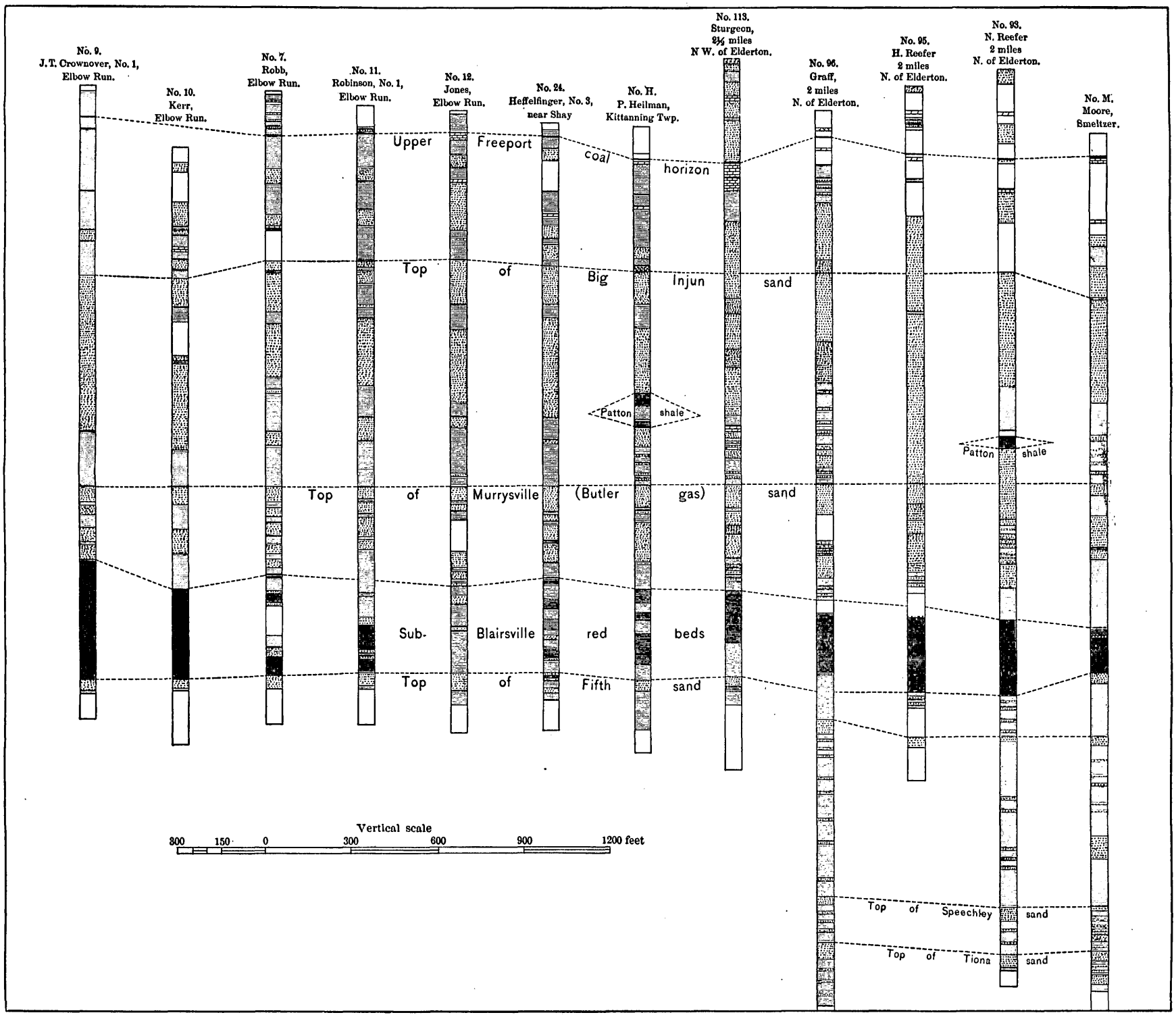
The relation of the gas fields to geologic structure appears to be definite and uniform. It will be noticed that the producing wells are near the crests or far up on the flanks of anticlinal folds, and that a number of holes located in the synclines are unproductive. Formerly it was the practice to pursue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

Natural gas is not confined to a single horizon in the wells in this quadrangle. The Murrysville and Hundred-foot sands are the uppermost and most productive, the Pine Run and Fifth sands yield some gas, and the lowest sands—the Speechley and Tiona—also are reservoirs. Several of these sands may be found to be productive in the same well. In fact, some companies operating in the northeastern part of Armstrong County have deepened the upper-sand wells, which were fast becoming exhausted after several years of productiveness, and have found large amounts of gas in the lower sands. Early in 1904 the Philadelphia Company deepened a well which had become weak, and obtained a flow of gas with a rock pressure of over 920 pounds in the Tiona sand about 1,300 feet below the Hundred-foot sand. This is a far greater pressure than the upper sands ever have and shows the possibilities of deep drilling.

STRATIGRAPHY OF GAS-BEARING ROCKS.

The lowest rock exposed in the quadrangle is the Vanport limestone, which is in the lower part of the Allegheny formation. The following description of rocks not exposed extends from this horizon to the bottom of the deepest well, taking up the rocks in the order in which they are reached by the descending drill. The description is based on well records which have been furnished by gas companies operating in the territory. It is well known that rocks exposed at the surface change in character and thickness from place to place, and the same thing may be expected in the hidden formations. Although the vertical interval between two easily recognized beds may be approximately constant, the details in the sequence of rocks filling the interval often change materially, both in exposed sections and in well sections. For this reason it is often difficult to correlate beds in the records of wells drilled in close proximity to each other, and the author upon plotting well records to scale has not always been able to agree with the drillers in their correlations.

The records of a number of deep wells in this quadrangle are shown



TWELVE DEEP-WELL SECTIONS.

on Pls. X and XI. It must be borne in mind that the holes were churn drilled, and that the value of such records varies with the care exercised by the recorder. The correlation lines on the plates are the author's interpretation of the records, and are more or less tentative.

The record of the W. G. King well on Crooked Creek, 2 miles west of South Bend, gives a typical section of the underlying rocks of the Elders Ridge quadrangle (Pl. XI, No. 235).[a] The author has taken the liberty of using the word shale instead of slate, as in the original record, and has named the members according to his interpretation. The well began near the horizon of the Lower Kittanning coal, and was drilled by the Ford City Gas Company in February, 1892.

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

	Thickness.	Depth.
	Feet.	*Feet.*
Conductor	5	0
Sand	15	5
Shale	35	20
Limestone (Vanport)	15	55
Shale	130	70
Sand	40	200
Shale	70	240
Sand (Big Injun)	300	310
Shale	150	610
Sand	105	760
Shale	77	865
Sand	40	942
Shale and shell	23	982
Sand (Murrysville)	35	1,005
Shale	30	1,040
Sand	15	1,070
Shale	20	1,085
Sand (Hundred-foot)	50	1,105
Shale and shell	140	1,155
Red rock	255	1,295
Shale	5	1,550
Red rock (Sub-Blairsville red beds)	25	1,555
Pebbly sand	7	1,580
Red rock	33	1,587
Shale	73	1,620
Depth		1,693

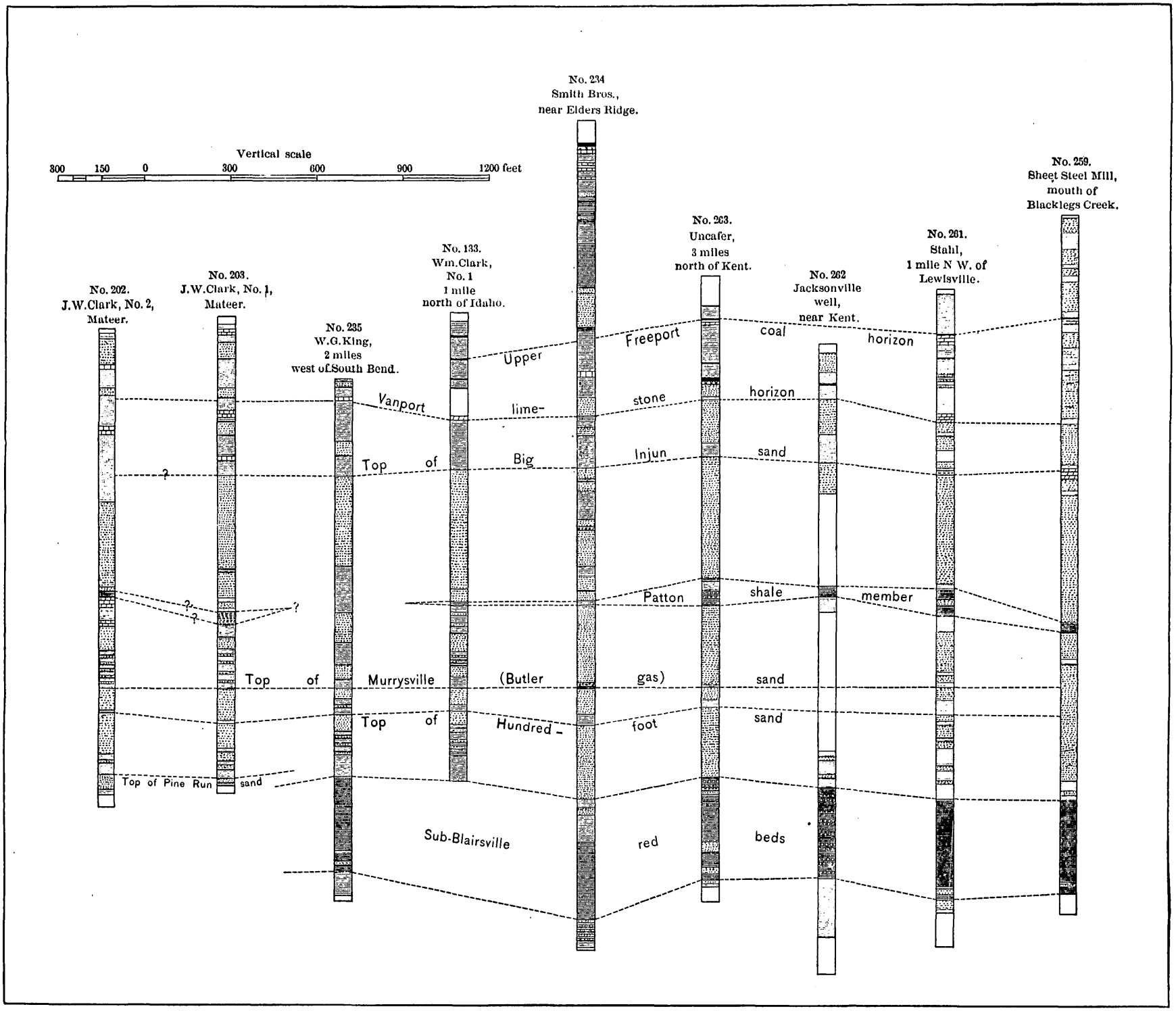
[a] Numbers in parentheses referring to deep wells indicate the location of wells on the economic geology map, Pl. I.

According to the records of a number of wells in the quadrangle, the interval between the Vanport limestone and the top of the Pocono sandstone or Big Injun sand is from 200 to 250 feet. This interval is occupied by sandstone and shale in varying proportions. Usually the lower portion is shale, and much of the sandstone probably is Pottsville. At the base of this interval in the George W. Stahl well (Pl. XI, No. 261), Conemaugh Township, is 8 feet of red rock. The color suggests that this occurrence is Mauch Chunk formation. It is possible that some of the shale shown in other well records as occurring between the Pottsville and Pocono formations is of Mauch Chunk age, although no mention of the color is made. What little Mauch Chunk may underlie this quadrangle probably is very thin. This scanty representation is interesting because of the well-known westward thinning of the formation, and of the erosional unconformity which separates the Pottsville from the underlying rocks. Farther westward, in the vicinity of Kittanning, M. R. Campbell and David White have shown that the Pottsville rests directly on the Pocono, with no intervening Mauch Chunk.

Big Injun sand.—Practically all well drillers in western Pennsylvania know the Big Injun sand, which to the geologist is the Pocono andstone. This sandstone is found from 450 to 500 feet below the Upper Freeport coal and often is from 300 to 500 feet thick. The records show considerable variation in this formation. While in one well there may be 300 feet of unbroken sandstone, other wells show large admixture of shale and shaly sandstone. In some wells shale appears less than 100 feet below the top of the formation, and the upper sand is called the 70-foot. It is the practice of some drillers to call the main sandy portion of the formation, which is separated from the 70-foot sand by a varying amount of shale, the Mountain sand. In fact, the term Big Injun is not always used. The variations in this formation can best be understood by examining the well sections on Pls. X and XI.

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

Murrysville sand.—At an approximate depth of 1,100 feet below the Upper Freeport coal a sand rock which often carries gas is found throughout this quadrangle. This is the Murrysville sand, which takes its name from a village of that name in Westmoreland County, where a



NINE DEEP-WELL SECTIONS.

strong gas pool was discovered at this horizon. Other names which are used in Armstrong County for the sand are Butler sand and Salt sand. The thickness of the Murrysville sand, based on drillers' recognition, varies from 20 to 105 feet, and 69 records give an average thickness of 64 feet. The top of the Murrysville sand is usually about 700 feet below the top of the Big Injun. The interval between it and the Big Injun or the Patton shale member, when the latter is present, is filled in some wells entirely with sandstone, in others with shale or sandy shale, and in others with all three types of rocks.

Hundred-foot sand.—From 100 to 125 feet below the top of the Murrysville sand, and separated from it by a varying amount of shale, is the Hundred-foot sand. The name is derived from its thickness, which, although it varies from 35 to 150 feet, in the record of 51 wells averages 94 feet. This sand also is a gas producer. Immediately below the Hundred-foot, and separated from it by a few feet of shale, the drillers sometimes recognize a sand known as the Thirty-foot. The term is used but little in the Elders Ridge quadrangle, but is common in the records of wells in the Rural Valley quadrangle on the north. This sand in a few wells appears to be merged with the Hundred-foot, the intervening shale being absent; sometimes it carries gas.

Pine Run sand.—In wells drilled at Mateer, a gas-bearing sand was found 275 feet below the top of the Murrysville. A sand at this horizon about 20 feet thick is shown in the records of wells in other parts of the quadrangle, but only at this point is it given a name. The origin of the term is not known. It is separated from the Hundred-foot sand by shale, sandstone, or sandy shale, and lies only a few feet above a considerable thickness of red beds.

Sub-Blairsville red beds.—A conspicuous mass of red shale is shown in all the wells which go more than 1,300 feet below the Vanport limestone. The top of this red rock is usually from 300 to 350 feet below the top of the Murrysville sand, and the color extends through an average thickness of 300 feet in this region. The rocks probably constitute a part of what is known as the Catskill formation and may be of Devonian age. They are not known in outcrop and because of their considerable development in wells drilled in the vicinity of Blairsville have been called by Campbell (Latrobe folio, No. 110) the Sub-Blairsville beds. Richardson noted this mass of red rocks as occurring in wells in the Indiana quadrangle at a depth of 1,400 to 1,500 feet below the Upper Freeport coal and correlated them in a number of well records on columnar section sheet 2 in the Indiana folio, No. 102.

It will be seen by reference to the plates of well sections that the correlation lines drawn at the top and bottom of the Sub-Blairsville red beds include in a number of cases more shales and sandstones than those which the drillers noted as being red. These lines limit the zone in which red beds occur rather than mark the occurrence as actually

noted, and are the author's interpretation of the probable correlation between the sections. In the Crownover, Kerr, King, Stahl, and other wells red beds occupy the entire interval; in the Sturgeon well they are in the upper portion, and in the Robinson well they are in the lower portion of the zone, while in the Jones well no red beds are recorded. It is assumed that if particular attention had been paid to the subject when the wells were being drilled, the drillers' records of a number of the wells would have shown more red beds.

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

Fifth sand.—A sand known as the Fourth sand, which occurs in the midst of the Sub-Blairsville red beds in the Rural Valley quadrangle, is not recognized by drillers in this field. The Fifth sand is at the base of the red beds from 600 to 700 feet below the top of the Murrysville sand and from 1,700 to 1,900 feet below the Upper Freeport coal. According to well records it ranges in thickness from 5 to 49 feet, the average of 21 records being 21 feet. The position and correlation of the Fifth sand are shown on Pl. X.

Three wells shown on this sheet, which go below the Fifth sand, show another sand of about the same thickness 150 feet below the bottom of the red beds. In the Moore well it is 225 feet below. This was called the Fifth sand in the Graff and Henry Reefer wells.

Speechley sand.—At least three wells in the Elders Ridge quadrangle have a depth of more than 2,900 feet. These are the Nicholas Reefer (No. 93) and Samuel Graff (No. 96) wells in Plum Creek Township, and the Samuel Bracken well (No. 149) in Washington Township. At depths of 2,460, 2,495, and 2,540 feet, respectively, below the Upper Freeport coal, these wells encountered a sand in the midst of "slate and shells." In two wells it is 40 feet thick and in the third 20. This sand produces gas in some fields.

Tiona sand.—The three wells mentioned in the preceding paragraph encountered a lower sand which drillers call the Tiona. In the Graff and Reefer wells the top of the Tiona is 150 feet below the top of the Speechley sand, and in the Bracken well 100 feet below it. On the other hand, the distance from the Upper Freeport coal to the Tiona sand in the Bracken and Graff wells is 2,640 and 2,646 feet, respectively, a remarkably close accordance, while in the Nicholas Reefer well the interval is 2,610 feet. The Speechley and Tiona sands are shown on Pl. X.

The well on the Samuel Bracken farm (No. 149), near Russell Hill,

3 miles north of Shelocta, is, so far as is known to the writer, the deepest well in the Elders Ridge quadrangle. Its total depth is 3,025 feet.

DESCRIPTIONS OF GAS FIELDS.

The seven gas fields in this quadrangle are described in the order in which they occur from east to west.

Willet field.—The locality of a group of producing wells, which extends across the Indiana–Elders Ridge quadrangle line on the south branch of Plum Creek, takes its name from Willet, at the mouth of Sugarcamp Run in the Indiana quadrangle. Gas was discovered in the Kelly No. 1 well in December, 1890, and other wells were soon put down. An effort to find a northeastern extension of this producing area has been without success thus far. To the southwest, however, several good wells have been struck and the field extended to Dutch Run, in the Elders Ridge quadrangle. The Willet field is located on the Dutch Run anticline. Of the 25 wells which have been drilled between Sugarcamp Run on the northeast and the John Snyder well (No. 150) on the southwest, all but 5 or 6 are producing. The pressure is light in this field, but none of the good producing wells have been exhausted thus far. It is said that the Kelly No. 2 well (No. 161) on Plum Creek had a rock pressure of 225 pounds when the well was drilled in 1891 and a minute pressure of 125 pounds in a 5⅝-inch casing. In 1901 the rock pressure in this well had decreased to 100 pounds. All of the wells in this field have a little salt water, but not enough to hurt them. The Willet field is operated almost entirely by the Indiana County Gas Company, only two or three wells having been sunk in this region by the Peoples Natural Gas Company. The gas is piped to Indiana and Pittsburg.

The gas-producing sand in this field occurs about 1,100 feet below the Upper Freeport coal, which is the horizon of the Murrysville sand. It varies from 15 to 25 feet in thickness, and is a uniform, moderately compact, light-gray sandstone.

Plum Creek field.—There is a group of wells near the mouth of Plum Creek, a locality known as the Plum Creek field. They number less than 20, and were drilled by the Indiana County Gas Company, the Peoples Natural Gas Company, and the Philadelphia Company. Most of the drilling has been done since 1898. The wells are producing from the Murrysville sand, which is found in this field at 1,085–1,115 feet below the Upper Freeport coal. One of the Boyer wells drilled in this field in 1901 on the east side of the creek is reported to have had a rock pressure of 350 pounds in a 6¼-inch casing. The Ralston well (No. 141), at the mouth of Dutch Run, is reported by the Indiana County Gas Company to have a rock pressure of 260 pounds in a 2-inch packed tubing, with a daily capacity of 1,100,000 cubic feet.

The rock pressure in the Ralston well (No. 132), drilled by the Philadelphia Company 1 mile north of Idaho, when completed in 1899, was 140 pounds.

The Plum Creek field is located on the southern portion of the Dutch Run anticline, the westernmost wells being near the point where the axis plunges against the flank of the Roaring Run anticline as it swings to the north.

Say Farm field.—The locality of a group of wells drilled in Plum Creek Township, in the northern part of this quadrangle, is yet sufficiently segregated to be known as a separate field. It takes its name from the farm on which the first producing well was drilled, and although usually limited to the close group in the immediate vicinity, the term may be extended to include all wells between Elderton on the south and Blanco, in the Rural Valley quadrangle, on the north. The development of this field began in 1897, when a well (No. 77) was put down on the A. L. Say farm. It was completed August 23, having passed through the Murrysville and Hundred-foot sands, and obtained a strong flow of gas. The pressure at the end of the first minute was 215 pounds and the rock pressure 530 pounds. Other wells which showed good rock pressure when they came in were as follows: Alex. Clark, 360 pounds; S. R. Say, 355; W. St. Clair, 353; McPherson No. 1, 205; N. & W. Reefer, 178; Rupp & Hemphill No. 2, 175. A few wells in this field have shown very little pressure or have been dry. The largest well in the field was completed in November, 1902, on the Jacob Wingard farm (No. 88) by the Eastern Oil Company. The Murrysville, Hundred-foot, and Thirty-foot sands were dry, but at a depth of 225 feet below the top of the Hundred-foot a sand was penetrated which yielded 2,200,000 cubic feet of gas per day. This was called the Third sand by the driller, and overlies the Sub-Blairsville red beds, being at the horizon of the Pine Run sand in the Shellhammer field.

The records of 20 wells in this field show that most of the gas comes from the top of the Murrysville and lower part of the Hundred-foot sands. The average thickness of the Murrysville in these records is 78 feet, although the recorded thickness varies from 35 to 134 feet. The Hundred-foot seems to vary from 40 to 165 feet in thickness, with an average of 95. The average distance from the top of the Murrysville to the top of the Hundred-foot is 139 feet. Another name used in this field for the Murrysville is Salt sand.

The earliest wells in this field were drilled in the following order in the latter part of 1897: A. L. Say, August 23 (No. 77); J. R. Dunmire, August 30 (No. 68); Absolom Smith, September 4 (No. 66); S. R. Say, October 13 (No. 76); Sturgeon, November 24 (No. 113).

Gas wells in a new field decline more rapidly during the first year or two than in subsequent years. At the present time the decline in

this field is very slow. All the producing wells are nearly as good as they were three years ago, some showing rock pressure as high as 75 and 100 pounds.

The Say Farm field is located on the crest and upper flanks of the Roaring Run anticline, the closest group of wells, including those on the Say, Rupp & Hemphill, McPherson, and adjoining farms, being in a structural saddle on the axis. Almost all of the wells have been drilled by the Philadelphia Company, the only other producers engaged in this field being the Peoples Natural Gas Company.

Girty field.—This field extends from Shady Plain, Kiskiminitas Township, northward to the head of Sugar Run, Plum Creek Township, and westward to within a mile of Cochran Mills. It contains about 45 wells, most of which have been drilled by the Philadelphia Company and the Peoples Natural Gas Company since 1895. The Murrysville or Salt sand and the Hundred-foot sand are the gas producers. The records of all wells give an average thickness of 63 feet for the Murrysville sand, and the distance from the top of it to the top of the Hundred-foot sand is 144 feet. In some records the Hundred-foot is recorded as being 25 to 40 feet thick, while in others from 100 to 125 feet. The Salsgiver well (No. 178), which was one of the first drilled in this field, had a rock pressure of 325 pounds. A majority of the wells are good producers after several years of activity. The field is located on the broad double crest of the Roaring Run anticline.

Roaring Run field.—The territory included in this field extends from Shady Plain southwestward along the valley of Roaring Run. The wells in that portion of the field which lies in the Elders Ridge quadrangle are about 20 in number and are for the most part close to the axis of the Roaring Run anticline. On the ridge east of Roaring Run a well was completed on the C. A. Wright farm (No. 254) September 20, 1894, the first one drilled in this portion of the field. The first well drilled at Equitable was the Lewis Kunkle No. 1 (No. 246), which was completed December 12, 1894. Before the following summer 6 wells had been drilled on the Kunkle farm and three on the Hilty Brothers farm, a short distance down the run. The wells in this field produce from the Murrysville and Hundred-foot sands, the larger amount coming from the latter. The records at hand show nothing concerning production except that rock pressure in the Chambers No. 1 (No. 223), drilled by the Carnegie Natural Gas Company, was 325 pounds, and that the casing of the Hilty Brothers No. 1, just beyond the boundary of this quadrangle, broke with 510 pounds pressure. A large number of the wells in this field were drilled by the Equitable Company and sold by them to the Philadelphia Company in 1899. In 1902 the Philadelphia Company sold all the wells in the field to the American Natural Gas Company, which is utilizing them to-day.

Shellhammer field.—The gas field in the vicinity of Mateer, Burrell Township, on the south side of Crooked Creek, takes its name from the farm on which the first producing well in the field was drilled. It is composed of thirty or more wells, which have been drilled by the Apollo Gas Company, Pittsburg Plate Glass Company, and Philadelphia Company. The first well in the field was completed on the Jacob Shellhammer farm early in 1899. Two wells were drilled on the Shellhammer farm (Nos. 194 and 195) by the Apollo Gas Company in the summer of 1894, and large flows of gas were obtained. The well which came in on July 2 had such a strong pressure of gas from the Hundred-foot sand that the tools were held off the bottom. A gauge showed 400 pounds in forty-five seconds. The well completed September 1 of the same year had a pressure of 200 pounds in thirty seconds and rock pressure of 280 pounds. Three wells drilled on the David Riffer farm (Nos. 188, 189, and 190) by the Philadelphia Company in the summer of 1894 also obtained strong flows of gas in the Hundred-foot sand. These wells showed minute pressures of 320, 225, and 115 pounds, and rock pressures of 340, 253, and 120 pounds, respectively. The Riffer wells were abandoned after six years of productiveness.

The Apollo Gas Company has two small gas-pumping stations in this field which have a daily capacity of about 1,500,000 cubic feet each. The stations draw from 14 wells.

The Shellhammer field seems to be located on a low anticlinal fold which crosses Crooked Creek a short distance below Cochran Mills, and which was called the Apollo anticline by Platt. Gas is found largely in the Hundred-foot and Pine Run sands.

Rockville field.—The locality of the group of gas wells on the Greendale anticline, in the northwest corner of the quadrangle, is known as the Rockville field. Most of the drilling here has been done by the Philadelphia Company and the Pittsburg Plate Glass Company. The first well in the field was drilled on the Anthony Kealor farm (No. 22), a half mile north of Rockville, by the Philadelphia Company in December, 1893. Gas was found in the Hundred-foot and Fifth sands, and flowed with a minute pressure of 32 pounds. The well developed a rock pressure, however, of 430 pounds. A well on the Savander Schall farm (No. 28), at Rockville, drilled by the same company in 1894, came in with a minute pressure of 365 pounds, gas coming from the Hundred-foot sand, while the Crim No. 1 (No. 27), located only a few hundred yards from the Schall well and completed the same year, found gas in the Fifth sand with a minute pressure of 130 pounds and a 30-minute pressure of 385 pounds.

Jackson Heffelfinger No. 1 well (No. 42), drilled by the Pittsburg Plate Glass Company three-fourths of a mile west of Rockville, went to the Fifth sand and got a 70-pound minute pressure and rock pressure

of 290 pounds. In comparison it is interesting to note that the Isaac Heilman well, 2 miles northwest of Rockville, yielded gas from the Fifth sand with a minute pressure of only 43 pounds, but the rock pressure went up to 345 pounds. The gas in this field comes from the Murrysville, the Hundred-foot, and the Fifth sands and is piped to Pittsburg and Ford City.

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

A well (No. 61) back of the schoolhouse at Brick Church, drilled in 1892, although located close to the axis of the Apollo syncline, had a minute pressure at the outset of 109 pounds and a rock pressure of 351 pounds in a 6¼-inch casing. The productiveness of this well diminished rapidly after three or four months, however, and is now very small. Also a well on the Hugh Blakley farm (No. 238), a mile north of West Lebanon, which was located on the axis of the Elders Ridge syncline, obtained a strong flow of gas. On the other hand, a well drilled on the same axis at the creamery on the Smith farm (No. 239), near Elders Ridge, yielded a very little gas, which was more than could be expected from its location. A second well (No. 240) drilled to the Fifth sand on the same farm in 1903 was absolutely "dry."[a]

A well at Salina (No. 257) and another at the mouth of Blacklegs Creek (No. 259), in the Elders Ridge syncline, have yielded enough gas to light a few burners only, while a well between these two at the mouth of Long Run (No. 258) was unproductive. In a few cases deep holes sunk near the crest of an anticline have been very light producers or unproductive. Among these are the Lohr No. 2 (No. 156), drilled by the Indiana County Gas Company on the Dutch Run anticline north of Advance; the Ramsey well (No. 148), drilled by the Peoples Natural Gas Company on Dutch Run between the Willet and Plum Creek fields; and a well a half mile west of Kent (No. 262) on the Jacksonville anticline, drilled by the Saltsburg Gas Company.

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

[a] During the prosecution of field work in 1902, the writer was on the Smith farm, and, being informed that a second well for gas was contemplated, advised strongly against further drilling, as the theory of the accumulation of gas pointed against the probability of there being any quantity of it in the immediate vicinity.

DISPOSAL OF GAS.

Gas produced in the fields of this quadrangle is carried by pipe lines to more or less distant markets. The Indiana County Gas Company pipes gas from the Willet and Plum Creek fields to the town of Indiana.

The Philadelphia Company's main trunk line from Pittsburg to the Armstrong County field is a 20-inch pipe line which crosses Crooked Creek on the Banks farm at the big bend, and thence running northward ends on the Wray farm at Rockville in Kittanning Township. Branches from this point to the Say farm and other fields are 8 and 10 inch lines.

The Peoples Natural Gas Company's trunk pipe line from Pittsburg to this part of Armstrong County sends tributaries to nearly all productive portions of the northern part of the quadrangle. This company has a pump station on Crooked Creek below Girty which is supplied by 58 of its own wells and 5 belonging to the Indiana County Gas Company. This string of wells is held in reserve much of the time, but when in use they yield between 7,000,000 and 8,000,000 cubic feet of gas per day. The gas is consumed in Pittsburg and surrounding towns for domestic and manufacturing purposes.

A 10-inch branch of the Carnegie Natural Gas Company's 16-inch main trunk line from Pittsburg extends to the vicinity of Cochran Mills. The pump station, located at Bagdad on Kiskiminitas River, is now handling about 5,000,000 cubic feet of gas daily from forty-five producing wells. The gas produced by this company is consumed in the Edgar Thomson, Homestead, and Duquesne steel works.

The Pittsburg Plate Glass Company, largely interested in the Rockville field, pipes its gas to its own plant at Ford City. The gas is taken through an 8-inch line to the pump station at Copes Mills. The main supply of this company is brought from north of Cowanshannock Creek.

A branch from the Apollo Gas Company's main trunk line, which extends from Vandergrift Mills, Vandergrift, Pa., northward through Armstrong County, runs from Dime post-office to the Shellhammer field at Mateer, where the company has two pump stations. With the exception of the amount used for domestic consumption at Vandergrift, the company's entire supply of gas is furnished for manufacturing purposes to the American Sheet and Tin Plate Company at Vandergrift, Hyde Park, and Leechburg.

Many dwellings in the northern part of the quadrangle are lighted and heated by natural gas. At some farmhouses not only is gas burned in the range and fireplaces but it is used for heating the brick oven, and burned as a torch in the yard all night (Pl. XII, *A*).

A. YARD GAS TORCH.

B. STONEWARE MADE FROM KITTANNING CLAY AT GIRTY.

LIST OF DEEP WELLS.

Deep wells in Elders Ridge quadrangle.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
1	Heilman, Isaac	Philadelphia Co	1,150	1,907
2	King, George	do	1,090	.....
3	McClune, Samuel	do	1,020	.....
4	Campbell, Daniel	do	1,020	.....
5	.....	.....	1,000	.....
6	Robinson, No. 2	Pittsburg Plate Glass Co	1,100	1,939
7	Robb, T. K	do	1,180	1,945
8	Walker	do	1,020	.....
9	Crownover, J. T	do	1,120	1,970
10	Kerr, Jacob	.....	880	.....
11	Robinson, No. 1	Pittsburg Plate Glass Co	1,050	1,891
12	Jones, Thomas	do	1,100	1,932
13	Heilman, Louis	do	1,030	1,829
14	Briney	Philadelphia Co	1,100	2,002
15	Nolder, Martin	do	1,290	1,975
16	Campbell, William	do	1,300	2,016
17	Cravener, Andrew	Pittsburg Plate Glass Co	1,250	1,618
18	Schaeffer, Salina	do	1,370	1,360
19	Blaney, J. A	Philadelphia Co	1,140	.....
20	Boarts, Ed	do	1,290	1,960
21	Schall, L. H	do	1,160	1,858
22	Kealor, Anthony	do	1,120	1,770
23	McCullough	do	1,160	1,420
24	Heffelfinger, J. F., No. 3	Pittsburg Plate Glass Co	1,230	1,871
25	Louden, Matthew	Philadelphia Co	1,200	1,899
26	Wilcox, John	.....	1,200	.....
27	Crim, J. R., No. 1	Philadelphia Co	1,190	1,894
28	Schall, Savander	do	1,050	1,315
29	Schall, G. A	do	1,040	1,324
30	Heilman, Henry	do	1,175	1,925
31	Heilman, Rueben	do	1,200	2,005
32	Crim, J. R., No. 2	do	1,250	1,987
33	Hankey, R. L., No. 1	.....	1,150	.....
34	Heffelfinger, G. W.?	Philadelphia Co	1,080	1,905
35	Schall, L. & S	Pittsburg Plate Glass Co	1,250	1,468
36	Hankey, Ben, No. 1	do	1,325	1,495
37	Hankey	do	1,280	.....
38	Hankey, Tom, No. 2	do	1,300	1,665

Deep wells in Elders Ridge quadrangle—Continued.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
39	Hankey, Tom, No. 1	Pittsburg Plate Glass Co	1,200	1,406
40	Hankey, R. L., No. 2		1,290	
41	Heffelfinger, Jackson, No. 2	Pittsburg Plate Glass Co	1,300	1,480
42	Heffelfinger, Jackson, No. 1	do	1,340	2,060
43	Heffelfinger, Jackson, No. 3	do	1,180	1,871
44	Waltonbaugh, Isaac	Philadelphia Co	1,170	1,835
45	Crownover	Pittsburg Plate Glass Co	1,030	1,095
46	Spangs, Oliver		1,190	
47	Altman, Amos	Carnegie Natural Gas Co. ?	1,130	
48	Altman, Sarah	Pittsburg Plate Glass Co	1,110	
49	Spang, Isaiah	Philadelphia Co	1,100	1,388
50	Riggle, Mary	Carnegie Natural Gas Co	1,060	1,765
51	Riggle, Thomas	do	1,050	1,865
52	Robb, Jacob	do	880	1,201
53	Wingard	do	960	
54	Myers, No. 1	Pittsburg Plate Glass Co	990	1,318
55	McConnell heirs, No. 2	Carnegie Natural Gas Co	850	1,206
56	Myers, No. 2	Pittsburg Plate Glass Co	850	1,187
57	McConnell heirs, No. 1	Carnegie Natural Gas Co	960	1,420
58	Nell, John	do	1,000	
59	Slease, George	Philadelphia Co.?	1,060	
60	Hankey, William	do	1,150	2,819
61	King, H. A	Home Co	1,195	1,528
62	Schaeffer, E. E	Conemaugh Gas Co	1,060	
63	Davis, George	Philadelphia Co	910	
64	McKee, Jos., No. 1	do	980	
65	McKee, Jos., No. 2	do	1,050	
66	Smith, Absalom	do	1,150	1,281
67	Young, Peter	do	1,050	
68	Dunmire, J. R	do	1,160	1,858
69	Cessna, Adam	Peoples Natural Gas Co	1,220	1,220
70	Elgin, H. H	do	1,470	1,811
71	St. Clair, William	Philadelphia Co	1,260	1,480
72	Ormond, John, No. 2	Peoples Natural Gas Co	1,380	1,680
73	Rupp & Hemphill, No. 1	Philadelphia Co	1,410	1,680
74	Rupp & Hemphill, No. 2	do	1,225	1,550
75	Rupp & Hemphill, No. 3	do	1,220	1,551
76	Say, S. R	do	1,310	1,386
77	Say, A. L	do	1,270	1,565

Deep wells in Elders Ridge quadrangle—Continued.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
78	St. Clair	Pittsburg Plate Glass Co	1,265	2,006
79	St. Clair, Milton	Peoples Natural Gas Co	1,350	1,750
80	Crawford	Home Co	1,080	.....
81	St. Clair	do	1,140	.....
82	Blaney, J. A	Philadelphia Co	1,250	.....
83	Hemphill, Archibald	do	1,200	.....
84	Shetler, H	Eastern Oil Co	1,240	1,515
85	Boyer, T. & F	do	1,200	.....
86	Gibson, L. C		1,180	.....
87	Smail, George	Peoples Natural Gas Co	1,130	1,870
88	Wingard, Jacob	Eastern Oil Co	1,430	1,620
89	McIntyre, Ed	Peoples Natural Gas Co	1,300	2,003
90	Rearick, Alex	Philadelphia Co	1,170	1,893
91	Reefer, N. & W	do	1,100	1,211
92	Chriss, Nicolas	Peoples Natural Gas Co	1,090	.....
93	Reefer, Nicolas	Philadelphia Co	1,270	2,965
94	Reefer, Jacob	do	1,100	1,881
95	Reefer, Henry	do	1,160	2,169
96	Graff, Samuel	do	1,075	2,943
97	Bier, George	Peoples Natural Gas Co	1,280	2,050
98	Hotham, William	do	1,210	1,515
99	Nelson, Mrs., No. 1	do	1,250	1,504
100	Nelson, Mrs., No. 2	do	1,170	1,510
101	Cribbs, Michael	do	1,120	1,505
102	Kaufman, Nicholas	do	1,310	1,635
103	Dick, P. & D	Philadelphia Co	1,260	1,580
104	Gibson, L. C., No. 2	Peoples Natural Gas Co	1,260	.....
105	Gibson, L. C., No. 3	do	1,260	.....
106	Yount, Andrew, No. 2	Philadelphia Co	1,260	1,680
107	McPherson, No. 2	do	1,280	2,126
108	McPherson, No. 1	do	1,340	1,653
109	Gibson, L. C., No. 1	Peoples Natural Gas Co	1,210	.....
110	Clark, Alex., No. 1	Philadelphia Co	1,280	1,665
111	Clark, Alex., No. 2		1,220	.....
112	Gibson, L. C., No. 1	Pittsburg Plate Glass Co	1,250	1,595
113	Sturgeon, W. B	Philadelphia Co	1,320	2,101
114	Yount, Andrew, No. 1	do	1,425	1,770
115	Yount, William	Peoples Natural Gas Co	1,340	1,660
116	Eyler, No. 1	do	1,220	1,515

Deep wells in Elders Ridge quadrangle—Continued.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
117	Rosborough	Peoples Natural Gas Co	1,180	2,405
118	McCullough, W. D	do	1,180	1,450
119	Strickland, C. D	do	1,300	1,640
120	Turner	Philadelphia Co	1,170	1,800
121	McCullough, Eliz	do	1,270	1,814
122	Peterman	Peoples Natural Gas Co	1,260	1,265
123	Rankin, Harvey	Philadelphia Co	1,400	.....
124	Frick, Simon, No. 2	Peoples Natural Gas Co	1,390	1,380
125	Rowland, John F	do	1,120	1,170
126	Smetzer, A	do	1,110	1,100
127	Smith heirs	do	1,080	1,475
128	Keener, R. M	do	1,210	1,972
129	Frick, Simon, No. 1	do	1,260	1,325
130	Walker, Eliz., No. 2	do	1,060	1,435
131	Harmon, A. C	do	1,040	1,435
132	Ralston, W. M	Philadelphia Co	1,090	1,765
133	Clark, William, No. 1	Peoples Natural Gas Co	1,110	1,520
134	Kimmel, J. B., No. 1	do	1,035	1,460
135	Clark, William, No. 2	do	1,000	.....
136	McCracken	.....	980	.....
137	Herron, Mrs. M. T	Peoples Natural Gas Co	990	.....
138	Frailey heirs	do	1,230	1,665
139	Herron, John C	do	1,050	1,175
140	Kimmel, J. B., No. 2	do	990	1,390
141	Ralston, No. 1	Indiana County Gas Co	1,050	.....
142	Clark, H. A	do	1,100	1,165
143	Beatty heirs	do	1,170	1,220
144	Boyer, No. 1	do	1,090	1,120
145	Boyer, No. 2	do	1,170	1,220
146	Croyle, Ralph	.....	1,190	.....
147	Gristmill well, near Gastown	.....	995	.....
148	Ramsey	Peoples Natural Gas Co	1,050	1,825
149	Bracken, Samuel	do	1,260	3,025
150	Snyder, John	Indiana County Gas Co	1,340	1,620
151	Peterman, No. 1	do	1,360	1,360
152	Miller, B. M., No. 2	do	1,120	1,155
153	Miller, B. M., No. 1	do	1,130	1,187
154	Miller, George	do	1,140	1,200
155	Speedy heirs	do	1,235	1,245

Deep wells in Elders Ridge quadrangle—Continued.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
156	Lohr, No. 2	Indiana County Gas Co	1,270	1,260
157	Lohr, No. 1	do	1,100	.....
158	Altemus, T. J	do	1,040	.....
159	Repine	do	1,035	1,100
160	Kelly, No. 5	do	1,060	.....
161	Kelly, No. 2	do	1,040	.....
162	Kelly, No. 3	do	1,050	.....
163	Kelly, No. 6	do	1,100	.....
164			960	.....
165	Kinnard (?)		865	.....
166	McKee, F. T	Philadelphia Co	885	2,311
167	Farster, D	do	1,090	1,859
168	Miller, Addison	do	1,250	1,296
169	Fiscus, James	do	1,290	.....
170	Davis, Jackson	do	1,200	1,447
171	Deshong, James, No. 2	do	1,300	1,260
172	Deshong, James, No. 1	do	1,330	1,325
173	Flickinger, J. F., No. 1	do	1,130	1,860
174	Flickinger, J. F., No. 2	do	1,325	1,735
175	Kinnard, B. F		1,030	.....
176	Rupert, Riley	Peoples Natural Gas Co	1,260	1,450
177	Grimm, D. W	do	1,130	1,315
178	Salsgiver	Philadelphia Co	1,020	1,280
179	McCormick, Mary	do	1,120	1,740
180	Christy	Peoples Natural Gas Co	1,020	1,280
181	Ambrose	do	990	.....
182	Barr, James T	do	1,040	1,225
183	Henderson, Thomas	do	1,220	1,650
184	Rayburn, Calvin	do	1,000	.....
185	McKee	Equitable Gas Co	910	990
186	do	do	910	.....
187			930	.....
188	Riffer, David, No. 1	Philadelphia Co	1,040	1,421
189	Riffer, David, No. 2	do	1,100	1,452
190	Riffer, David, No. 3	do	1,130	1,506
191	Riggles		1,000	.....
192	Rearick		1,050	.....
193	do		1,060	.....
194	Shellhammer, Daniel	Apollo Gas Co	1,080	1,444?

Deep wells in Elders Ridge quadrangle—Continued.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
195	Shellhammer, Daniel	Apollo Gas Co	1,090	1,464?
196	Eakman (?)	Pittsburg Plate Glass Co	1,200	.....
197	Riggle, P. T	.....	1,230	.....
198	.....do	.....	1,220	.....
199	Porter	Peoples Natural Gas Co	1,150	1,515
200	.....do	.....do	1,090	.....
201	Riggle	.....	1,150	.....
202	Clark, J. W., No. 2	Apollo Gas Co	1,050	1,523
203	Clark, J. W., No. 1	.....do	1,070	1,536
204	Ramaley	.....do	1,100	1,572
205	Hauser	.....	1,030	.....
206	Klingensmith, No. 1	Apollo Gas Co	1,060	.....
207	Altman, Foster	.....	1,070	.....
208	Klingensmith, No. 2	Apollo Gas Co	1,150	.....
209	Waltonbaugh, Mrs	.....do	1,000	1,362
210	Knappenberger	.....do	980	1,372
211	Smith	.....	1,100	.....
212	.....do	.....	1,170	.....
213	.....do	.....	1,300	.....
214	Klingensmith	Apollo Gas Co	1,250	.....
215	Miller, Emma	.....	1,190	.....
216	.....do	.....	1,190	.....
217	Marshall	.....	1,200	.....
218	.....do	.....	1,220	.....
219	.....do	.....	1,240	.....
220	Dible, Samuel	Carnegie Natural Gas Co	1,405	2,180
221	Lunderstead	.....	1,370	.....
222	Cochran, George	.....	1,400	.....
223	Chambers	Carnegie Natural Gas Co	1,390	1,410
224	Howell	.....	1,290	.....
225	Heasley	Peoples Natural Gas Co	1,350	1,524
226	Dice, T. M., No. 1	Conemaugh Gas Co	1,180	1,500?
227	Dice, T. M., No. 2	.....do	1,080	.....
228	Pierce	.....	920	.....
229	Kirkland, J. G., No. 1	.....	1,300	.....
230	Kirkland, J. G., No. 2	.....	1,070	.....
231	Matson, Amanda	.....	1,120	.....
232	Miller, Mary	Peoples Natural Gas Co	1,070	.....
233	Painter (?)	.....	1,200	.....

Deep wells in Elders Ridge quadrangle—Continued.

No. on map.	Name of well.	Owner.	Approximate elevation above sea level.	Depth of well.
234	King, W. G., No. 2	Ford City Gas Co	950	.....
235	King, W. G., No. 1	do	990	1,620
236	Dever, Joseph		1,040	.....
237	Orr, W. C	Home Co	1,280	.....
238	Blakley, Hugh		1,085	2,822
239	Smith Bros	Peoples Natural Gas Co	1,160	2,707
240	Smith heirs	Home Co	1,280	2,078
241	Nepshell, George	Equitable Gas Co	1,490	.....
242			1,150	.....
243	Scott (?)		1,130	.....
244	Amment (?)		1,080	.....
245	Bowser (?)		1,080	.....
246	Kunkle, Lewis, No. 1	Equitable Gas Co	1,080	1,236
247	Kunkle, Lewis, No. 6	do	1,090	.....
248	Kunkle, Lewis, No. 2	do	1,080	1,245
249	Martin, W. P	do	1,220	.....
250	Martin, Daniel (?)		1,250	.....
251	Deemer, Philip		1,240	.....
252	Fass, Andrew	Apollo Gas Co	1,350	.....
253	Wright, C. A., No. 3	Equitable Gas Co	1,400	1,528
254	Wright, C. A., No. 1	do	1,280	1,593
255	Bier, Herman	do	1,400	1,602
256	Guthrie, William		1,250	.....
257	Salina	Kier Fire Brick Co	810	.....
258	Avonmore	Home Co	840	.....
259	Sheet Steel Mill	Apollo Gas Co	860	2,172
260	Dunlop	Equitable Gas Co	1,300	1,545
261	Stahl, Geo. W	Conemaugh Gas Co	1,420	2,018
262	Jacksonville	Saltsburg Gas Co	1,170	1,930
263	Uncafer, Augustus	Conemaugh Gas Co	1,360	1,992

OIL.

A trace of oil has been detected at various horizons in a number of wells drilled in this quadrangle, but only one well is producing and that in very small quantity. It is located on the St. Clair farm (No. 81), a quarter of a mile east of Whitesburg, on the axis of the Apollo syncline, and is said to spray one barrel of oil every two days. The gas has a minute pressure of 2 pounds, and a rock pressure of 70 pounds.

LIMESTONE.

There are several thin beds of limestone and two heavy ones in the formations exposed in the area under discussion. It happens that the lowest rock in the geologic column here exposed is the Vanport limestone, which outcrops at two points on Crooked Creek, and the highest is the Benwood limestone, which crowns the hills at Elders Ridge.

The Vanport limestone occurs below the lower Kittanning coal and fire clay, from which it is separated by sandstone. The limestone is usually compact and brittle, and has a grayish color; it is of good quality through its entire thickness, which is from 8 to 10 feet on Crooked Creek. As seen near the "Loop" it is very fossiliferous, containing a marine fauna consisting principally of crinoids, brachiopods, and lamellibranchs. Throughout western Pennsylvania this limestone universally contains less than 2 per cent of magnesium carbonate. The insoluble siliceous matter is likewise low, while the proportion of calcium carbonate is high. The stone has been used for the manufacture of Portland cement. For this cement a limestone must carry less than 5 per cent of magnesium carbonate and at least 75 per cent of calcium carbonate, and in an ideal cement limestone the proportion of silica to alumina plus iron should be 5:2. However, as this ratio can usually be obtained by mixing with other raw materials, it is not necessary that the stone should possess such a silica-alumina ratio. This limestone also makes excellent ballast, road metal, flux, and fertilizer.

An analysis of this stone, from Girty, made by Mr. McCreath, shows the following chemical composition:[a]

Analysis of Vanport limestone at Girty.

	Per cent.
Insoluble residue	2.100
Calcium carbonate	94.185
Magnesium carbonate	1.483
Alumina and ferric oxide	2.089
Phosphorus	.031

The Johnstown limestone, which lies under the Upper Kittanning coal and is seen a few feet above the creek at Cochran Mills, contains high percentages of magnesia, silica, and other impurities and is wholly unsuited for Portland cement, although it will make natural cement. A peculiarity of this limestone is its great variation in the amount of calcium carbonate, from 36 to 92 per cent, and of magnesium carbonate, from 1 to 30 per cent. A specimen taken from the M. Davis property at Cochran Mills was analyzed by Mr. McCreath with the following results:[b]

[a] McCreath, A. S., Second Geol. Survey of Pennsylvania, Rept. H5, p. 64.
[b] McCreath, A. S., Second Geol. Survey of Pennsylvania, Rept. H5, p. 67.

Analysis of Johnstown limestone at Cochran Mills.

	Per cent.
Insoluble residue	23.840
Calcium carbonate	53.750
Magnesium carbonate	9.989
Ferric oxide and alumina	7.730
Phosphorus	.131

This stratum, as seen on Crooked Creek, is not more than 3 feet thick, and is from 2 to 8 feet below the Upper Kittanning coal.

The Lower Freeport limestone is a thin bed, variable both in occurrence and in amount of impurities, and can generally be little depended on for economic purposes. It was not noted in this quadrangle. It is reported at many points in southwestern Pennsylvania, but probably is not persistent for long distances, and is not known to have at any place a greater thickness than 5 feet.

The Upper Freeport limestone is occasionally of workable thickness, and usually of considerable purity. It underlies the Upper Freeport coal, and throughout the Allegheny Valley is usually less than 6 feet thick. The majority of the analyses made by the Second Survey show a small percentage of magnesia with about the right proportions of iron, alumina, and silica to qualify it for a good flux or Portland cement. Two analyses are given below. One specimen was from Rev. S. Brown's quarry, 1½ miles southwest of Willet at the mouth of Sugarcamp Run and therefore in the valley of the South Branch of Plum Creek, less than a mile east of the boundary of the Elders Ridge quadrangle. The other was from Hazlett's quarry 2 miles south of Jacksonville. In both cases the limestone was compact, brittle, and bluish gray, with subconchoidal fracture.

Analyses of Upper Freeport limestone.

	Plum Creek.	Jacksonville.
	Per cent.	*Per cent.*
Insoluble residue	6.021	5.430
Calcium carbonate	84.125	89.821
Magnesium carbonate	5.198	1.801
Ferric oxide and alumina	3.220	1.700
Sulphur	.073	.133
Phosphorus	.014	.027

The Pittsburg limestone underlies the Pittsburg coal at an interval of 10 to 15 feet and is several feet thick. It is confined to the southern half of the quadrangle. This stone is burned for lime on a number of farms and is used for fertilizer. It is quarried for this purpose in a small way on the Simon Townsend farm east of Olivet. It seems

to be of a moderate degree of purity, as shown by the following analysis made from a sample taken at A. H. Fulton's quarry, West Lebanon:

Analysis of Pittsburg limestone at West Lebanon.

	Per cent.
Insoluble residue	10.327
Calcium carbonate	82.768
Magnesium carbonate	2.875
Ferric oxide and alumina	2.830
Sulphur	.156
Phosphorus	.011

The limestone at this point is generally compact and brittle, with irregular fracture and bluish-gray color. It is seamed with bluish-black limestone.

The Sewickley limestone in general is obscure. According to Platt it is exposed in the cliffs on the north side of Kiskiminitas River at Hicksville, and is about 6 feet thick. It is about 85 feet above the Pittsburg coal and a few feet below the Sewickley coal. The rock is seen in the ravine below Mr. Ewing's house near Olivet, and has been quarried there. The only available analysis of the limestone in this region is of a sample from Robert Smith's quarry, 2 miles northeast of Blairsville:

Analysis of Sewickley limestone, Indiana County.

	Per cent.
Insoluble residue	12.160
Calcium carbonate	79.821
Magnesium carbonate	3.601
Ferric oxide and alumina	3.020
Sulphur	.117
Phosphorus	.018

The Benwood limestone, which occurs about 80 feet above the Sewickley coal in this quadrangle, caps a number of rounded knobs near Elders Ridge. It consists of several layers separated by variable intervals of shale, the whole deposit being not less than 25 feet thick. The limestone strews the surface where it outcrops with small pieces of grayish nonfossiliferous rock. Calcined, it makes strong lime, excellent for fertilizing purposes. The rock can be quarried at little expense, no stripping being required. Nothing is known of its chemical composition in this region.

Further information concerning the limestones of western Pennsylvania is contained in Bulletin No. 249, by Mr. F. G. Clapp, to whom the author is indebted for some of the above statements on this subject.

SANDSTONE.

Sandstone suitable for building purposes occurs in several localities within the Elders Ridge quadrangle. The principal beds are the Kittanning, Freeport, and Butler of the Allegheny formation, and the

Mahoning, Saltsburg, Morgantown, and Connellsville of the Conemaugh formation. These sandstones are mostly gray and buff and vary from soft and loose textured to hard and compact rocks. But few stone buildings have been constructed within this area, so the durability of the dressed stone is not known. The Kittanning, Freeport, and Butler sandstones are conspicuous in the bluffs on Crooked Creek below South Bend. The Kittanning sandstone was quarried at Girty many years ago for flagstones and tombstones. It separates easily into large smooth layers from 1 to 5 inches thick. The Mahoning is particularly heavy at Jacksonville, and forms the top of the bluff at Cochran Mills. The Saltsburg is well developed in the vicinity of Lewisville and Salina and on the ridge between Long Run and Roaring Run. A heavy sandstone which seems to be at the horizon of the Morgantown is conspicuous on the hilltops in the extreme northeastern corner of the quadrangle, and in the vicinity of West Lebanon.

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

CLAYS AND SHALES.

FIRE CLAY.

Two beds of fire clay in the Allegheny formation are known to be of some value. They are the Upper Freeport and Lower Kittanning clays. The first of these lies a few feet below the Upper Freeport coal and is known as the Bolivar clay. The type locality is Bolivar, on the Conemaugh River, where the clay occurs from 10 to 20 feet below the Upper Freeport coal and is worked extensively. This clay is mined at Salina on the Kiskiminitas River by the Kier Fire Brick Company. The following statement regarding the industry at Salina is taken from the Annual Report of the Pennsylvania State College for 1897, with corrections to date.

The mine and works of the Kier Fire Brick Company are located at Salina, on the West Pennsylvania Railroad, on the south side of Kiskiminitas River. They are among the oldest in the State, having been established in 1845, nearly sixty years ago. The Pittsburg office of the company is in the Stevenson Building. The company manufactures high-grade fire brick. It has 16 kilns and a daily capacity of 30,000 brick, employing 100 men and boys at the works. Pittsburg is the chief market, but shipments are made to Cleveland, the Boston Navy-Yard, and other points.

The clay used is taken from the company's own mine at the works. It is from the same geologic horizon as the Bolivar clay. The dip of the strata is to the eastward, and the drift from which the clay is

taken runs down the first hundred feet at an angle of about 15°, then changes to a more nearly horizontal position. The mine now extends probably lower than the bed of the river, and it is necessary to pump out the water. As the main heading follows the dip of the rock and the rooms branch off at a slight upgrade, the pumping can all be done from one point, the end of the main heading, and the rooms are all comparatively dry.

The clay varies from 6 to 13 feet in thickness, including both the hard flint clay and the soft plastic clay. The variation in the thickness of the flint clay is even more marked than that of the entire bed, varying in some places from a thickness of 12 or 13 feet to 2 or 3 in the same room. In some places it lies underneath the soft clay and in some places on top. The flint clay is of good quality, in most places quite clean, but in some spots it contains iron-ore balls in considerable numbers. As the ore balls are generally black, or nearly black, and much heavier than the clay, they are readily detected and picked from the clay by hand.

An average of five analyses of the clay at Salina[a] is as follows:

Average analysis of Bolivar fire clay at Salina.

	Per cent.
Silica	51.148
Alumina	31.216
Protoxide of iron	1.768
Titanic acid	1.558
Lime	.524
Magnesia	.323
Carbonic acid	.511
Alkalies	1.073
Water	10.815
Total	98.936

STONEWARE CLAY.

On Crooked Creek, just above Girty, the geologic section is as follows:

Section at Girty.

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

[a] Second Geol. Survey of Pennsylvania, Rept. H5, p. 14.

The clay, which occurs a few feet below the Lower Kittanning coal, is white, of fairly good quality, and from 3 to 5 feet thick. Judging by the quality of the articles made from it, this is properly a stoneware clay. Apparently it exists in some abundance and can be raised at little cost. The present method is stripping where the bed is from 2 to 4 feet below the surface. The McNees & George pottery at Girty, which has been conducted in a small way for twenty-five years, uses this clay, taking its supply from the south bank of Crooked Creek, a mile above Girty, on the W. A. Coleman farm. The industry can not be greatly enlarged, because there is no railroad at this point. The stoneware articles made at this pottery are crocks, jugs, and pump tile (Pl. XII, *B*), all of which are much esteemed in the neighborhood.

SHALE.

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

WATER.

The drainage system extends to all parts of the quadrangle, so that running water can be found within a short distance of any point. The largest stream is Kiskiminitas River, which has a width of about 500 feet but is very shallow at many points. The other waterways are classed as creeks and runs.

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

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

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

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