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ECONOMIC GEOLOGY

OF THE

SUMMERFIELD AND WOODSFIELD QUADRANGLES, OHIO

WITH DESCRIPTIONS OF

COAL AND OTHER MINERAL RESOURCES EXCEPT OIL AND GAS

BY

D. DALE CONDIT

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ECONOMIC GEOLOGY OF THE SUMMERFIELD AND WOODSFIELD QUADRANGLES, OHIO,

WITH DESCRIPTIONS OF COAL AND OTHER MINERAL RESOURCES EXCEPT OIL AND GAS.

By D. DALE CONDIT.

INTRODUCTION.

SCOPE OF REPORT.

This report describes some features of the economic geology of the Woodsfield and Summerfield quadrangles, in southeastern Ohio. Most of the text consists of detailed information concerning the mineral resources except petroleum and natural gas, which have been described briefly in preliminary reports.[1]

The area covered comprises parts of four counties, all of which contain valuable beds of coal, as well as pools of oil and gas. The western part of the area extends into the Cambridge coal field, and the eastern half includes the Pittsburgh coal bed, which is as yet almost untouched by mining operations and which extends continuously eastward beyond Ohio River into West Virginia.

FIELD AND OFFICE WORK.

The field work on which this report is based occupied a little more than four months during the season of 1914. The members of the party were D. Dale Condit, R. Van A. Mills, Frank Reeves, and for a short time C. A. Bonine. Much of the work consisted in obtaining data for the preparation of a map showing the geologic structure, which involved the instrumental determination of the elevations of limestone and coal beds and of oil-well heads by means of plane table and telescopic alidade. In this work two rodmen were employed. In addition to mapping the geologic structure the members of the party mapped the outcrops of coal beds, limestones, and other strata of prospective value; measured thicknesses in coal mines, prospects, and natural exposures; collected samples of coals and of oil, gas, salt water, and oil sands; and obtained records of hundreds of wells drilled for oil and gas and for the testing of coal beds.

[1] U. S. Geol. Survey Bull. 621, pp. 217–231, 233–249, 1916.

ACKNOWLEDGMENTS.

It is impossible to mention here the names of all the pepople to whom the Survey party is indebted for courtesies and material aid. Special thanks are extended to Prof. F. A. Ray, mining engineer, of Columbus, Ohio; Mr. Edward Christman, specialist in the development of mineral lands, of Massillon, Ohio; Mr. Albert Gaddis, of Uniontown, Pa.; Mr. J. I. Johnson, of Johnstown, Pa.; and Mr. W. A. Clugston, of Pittsburgh, Pa., all of whom have contributed data concerning coal beds. For well records and detailed information concerning oil fields the author is indebted to dozens of persons. Those deserving special credit are Messrs. George Vandergrift, of Woodsfield; G. W. Aggas, of the Pure Oil Co.; M. U. Ward and L. Rawson, of the Carter Oil Co.; J. W. Hardwick and other officials of the Ohio Fuel Supply Co.; T. N. Barnsdale, of Pittsburgh; H. A. Burns, of Chaseville; C. W. Paine, of Ozark; William F. Borchers, of Washington, Pa.; C. B. Barry, of Marietta; Phillip Berry, of Caldwell; H. G. Young, of Sarahsville; Merrit Cox, of Jerusalem; the Larrick Bros., of Pleasant City; and Herbert Howell, of Somerton.

GEOGRAPHY.

LOCATION.

The Woodsfield and Summerfield quadrangles include parts of Belmont, Monroe, Guernsey, and Noble counties, in eastern Ohio. The two quadrangles placed side by side form a rectangular area about 17¼ by 27 miles, which includes about 462 square miles. The east and west boundaries are meridians 81° and 81° 30′; the south and north boundaries are parallels 39° 45′ and 40°. Each quadrangle includes one-sixteenth of a "square degree" of the earth's surface. The location of this and other areas in eastern Ohio and western Pennsylvania covered by geologic reports is represented in figure 1.

Before undertaking geologic investigations such as are the subject of this report the United States Geological Survey makes topographic maps showing surface features, such as hills, valleys, streams, roads, and houses. Maps of this kind have been prepared for all of Ohio. The quadrangles adjoining the Summerfield and Woodsfield are named as follows: On the north, Antrim and Flushing; on the east, Clarington; on the south, Macksburg and New Matamoras; on the west, Cumberland.

The boundaries of the quadrangles have been located exactly from triangulation and plane-table stations situated upon some of the most prominent hilltops of the region, which have been connected by triangulation with astronomical stations at the Maryland Heights and Sugarloaf stations of the Coast and Geodetic Survey, computed

on the United States standard datum. An account of triangulation and primary traverse in Ohio is given in Bulletin 552 of the Survey, and the results of spirit leveling are given in Bulletins 411, 476, and 518. These reports describe bench marks placed by the Survey at many localities and give their exact elevation above sea level.

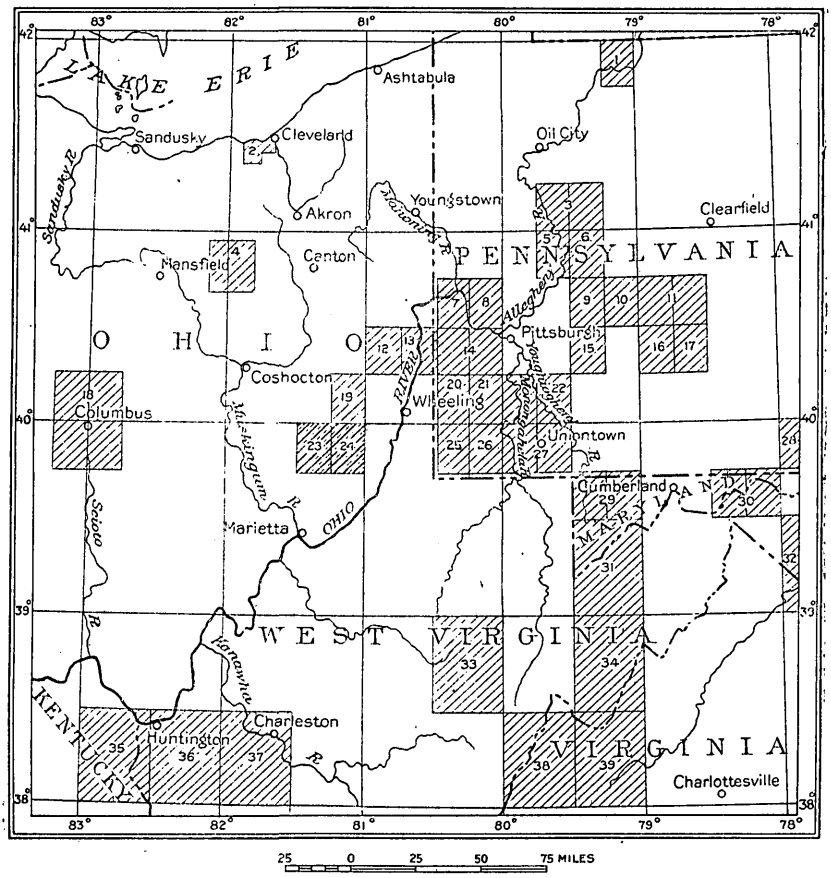


FIGURE 1.—Index map showing location of Summerfield and Woodsfield quadrangles (area indicated by heavy shading) and other areas in eastern Ohio and parts of Pennsylvania, West Virginia, and neighboring States for which geologic reports have been prepared. (See list on p. 6.)

TOPOGRAPHIC FEATURES.

DRAINAGE.

One of the principal water partings of southeastern Ohio extends in a north-south direction across the west side of the Woodsfield quadrangle. The waters east of this divide follow a fairly direct route to Ohio River. The principal streams on the east side are Captina Creek and Sunfish Creek, both of which follow meandering courses in deep, narrow valleys with narrow flood plains and little alluvial bottom land. The gradient is about 23 feet to the mile in

the main valleys, but increases toward the headwaters. It is evident that the streams are actively engaged in deepening their channels, for the stream beds are at many places solid rock. The characteristics of the two principal streams are imparted to dozens of small tributaries, which reach back into the uplands in deeply notched ravines that produce the rough, hilly surface so characteristic of the region.

West of the divide the drainage is carried by branches of Wills Creek, a tributary of Tuscarawas River. A small area at the south side of the Summerfield quadrangle is tributary to Duck Creek and Clear Fork of Little Muskingum River. The broad alluvial valleys of the Wills Creek drainage system form the most striking feature in the region. The sluggish muddy streams flow in meandering courses in swampy valleys that are in places nearly a mile wide—as broad even as parts of the valley of Ohio River to the east. The fall of the principal streams is 2 to 4 feet to the mile, and an only slightly increased gradient prevails in the smaller tributaries almost to their sources. The rock floor of the valleys is in most places many feet below the surface, and the streams flow on sand and clay. It is evident that the entire drainage system was formerly lower, and that for some reason there has been an obstruction to the downward cutting and carrying away of the valley material, resulting in a partial filling of the channels. In fact, there is evidence that the silting up of the valleys filled them to a depth of 100 feet or more above the present level. In Recent time the streams have made considerable progress in removing this material.

The cause of the peculiar aspects of the Tuscarawas drainage system is a physiographic study which can not be undertaken in this report. It is certain that they may be attributed chiefly to events during the glaciation of much of Ohio in Pleistocene time. The river was dammed by the ice front in the vicinity of the present location of Newark, and the ponded waters were forced to seek a new outlet to the south toward Zanesville, along the course of the modern Muskingum River.

RELIEF AND LAND FORMS.

The least elevation at the east side of the Woodsfield quadrangle is about 710 feet above sea level, in Sunfish Valley, and 825 feet in Captina Valley. The valley of Seneca Fork of Wills Creek, at the west side of the Summerfield quadrangle, is slightly less than 800 feet above the sea. West Fork of Duck Creek, at the south side of the area, is about 740 feet above the sea. The highest summits along the principal divide are about 1,400 feet in elevation, giving a relief of about 700 feet for the entire area. The local relief along Sun-

UPLAND LANDSCAPE NEAR SUMMERFIELD.

fish and Captina creeks, which have the deepest valleys, is 400 to 500 feet.

The principal divide extends southward from Barnesville to Lewisville. The ridge dividing the waters of Captina and Sunfish creeks extends eastward across the north edge of Monroe County, and along it are the villages of Malaga, Jerusalem, and Beallsville. The crest of this divide, like those of most other divides in the region, is comparatively even. Extending north and south from it are numerous long parallel ridges that alternate with deep ravines. The elevation of all the ridges ranges from about 1,200 feet to more than 1,300 feet. A few isolated hills of unusual height near Miltonsburg attain 1,400 feet. All the upland has an undulating surface with almost no level areas, but the slopes into many of the smaller valleys are gentle. The alternation of hard and soft strata produces a terraced effect that is evident on almost every hillside. Steep slopes are succeeded by slopes of gentle inclination, suitable for cultivation. An upland landscape near Summerfield is shown in Plate I.

The broad valleys west of the principal divide are bounded by fairly abrupt slopes that terminate in narrow ridges of less altitude and of more rugged contour than those to the east. At the west side of the Summerfield quadrangle, near Senecaville and Lore City, the slight relief is especially noticeable, there being few summits as high as 1,050 feet above the sea. The lower altitude may be attributed to the fact that less durable, more easily eroded rocks make up the surface in that part of the area.

AGRICULTURAL AND COMMERCIAL CONDITIONS.

TRANSPORTATION FACILITIES.

Railroads.—The northern part of the area is crossed by the main line of the Baltimore & Ohio Railroad. From Lore City a branch extends southwestward to Senecaville and Cumberland. These lines are of great importance as coal carriers and will be increasingly so as new branches are built.

The Ohio River & Western Railroad, a narrow-gage line, crosses the southern part of the area. It runs from Zanesville eastward to Bellaire, on Ohio River. This railroad is of chief value as a carrier of merchandise and agricultural products. The route followed takes little account of either hill or valley, and steep grades are so numerous that the line can never be of great importance for the handling of heavy freight.

New railroad routes.—So large a portion of the Woodsfield quadrangle is underlain by coal of demonstrated value that it will in the not distant future be the scene of a great mining industry. There is

some question as to whether railroads can most readily reach the area by the valleys of Captina and Sunfish creeks or from the west up certain valleys tributary to Leatherwood Creek and Seneca Fork of Wills Creek. The approach by the latter route would seem to be the less difficult, there being numerous level valleys offering an excellent grade up to the divide at the west edge of Belmont County, thence through a short tunnel to tributaries of Captina Creek. The crossing of the divide could be made at an elevation somewhat less than that of the railroad at Barnesville, which is about 1,235 feet. Such a route could readily extend eastward from Baileys Mills either up Dog Hollow or Cat Hollow, or up Beaver Creek through Temperanceville.

The principal branches of Captina Creek are fairly straight, but the main stream formed by the union of these branches near the center of the Woodsfield quadrangle follows a devious route eastward that would not favor the construction of a railroad without numerous tunnels, cuts, fills, and bridges. The same is true of Sunfish Creek.

Highways.—The area here considered lies a few miles south of the old National Road from Wheeling to Columbus, which has been for many years an important line of travel. Most of the roads follow the principal ridges or valleys, and therefore the accessibility of many points is largely dependent on the direction of drainage lines. There are only a few miles of improved limestone pike in the area; the longest stretch extends from Barnesville to Malaga. Paved roads lead out a mile or so from Woodsfield in several directions, and short stretches of limestone-surfaced road have been built between Lore City and Quaker City, between Quaker City and Summerfield, and from Barnesville to Baileys Mills. Elsewhere the roads are as a rule unimproved, and any qualities they possess are due to the character of the substrata. The roads that follow sandy ridges are fairly good throughout the year, but the valley roads are almost impassable during the rainy season.

MANUFACTURING AND MINING.

Most of the industries of the area are more or less related to coal mining and the production of oil and gas. The prosperous growth of Woodsfield is attributed largely to its situation in the midst of a number of important oil fields. It contains one manufacturing establishment that specializes in drilling machinery. Barnesville has a glass factory that employs several hundred men, and an establishment that makes coal-mine cars.

Two commercial coal mines are operated in the Pittsburgh coal bed at Baileys Mills, near Barnesville. The Upper Freeport coal is mined by shafting at Blacktop, Senecaville, and Waldhonding, in the western part of the area. Sandstone was formerly quarried at Woods-

field, but the work has been abandoned and no stone quarries are now in operation.

AGRICULTURE.

Notwithstanding the general hilly character of the country, most of it is under cultivation. For a few years after the steep hillsides are cleared of timber they are commonly planted in tobacco. The loss of the soil by wash, however, is so great that the fertility is greatly reduced in a short time, and the ground is then given to grazing or allowed to revert to brush. Where the underlying rocks consist largely of clay and shale landslides are common, and in this way the entire hillside farms are ruined. The region has long been prominent for its sheep and cattle raising. Portions near the mining towns find good profit from gardening and fruit growing.

Not all the extensive bottom land along Seneca Fork and other branches of Wills Creek is productive of good crops each year. The soil is excellent, but the drainage is poor, and floods are frequent. In seasons of heavy rainfall the ground becomes too wet, and in other years the crops, when well advanced, may suddenly be destroyed by floods, which are of common occurrence. On the whole it seems safe to state that the most successful farmers have lands on the hills.

GENERAL GEOLOGY.

STRATIGRAPHY.

All the rocks in this area are of sedimentary origin and exist as more or less continuous beds laid down for the most part in or by water. The outcropping strata consist of sandstone, shale, clay, limestone, and coal, and have a total thickness between 1,100 and 1,200 feet. They are of Pennsylvanian ("Coal Measures") and Permian age and include in ascending order the Conemaugh, Monongahela, and Washington formations as classified by geologists. The dip of the beds is in general southeastward; therefore higher and higher strata are crossed when one travels in that direction. In the valley flood plains and on terraces are unconsolidated alluvium of Quaternary age.

GENERAL SECTION.

The stratigraphy of eastern Ohio has been described in previous reports [2] and only a brief outline is needed here. The several formations represented, with their approximate thicknesses, are listed below. The classification given for the Mississippian rocks is the

[2] Bownocker, J. A., Oil and gas: Ohio Geol. Survey Bull. 1, 4th ser., 325 pp., 1903. Orton, Edward, The stratigraphical order of the Lower Coal Measures of Ohio: Ohio Geol. Survey, 2d ser., vol. 5, pp. 1–300 868–1058, 1884. Griswold, W. T., and Munn, M. J., Geology of oil and gas fields in Steubenville, Burgettstown, and Claysville quadrangles, Ohio, W. Va., and Pa.: U. S. Geol. Survey Bull. 318, 196 pp., 13 pls. 1907.

one introduced by the late Professor Prosser,[3] of the Geological Survey of Ohio, for these beds where they crop out in the central part of the State, and the one adopted by the United States Geological Survey. Recent detailed work done by Jesse E. Hyde [4] has, however, led to the proposal of a slightly different classification.

General section of formations in eastern Ohio.

	Feet.
Permian series:	
Washington formation ("Upper Barren")	400±
Pennsylvanian series ("Coal Measures"):	
Monongahela formation ("Upper Productive")	255–275
Conemaugh formation ("Lower Barren")	460–475
Allegheny formation ("Lower Productive")	250–265
Pottsville formation	155–170
Unconformity.	
Mississippian series:	
Maxville limestone (Big lime)	0–110
Unconformity.	
Logan formation (includes Keener sand)	600–700
Black Hand formation (includes Big Injun sand)	
Cuyahoga shale	
Sunbury shale	
Berea sandstone	
Bedford shale [Devonian or Mississippian [5]]	

The Mississippian formations constitute the great oil-bearing rocks of southeastern Ohio and include the Berea, Big Injun, Keener, and Big lime sands, all of which are productive in the Woodsfield quadrangle. In outcrops some 80 miles to the west and northwest the same beds are quarried for building stone. Below the Berea is a great thickness of shale, the bottom of which has never been penetrated by the drill within the Woodsfield or Summerfield quadrangles. The Clinton sand, which yields much oil and gas in central and northeastern Ohio, if present in this region lies more than 4,000 feet below the Berea sand.

The Maxville limestone, known among oil drillers as the Big lime, varies considerably in thickness and is apparently missing in some parts of the Woodsfield quadrangle and much of the Summerfield quadrangle. This is to be expected, for the limestone is variable where seen in outcrop. It is overlain unconformably by sandstone, which forms an undulating contact and locally extends across the limestone, entirely replacing it.

The Pennsylvanian rocks or "Coal Measures" are made up largely of shale, clay, and sandstone, with numerous beds of coal and lime-

[3] Prosser, C. S., Revised nomenclature of the Ohio geological formations: Ohio Geol. Survey Bull. 7, 4th ser., 36 pp., 1905.

[4] Hyde, J. E., Stratigraphy of the Waverly formation of central and southern Ohio: Jour. Geology, vol. 23, pp. 655-682, 757-779, 1915.

[5] The Bedford shale is now regarded by some geologists and paleontologists as of Devonian age. It is at present classified by the United States Geological Survey as Devonian or Carboniferous.

stone. Most of the sandstones are oil bearing at one place or another. The Pottsville and Allegheny formations are below the surface throughout the quadrangles. The Allegheny is the great coal-bearing formation in the northern Appalachain coal basin. In Ohio, though only a little more than 250 feet thick, it includes a number of coal and clay beds of great economic importance. The Upper Freeport coal, which constitutes the uppermost member of the Allegheny formation, lies in the floor of Leatherwood Valley 3 miles west of Lore City and is mined at Blacktop, Klondyke, and other points to the south and southeast. Exposures a few miles to the northwest, beyond the limits of the area here considered, show the Lower Freeport coal, a bed about 1½ feet thick lying about 40 feet below the Upper Freeport. This and other strata are recorded in wells drilled for oil.

The Conemaugh formation was appropriately called the "Lower Barren Measures" by early geologists of the Pennsylvania Survey, for its few coal beds are of little economic importance, and the formation is for the most part made up of shale and irregular sandstone lenses interlayered with clay, which is commonly reddish brown. The formation includes also a few persistent beds of limestone, several of which contain marine fossils. The strata included in the Conemaugh formation lie between the top of the Upper Freeport coal and the base of the Pittsburgh coal, and their thickness is about 450 feet.

The Monongahela formation contains nearly, if not quite, as much coal as the Allegheny. It includes the Pittsburgh, Meigs Creek, Uniontown, and Waynesburg coal beds, all of which are minable within this area. The coals are interbedded with sandy shale, clay, numerous layers of limestone, and a few nonpersistent sandstones.

The Washington formation of the Permian series lacks valuable beds of coal and is characterized by nonpersistent sandstone members, with shale and clay, commonly of reddish-brown color. The few coal beds and thin limestones of the formation are found near the base.

ROCKS AT THE SURFACE.

The rocks at the surface are described briefly below in ascending order. Their general sequence is illustrated by the section (fig. 2), which represents all but the uppermost 200 feet of strata within the area. In another part of this report is given a detailed account of the local stratigraphy in each township.

CONEMAUGH FORMATION.

The Mahoning sandstone, the basal member of the Conemaugh formation, rests directly on the Upper Freeport coal or is separated from it by a few feet of black shale. The sandstone is well known among oil men on account of its yield of oil at Lore City and other

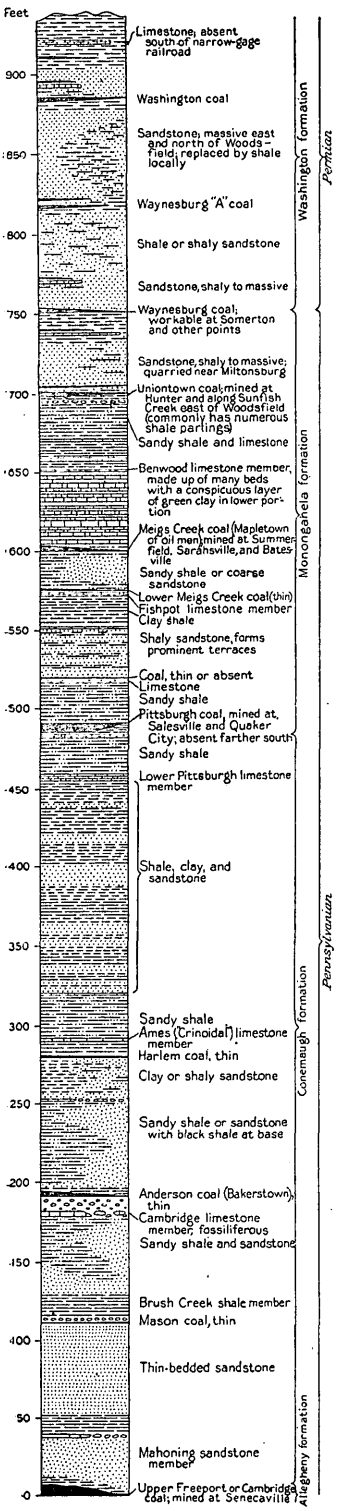


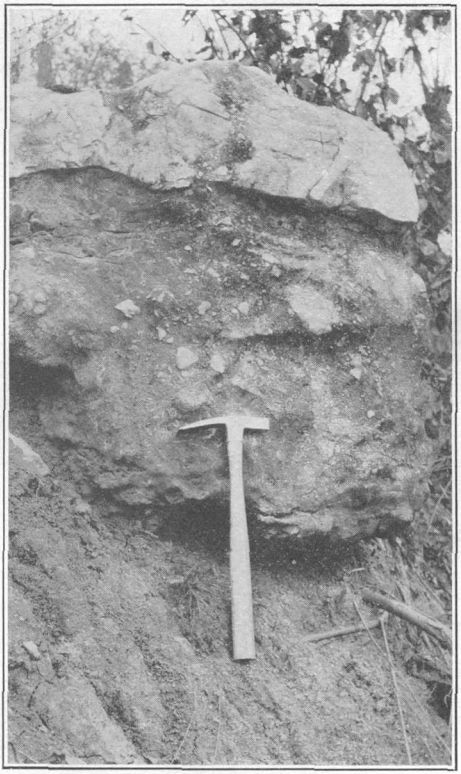
FIGURE 2.—Generalized section of rocks that crop out in the Summerfield and Woodsfield quadrangles.

places to the south. It may be seen in outcrop along Leatherwood Valley, 1 mile west of Blacktop.

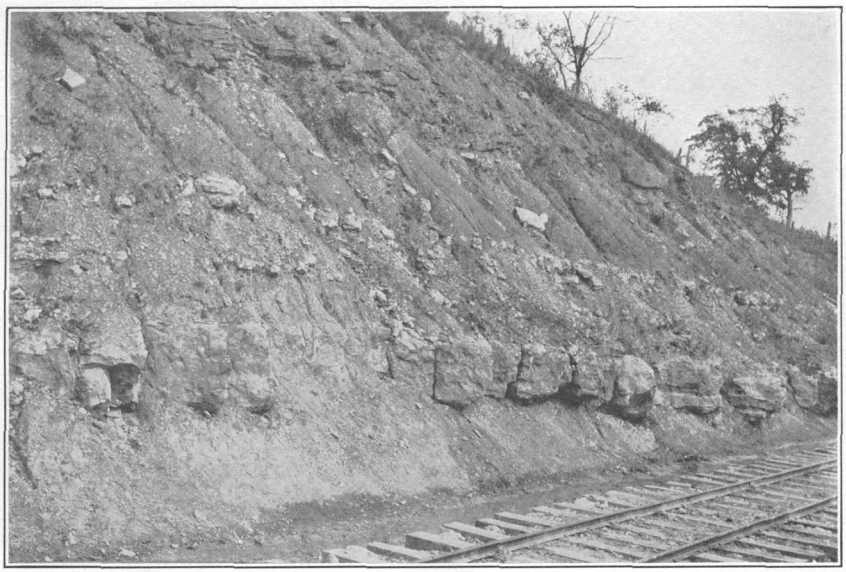
The position and character of the members of the Conemaugh formation are shown in the generalized section (fig. 2). Some of the more persistent beds have been named. The fossiliferous Cambridge and Ames limestones are especially noteworthy and serve as excellent key rocks to the geologist. The Lower Pittsburgh member, near the top of the formation, is also noteworthy for its persistence. Neither these nor higher strata in the region contain marine fossils. The principal limestone strata are described below.

The Cambridge limestone crops out along valleys in the vicinity of Senecaville and Lore City. Its position is about 175 feet above the Upper Freeport coal. It is a dark-gray smooth-textured fossiliferous bed easily distinguished from the other limestones. In numerous places it does not appear as a continuous layer but rather as nodules embedded in clay, and in such places the outcrop is not easily discovered.

The Ames limestone crops out in the northwestern part of the Summerfield quadrangle. It is about 108 feet above the Cambridge limestone and 160 to 190 feet below the Pittsburgh coal. It has a granular texture, is highly fossiliferous, and assumes a greenish-gray to rusty-brown surface on weathering. The freshly broken rock is greenish and shows cleavage faces covered with calcite, and it contains cross sections of crinoid stems, which produce the granular texture.



A.



B.

LOWER PITTSBURGH LIMESTONE NEAR SARAHSVILLE.

A, Close view, showing pebbly texture; *B*, general view.

From 15 to 20 feet above the Ames and a like distance below it are somewhat similar but less persistent limestone beds, and care is required not to confuse these with the Ames.

About 25 feet below the Pittsburgh coal is a conspicuous limestone member to which the name "Summerfield" was applied by the writer in 1912,[6] but which, being regarded as the same as the Lower Pittsburgh limestone member of the Conemaugh in Pennsylvania, is here designated by the older name Lower Pittsburgh. This rock has a characteristic roughened, lumpy surface that serves to differentiate it from other beds. (See Pl. II.)

The Conemaugh formation is everywhere characterized by the reddish-brown color of certain clay and shale beds in it. This color is particularly prevalent in the strata lying a little below and above the Ames limestone, but it is not uncommonly found in beds locally extending upward almost to the position of the Lower Pittsburgh limestone.

MONONGAHELA FORMATION.

The Monongahela formation includes limestone, shale, sandstone, clay, and coal, aggregating 260 to 280 feet in thickness. Its lower limit is formed by the base of the Pittsburgh coal, and its upper limit by the top of the Waynesburg coal.

The Pittsburgh coal crops out along the valleys west and southwest of Barnesville and also at Temperanceville. Farther east in this area it is 100 feet or more below the surface. It is recorded in nearly all oil wells and has also been tested by core drilling and is known to be present in workable thickness in the greater part of the area. The chief exception is the southwest corner, the limit of the workable coal being, roughly, a line drawn from Temperanceville to Miltonsburg and thence to Lewisville, or possibly to Woodsfield. The rocks at the Pittsburgh horizon are exposed along the valleys of Seneca and Paynes forks south of Temperanceville, but the coal is too thin to be of value.

The Pittsburgh coal is correctly identified by oil men in drilling operations throughout the region, and its position with reference to higher strata is so well established by dozens of hillside measurements and by core-drill and oil-well records that it is chosen as the most convenient key bed for mapping the structure of quadrangles in this part of Ohio.

The Meigs Creek (Mapletown) coal lies 90 to 120 feet above the Pittsburgh bed. The larger interval is unusual and was found only in the region west of Barnesville. Another coal, the Lower Meigs Creek, is found in numerous places in the quadrangle 18 to 35 feet below the

[6] Condit, D. D., Conemaugh formation in Ohio: Ohio Geol. Survey Bull. 17, 48 ser., p. 23, 1912.

Meigs Creek proper. The two coals are commonly separated by massive sandstone. Typical exposures of the lower coal may be seen along Seneca Fork of Wills Creek, where it is mined for local use. It is underlain by a few feet of limestone known as the Fishpot. The Meigs Creek coal lies near the valley floor of Captina Creek for miles eastward from Barnesville, and at the east edge of the area it is a few feet below the bed of the creek. In Adams Township the same coal is a few feet beneath the valley floor of Sunfish Creek and no outcrops were discovered.

Over the Meigs Creek coal is the Benwood limestone, which consists of numerous layers having a combined thickness of about 70 feet. Here and there the limestone is in part replaced by shale or by sandstone in the basal portion. In the vicinity of Summerfield and at other places to the south a conspicuous bed of olive-green clay appears about 16 feet above the Meigs Creek coal. At the same position in outcrops on Captina Creek is a calcareous clay which presents a peculiar checkered surface made up of angular blocks, well illustrated in Plate III, *B*.

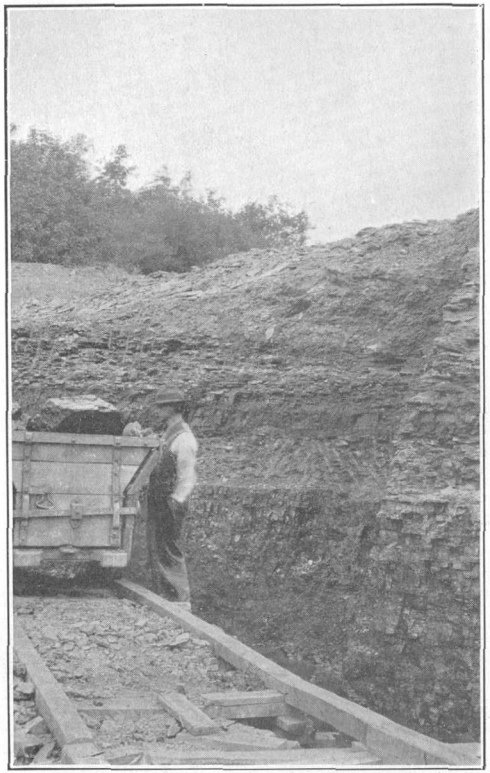
From 100 to 120 feet above the Meigs Creek coal is the Uniontown coal, which is useful as a structural key bed on account of its extensive outcrop. Its value for this purpose is somewhat lessened, however, because the coal is in places divided into two beds separated by about 10 feet of shale. The Uniontown coal is mined on Sunfish Creek east of Woodsfield and also on Jakes Run and Bend Fork, tributaries of Captina Creek. (See Pl. IV, *A*.)

Over the Uniontown coal is a sandstone member known as the Gilboy among geologists of the West Virginia Survey. It is prominently developed west of Malaga and Miltonsburg, where it has been quarried.

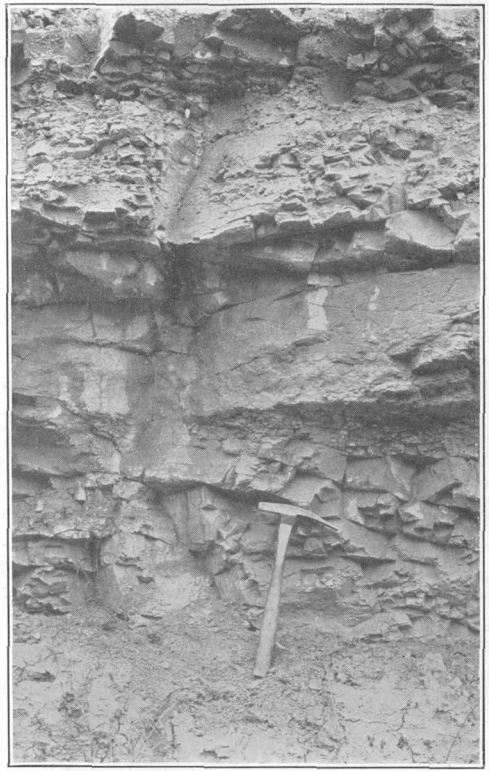
The Waynesburg coal, like the Uniontown, varies greatly in thickness from place to place and is of no value along much of its outcrop. It also is accompanied by another coal bed 10 feet or so lower.

WASHINGTON FORMATION.

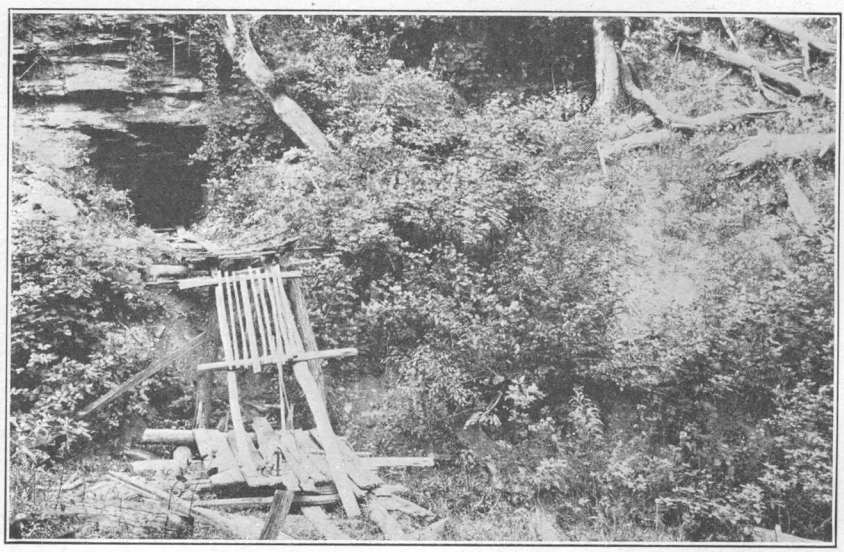
The principal members of the Washington formation are, in ascending order, the Waynesburg sandstone, the Waynesburg "A" coal, a sandstone that occurs at the horizon of the Mannington sandstone of the West Virginia Survey, and the Washington coal. The sandstone correlated with the Mannington of the West Virginia Survey is prominently developed along certain ridges southeast of Barnesville and also eastward from Woodsfield for several miles. (See Pl. XI, *B*.) The Washington coal is persistent throughout the area and has a thickness of 1 to 2 feet. It is locally accompanied by other coal beds, one 10 feet higher and another 26 feet higher. The Washington coal is about 350 feet above the Pittsburgh in Goshen Township, in



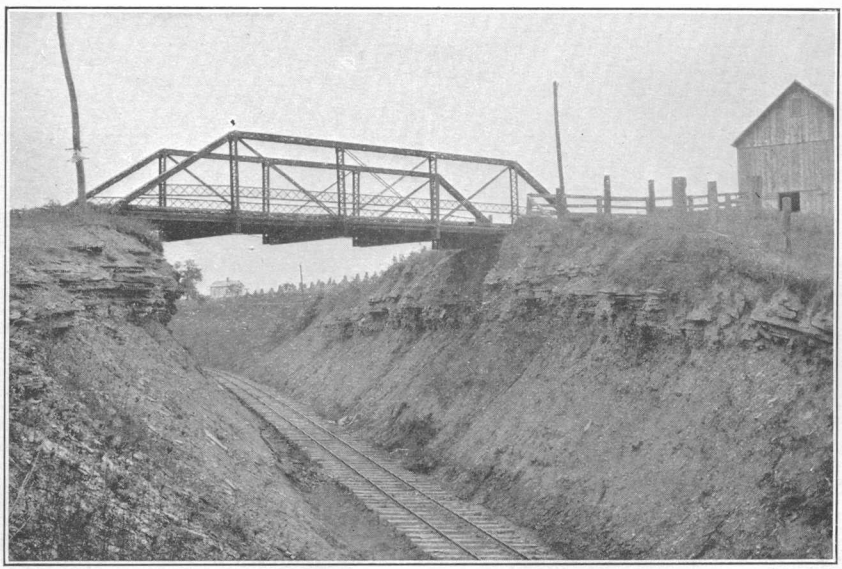
A. OPEN-CUT WORKING OF MEIGS CREEK COAL NEAR BETHESDA.



B. STRUCTURE OF CALCAREOUS CLAY NEAR BASE OF BENWOOD LIMESTONE.



A. PROSPECT IN UNIONTOWN COAL BED NEAR HUNTER.



B. SANDY SHALES OVER UNIONTOWN COAL AT WHIGVILLE.

the northeast corner of Woodsfield quadrangle. Toward the south the interval between the two coals gradually increases to about 400 feet at the Belmont-Monroe county line and to 420 feet at the south edge of the quadrangle.

About 40 feet above the Washington coal is a bed of limestone 1 to 3 feet thick which was used as a guide in mapping in Belmont County. To the south, in Monroe County, this limestone is lacking, and in its place is greenish-gray brittle granular clay.

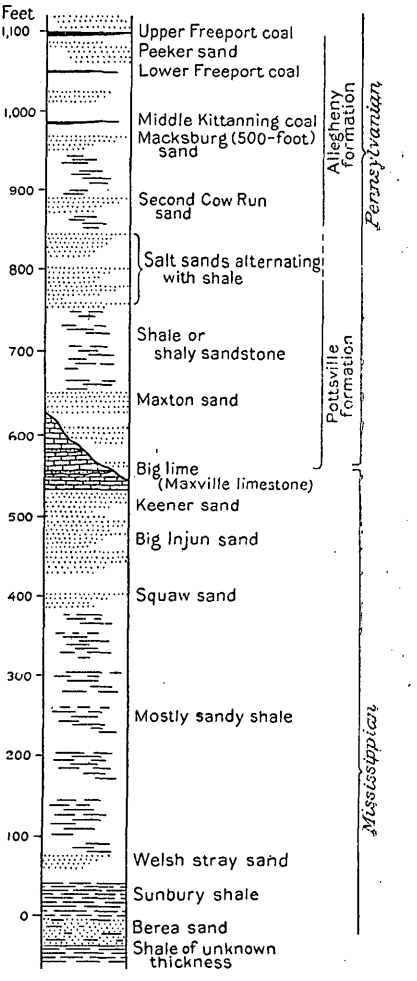


FIGURE 3.—Generalized section of beds below the surface in the Summerfield and Woodsfield quadrangles, with names applied by oil men.

QUATERNARY DEPOSITS.

The unconsolidated alluvial material in the valleys constitutes the youngest bedded deposit in the region. It makes up the flood plains of large and small streams and extends well up to their heads. The material is being constantly cut out and redeposited by variations in the currents at each period of high water.

Some of the deposits within the area may be considered of Pleistocene age, although the region is far removed from the glacial boundary. Many of the branches of Wills Creek valley are partly buried under a considerable thickness of sandy material which fills the rock channel to a depth of 50 feet or more. Traces of similar material are found on terraces and gentle slopes bordering the valleys to a height of more than 100 feet above the present valley floor. Along Seneca Fork in Wayne Township, a few miles southeast of Senecaville, gravel was found at an elevation of about 980 feet, or 160 feet above the valley floor. In the interval of 160 feet between this gravel and the valley are sandy silts in stratified layers lying on the hillsides and effectually mantling the bedrock nearly everywhere.

Along the eastward-flowing streams directly tributary to the Ohio in the Woodsfield quadrangle are rock benches that lie at various elevations, from a few feet to a hundred feet or more above the valleys, and are covered by more or less gravelly material. Each bench is the remnant of a former valley floor which has been almost destroyed in the deepening to the modern valley.

ROCKS NOT EXPOSED IN THE AREA.

Below the surface of this area there are about 2,000 feet of rocks that are fairly well known through evidence furnished by the drill. The Berea sand, the chief objective in the search for oil, lies 1,550 to 1,660 feet below the Pittsburgh coal, and a few test holes have been drilled several hundred feet into the thick black-shale formation beneath the Berea. The general succession of strata below the Upper Freeport coal, with names as applied by oil men, is shown in figure 3. The records of two wells drilled for oil are given below to illustrate the character of the strata below the surface.

Log of well No. 126 (No. 2 on Silas McLoughlin farm), sec. 19, Seneca Township, Noble County.

[Oil well.]

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Ames limestone	3	45–48	Sand (record incomplete).		
Shale	57	48–105	Sand	20	680–700
Sand	55	105–160	Shale	100	700–800
Fire clay, bad cave (record incomplete).			Sand	20	800–820
			Shale	47	820–867
Sand	55	275–330	Sand, Keener (show of oil at 878 feet)	143	867–1,010
Fire clay	10	330–340	Shale	15	1,010–1,025
Sand	10	340–350	Sand, Big Injun	10	1,025–1,035
Shale	15	350–365	Shale	391	1,035–1,426
Coal marker		368	Berea sand (oil at 1,432 feet).		
Sand, show of gas	62	368–430	Total depth		1,436
Shale	45	430–475			

Log of well No. 372 (No. 1 on Martha Mobley farm), sec. 31, Adams Township, Monroe County.

[Gas well.]

	Thickness.	Depth.
	Feet.	*Feet.*
Conductor		0– 9
Coal	3	167– 170
Coal (Pittsburgh)	4	504– 508
Red rock	100	600– 700
Lime	50	700– 750
Red rock	75	750– 825
"Slate"	45	825– 870
First Cow Run sand	20	870– 890
Second Cow Run sand	185	950–1,135
"Slate"	115	1,135–1,250
First salt sand (water at 1,280 feet)	60	1,250–1,310
Lime	10	1,310–1,320
Second salt sand (water, 1½ barrels an hour, at 1,335 feet)	65	1,320–1,385
"Slate"	15	1,385–1,400
Maxton sand	50	1,400–1,450
"Slate"	30	1,450–1,480
Big lime		1,480
Keener sand (scum of oil at 1,586 feet; water rising 200 feet in 3 hours at, 1,591 feet; water, 1 barrel an hour, at 1,615 feet)	33	1,582–1,615
"Slate"	10	1,615–1,625
Big Injun sand (little dark oil and gas at 1,665 feet)	175	1,625–1,800
"Slate" and lime	115	1,800–1,915
Welsh sand, limy	75	1,915–1,990
Berea sand (gas at 2,163 feet)	10	2,160–2,170
Total depth		2,179

STRUCTURE.

DEFINITION OF STRUCTURE.

The rocks throughout most of eastern Ohio as viewed in outcrop appear to lie level or so nearly level that the inclination is not noticeable to the eye. Anyone who has been in a coal mine, however, will remember that the floor is generally far from level and slopes up and down with considerable irregularity.

When by means of instrumental leveling numerous observations are obtained along the outcrop of a coal or limestone bed and its "lay" or attitude is thus determined, it will be found to slope in various directions and at an ever-varying rate from place to place. The term "structure" is used by the geologist to designate such changed positions of rock beds from the nearly horizontal one in which they were originally deposited.

APPALACHIAN TROUGH.

The rocks of southeastern Ohio form the west side of the Appalachian trough, a great shallow structural basin lying between the Allegheny Mountain front and the Cincinnati arch. The general direction of dip is southeastward at a gentle rate, averaging about 20 feet to the mile. The bottom or axis of this trough is a little east of Ohio River, and east of it the rocks rise across West Virginia. The slopes of this basin are far from uniform and are traversed by numerous minor wrinkles that form anticlines and synclines. These are very insignificant when the basin is considered as a whole but are of great economic importance because of their influence on the accumulation of petroleum and natural gas.

FIELD METHODS IN STRUCTURAL STUDY.

Various methods are employed by geologists in the study and mapping of geologic structure. An instrument commonly used but not suited to the most refined work is the aneroid barometer. This is serviceable where extreme accuracy is not required, especially if the region has a well-distributed set of bench marks showing the elevation above sea level at numerous points. Where greater accuracy is desired, surveying instruments for leveling and stadia traverse are recommended. In carrying on the work in the Summerfield and Woodsfield quadrangles the Gale alidade was the principal instrument used.

The area is favored with a number of persistent, easily recognized limestone and coal beds which serve as excellent key strata for the determination of structure. Elevations at about 2,000 points along the outcrops of the strata were obtained, and hundreds of measurements of the intervals between the beds were made in ravine and

roadside exposures. These data were supplemented by others obtained from records of oil wells and coal test holes, and thus the intervals between the key strata throughout the area were accurately determined. With elevations on the key strata in every square mile of the area and information as to the relation of these beds to one another it was easy to reduce the observations to one datum by addition or subtraction of the appropriate interval. The Pittsburgh coal forms the most convenient datum and is generally used in structural mapping wherever it is present in southeastern Ohio and adjacent parts of Pennsylvania and West Virginia.

The variations in interval between some of the important key strata and in their positions with reference to the Pittsburgh coal are tabulated below.

Intervals between principal strata.

Pittsburgh and Washington coal beds.

	Feet.		Feet.
Hunter, Goshen Township	355	Lewisville[7]	386
Somerton	378	Woodsfield	415
Malaga	393	Junction of Piney Fork and Sunfish Creek	416
Beallsville	398		

Pittsburgh and Waynesburg coal beds.

	Feet.		Feet.
Temperanceville	265	Hunter	263
Somerton	277	Summerfield	273
Newcastle	268		

Pittsburgh and Uniontown coal beds.

	Feet.		Feet.
Barnesville	206	Malaga	220
Temperanceville	215	Junction of Piney Fork and Sunfish Creek	230
Hunter	205		

Pittsburgh and Meigs Creek coal beds.

	Feet.		Feet.
Hunter	87	Calais	113
Barnesville	108	Mount Ephraim	116
County line west of Barnesville	120	Sarahsville	116
Temperanceville	111	Summerfield	117
Malaga	87	Junction of Piney Fork and Sunfish Creek	98
Wayne Township, Belmont County, east side	105	Beallsville	98

Upper Pittsburgh and Lower Pittsburgh limestones.

	Feet.		Feet.
Quaker City	23	Summerfield	24
Temperanceville	22		

[7] There is some doubt as to the accuracy of this figure because the identity of the coal at Lewisville as the Pittsburgh is not certainly established. It may possibly be the Pomeroy, a rider coal 25 to 35 feet above the Pittsburgh.

Pittsburgh coal and Ames limestone.

	Feet.		Feet.
Chaseville	175	Kennonsburg	190
Gibson station	190	Riches School, 3 miles north of Sarahsville	159
Salesville	186	Sarahsville	192
Quaker City	188		

Lower Pittsburgh limestone and Lower Meigs Creek coal.

	Feet.		Feet.
Sarahsville	115	One mile west of Calais	110
One mile south of Kennonsburg	120	One mile southeast of Mount Ephraim station	124
Two miles southwest of Batesville	117		

Ames and Cambridge limestones.

	Feet.		Feet.
Blacktop	109	Senecaville	107
Waldhonding mine	108		

Ames limestone and Upper Freeport coal.

	Feet.		Feet.
Blacktop	275	Senecaville	265

It is evident from the above data that there is considerable variation in the interval between beds from place to place. This is true of limestone beds as well as of coal.

DELINEATION OF STRUCTURE.

After the elevations on key strata have been reduced to the Pittsburgh coal datum, the contour map (see Pl. XII, in pocket) is drawn to illustrate the structure of that bed. The method is illustrated in figure 4, which shows elevations above sea level at a number of points of outcrop. The contour lines are drawn at vertical intervals of 10 feet through points of equal elevation in the manner illustrated in the diagram.

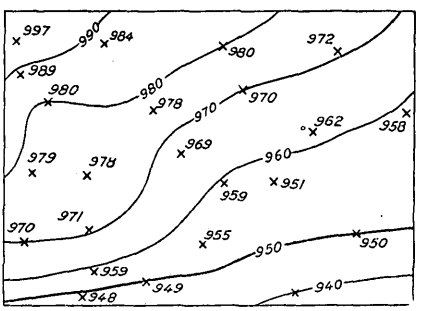


FIGURE 4.—Diagram illustrating method of drawing structure contours.

The accuracy of structure contours in expressing the "lay" of a coal bed depends on several factors. The elevations must be taken at points not too widely spaced, else they will fail to disclose numerous minor flexures. More or less error is inevitable in the reduction of elevations of different key strata to terms of the bed which is being used as a datum, because the interval between beds varies from place to place owing to the irregularities of the surface on which each bed was deposited.

USES OF STRUCTURE CONTOUR MAP.

The structure contour map is an important aid to prospecting for petroleum and natural gas, and its value is generally recognized by oil men.[8] Aside from this use, such a map is of service to the coal miner in selecting favorable locations for mine shafts and drift mine openings. At one locality in the Woodsfield quadrangle the Pittsburgh coal dips eastward as much as 80 feet in 1 mile, and at another locality it dips at a similar rate toward the southwest. In the selection of a location for sinking of a shaft to be used for hoisting coal the operator may wish to place it near the lowest point on the coal bed on the property. He will be able to make an intelligent choice by consulting the structure contour map. The same use is applicable in opening drift mines. The farmers have learned from experience to open mines on the south or southeast side of the hill in order that the water may drain readily. This rule is usually a safe one on account of the general southeasterly dip, but there are numerous local exceptions that only structural mapping will bring out.

Of course, the contours on the base of the Pittsburgh coal can readily be used to determine its depth below the surface at any point. For instance, the bed is shown to be 640 feet above sea level at the mouth of Piney Fork, 5½ miles east of Woodsfield. The surface of the valley at that point is about 775 feet above sea level, and therefore by subtraction the depth of the bed is shown to be 135 feet below the surface. In like manner the map may be used in calculating the depth below the surface of other coal beds whose positions with reference to the Pittsburgh coal are known.

SALIENT STRUCTURAL FEATURES.

The general southeastward dip of the strata is evident from an inspection of the map (Pl. XII). At the southeast corner of the Woodsfield quadrangle the position of the Pittsburgh coal is about 600 feet above sea level. The northwest rise brings it to an elevation of 1,000 feet at Barnesville, 1,080 feet at Quaker City, and 1,200 feet at the northwest corner of the Summerfield quadrangle. The elevation last named is the position at which the coal would lie in case the hills west of Lore City were high enough to contain it.

The term "strike," as used in the geologic sense, means the direction of a line drawn along the outcrop of any rock stratum at a right angle to the dip. Therefore, each contour on the structural map shows not only the elevation of the coal, but also its strike. The numerous local variations from the general northeasterly direction followed by the contours represent minor folds or cross flexures that

[8] See U. S. Geol. Survey Bull. 621 for structural maps of the Berea oil sand in the Summerfield and Woodsfield quadrangles.

give structural forms of various shapes for which the appropriate terms are "terrace," "nose" or "promontory," "embayment" or "trough," "synclinal basin," and "anticlinal fold." True anticlinal folds or arches in the strict sense of the term are few in this area, and there are only two such folds of any prominence—one near Barnesville, which contains the Barnesville oil and gas pool, and the other at Chaseville, which yields oil and gas. In these folds the axis or crest line slopes or pitches both to the northeast and to the southwest from a point that may be designated the summit of the fold.

At Lore City and at two points south of Barnesville are synclinal basins or troughs, the opposite of the anticlines in structure. Another depression of similar character is situated at Woodsfield. The rocks slope into the center of these basins from all sides, thus giving them a saucerlike form.

One illustration may be given to explain the method of interpreting structure by means of the coutour map. It will be noticed that the contours are far apart for a distance of a mile or so to the south and east of Temperanceville. As each contour interval represents a difference of 10 feet, it is evident that the rocks lie nearly flat at that locality and rise gently west of the village. The almost flat terrace-like structure at Temperanceville is succeeded eastward by an abrupt increase of dip to more than 80 feet to the mile, which continues as far as the shallow depression southwest of Somerton. East of the depression the strata are nearly flat, but farther east they show an increased downward slope toward Malaga and Newcastle and in other directions.

On the map (Pl. XII, in pocket) are drawn the axes of the principal folds, including anticlines, synclines, and cross flexures, most of which pitch in a south to east direction. Practically all these folds begin and end in the area and are only a few miles in extent.

SUMMARY OF ECONOMIC GEOLOGY.

COAL.

STATISTICS OF PRODUCTION.

In the mining of coal in eastern Ohio for railroad shipment the most extensive operations are in the Pittsburgh and Upper Freeport beds. The Lower Freeport ranks next in importance, and is mined at Amsterdam and other places in Harrison, Jefferson, and Columbiana counties. The Meigs Creek coal has been mined in a large way only at Flushing, in Belmont County. The Pittsburgh bed, the most extensive of all, is mined chiefly in the northeastern part of Belmont County, where transportation facilities are good and where the bed is accessible by drifts or by shafts of slight depth. The

following table shows the production of coal for a number of counties in eastern Ohio through a period of years:

Coal produced in certain counties of eastern Ohio, in short tons.

County.	1890	1900	1910	1911	1912	1913
Mahoning	256,319	46,462	60,434	52,748	33,194	15,786
Columbiana	567,595	692,264	715,252	660,196	448,778	522,804
Jefferson	491,172	1,110,586	5,241,681	4,687,731	4,858,529	5,178,922
Harrison	8,600	6,342	560,937	559,267	812,953	730,221
Stark	836,449	1,116,524	496,509	450,256	414,452	417,238
Carroll	328,967	167,521	313,517	269,167	322,969	379,064
Guernsey	413,739	1,852,327	4,686,994	3,895,682	4,246,955	4,321,992
Belmont	774,110	1,345,284	8,265,019	8,092,127	9,382,330	10,436,259
	3,676,951	6,337,310	20,340,343	18,667,174	20,520,160	22,002,286

County.	1914	1915	1916	1917	1918	1919
Mahoning	15,903	12,556	19,073	42,028	34,451	50,681
Columbiana	342,366	541,862	589,527	566,317	673,271	634,411
Jefferson	2,172,881	3,608,453	5,532,929	5,597,720	6,689,936	5,030,419
Harrison	184,892	214,630	973,628	1,216,253	2,070,414	1,427,972
Stark	457,933	352,020	296,381	373,222	533,591	387,074
Carroll	235,480	344,966	301,137	432,827	451,024	344,626
Guernsey	2,936,707	3,232,961	4,386,161	3,949,852	4,298,812	3,334,973
Belmont	2,849,181	4,304,566	10,330,941	11,166,504	11,852,508	10,101,682
	9,195,343	12,612,014	22,429,777	23,344,723	26,604,007	21,311,838

COAL BEDS IN STRATA THAT DO NOT CROP OUT IN THE AREA.

Here and there in the Woodsfield quadrangle and especially in the Summerfield quadrangle coal beds lower than the Upper Freeport have been noted in the drilling of oil wells. Most of the reports have come from the vicinity of Quaker City and Salesville from the Summerfield gas field, and from the area between Sarahsville and Senecaville. A coal commonly recorded is probably the Lower Freeport, which lies about 40 feet below the Upper Freeport and is generally less than 2 feet thick where seen in outcrop to the west, in the vicinity of Cambridge. Both this and lower beds recorded by the driller may prove of value on further investigation, but it must be borne in mind that the churn drill is at best a crude apparatus for coal testing, giving little reliable evidence as to composition or thickness. The same coal tested by the core drill might prove to be only "bone" or shaly coal of little value. Some of the reported occurrences of deep-lying coal beds are mentioned in the township descriptions.

UPPER FREEPORT COAL BED.

The western part of the Summerfield quadrangle includes the east border of the Cambridge coal field, the most valuable area of the Upper Freeport bed in Ohio. Cambridge, the principal city in the region, is at the north edge of the field, and to the south as far as Caldwell, a distance of 20 miles, commercial mines are distributed

on and near the Cambridge & Marietta branch of the Pennsylvania Railroad and the Cumberland branch of the Baltimore & Ohio Railroad. Commercial mines are in operation at three places in the area here described—Blacktop, Senecaville, and Waldhoning.

All mining operations are preceded by careful exploratory testing by the diamond drill or the hollow-rod drill, for the reason that the coal, although 6 to 7 feet thick in large areas, is subject to abrupt changes in thickness. The Mahoning sandstone, which lies above the coal, is ordinarily separated from it by a few feet of black shale, but here and there the sandstone extends downward, forming an undulating contact with the coal and locally even replacing the coal throughout large areas.

The uncertainty of the bed and the failure of the companies to furnish records of all the test holes makes it impossible to give any information as to the acreage of the bed. Most of the exploratory work has been carried on near the principal mining centers, in outlining the limits of minable coal on the property of each company. The locations of most of the test holes are represented on the accompanying map (Pl. XII, in pocket) and also on the farm map in an earlier report.[9] At many places the bed is limited by sandstone "rolls." The Upper Freeport coal bed is probably at its best in a large area of proved coal land east and northeast of Senecaville. South of this area the coal bed is, according to information obtained in the drilling of oil wells, broken by sandstone rolls and in places seems to be absent. In most of the area of the Chaseville oil pool the coal is lacking. The same is true in the vicinity of Sarahsville, as indicated both by oil-well drilling and hollow-rod test holes. The information available for the area south of Sarahsville does not indicate commercial quantities of the Upper Freeport coal.

Records of nearly all oil wells in the area south of the railroad between Sarahsville and Summerfield show no coal at this horizon. In a few wells drilled north of Summerfield a coal bed that may be the Upper Freeport has been recorded. Of course, the failure of the driller to mention coal in the well record does not necessarily mean that no coal beds were encountered. Numerous records, however, mention certain thin coal beds other than the Upper Freeport, and it is taken for granted that in the places represented by these and other records that are fairly detailed the Upper Freeport bed is not present.

For information as to the thickness of the Upper Freeport coal in the several mines in the area the reader is referred to the descriptions given under Richland, Center, and Wills townships, Guernsey

[9] Condit, D. D., Structure of the Berea oil sand in the Summerfield quadrangle, Guernsey, Noble, and Monroe counties, Ohio: U. S. Geol. Survey Bul 1.621, p 1.22, 1915.

County (pp. 59–65). Samples for analysis were taken in the mines, and the results are given on page 38.

ANDERSON (BAKERSTOWN) COAL.

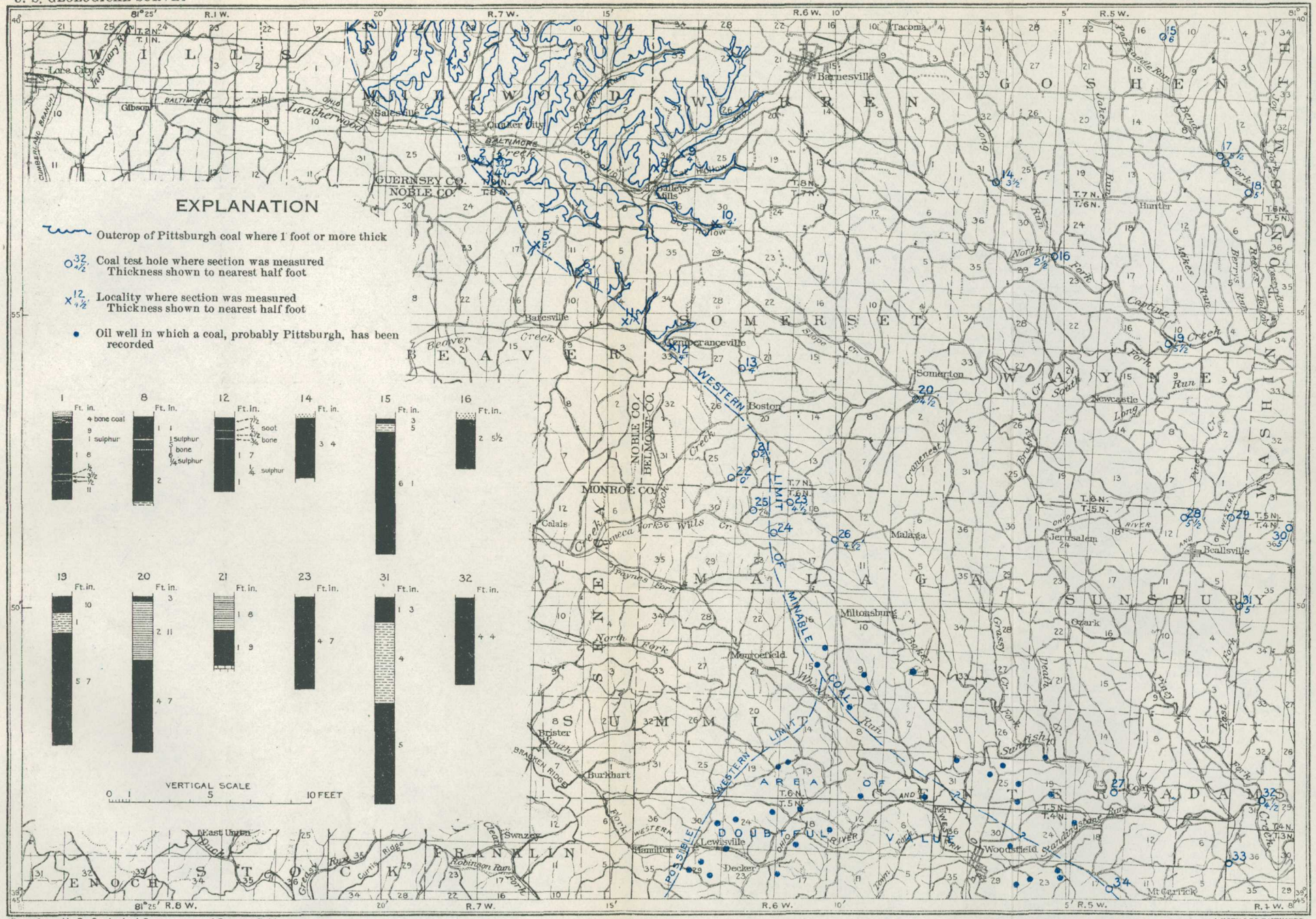
The Anderson coal bed is thin and of small extent. Its geologic position is about 10 feet above the Cambridge limestone. It is 1 to 2 feet thick in parts of Richland and Valley townships, Guernsey County, and has been used to a small extent by the farmers. The bed is probably at its best in the Andy Slovak mine, in sec. 11, Valley Township, where a thickness of 1 foot 10 inches was measured. A sample was cut for analysis and the result is given on page 39, No. 20243.

PITTSBURGH COAL.

The Pittsburgh coal bed will in the not distant future constitute the basis of a great mining industry. Practically all of the Woodsfield quadrangle except the southwest quarter is underlain by the coal in thicknesses of 4 to 5 feet, as yet almost untouched. Two commercial mines are in operation on the outcrop near Barnesville, and these are the only places where the coal has been mined in a large way in the southwestern part of Belmont County or the adjacent part of Monroe County. The bed in its extension eastward from Barnesville and Woodsfield to Ohio River, a distance of 25 miles, and beyond into West Virginia constitutes one of the greatest fuel reserves in the northern Appalachian region. (See fig. 5.)

There has been keen competition among lessees of coal tracts during the last 15 years, and nearly all the coal land is now under the control of coal companies. The prices paid have varied greatly, being only a few dollars an acre at the start but increasing to $25 or even as much as $40 an acre when the farmers had begun to realize the value of the coal.

Diamond-drill tests have, with the few exceptions noted elsewhere in this report, demonstrated the regularity in thickness of the Pittsburgh bed in Warren, Goshen, Somerset, Wayne, Smith, and Washington townships, Belmont County, and in Sunsbury, Adams, and parts of Malaga and Center townships, to the west, in Monroe County. Somewhere under cover in the southwestern part of the Woodsfield quadrangle the bed abruptly thins, and it is of no value farther southwest for many miles. At Temperanceville and northwestward toward Quaker City the line limiting the minable coal can readily be drawn, as represented on the maps (Pls. V and XII). For the area to the south, where the coal lies under cover, the line is drawn with less certainty from information derived from a few core-drill records and from oil-well records.



INDEX MAP AND SECTIONS SHOWING EXTENT AND THICKNESS OF PITTSBURGH COAL BED IN SUMMERFIELD AND WOODSFIELD QUADRANGLES

1 0 1 2 3 4 5 MILES

1922

The doubtful character of the coal in the west half of Malaga Township, much of Center Township, and all of Summit Township is such that anyone considering the purchase of coal land in this area should insist on thorough prospecting with the diamond drill. Oil-well records, no matter how many, can not serve the same purpose, and the fact that the drillers report "Pittsburgh No. 8" coal as far west as Lewisville should be given little weight. There is always a possibility that the coal so reported may consist mostly of bone and shale or that it is not the Pittsburgh bed but rather another thin bed about 30 feet higher, variously known as the Pittsburgh Rider, Red-

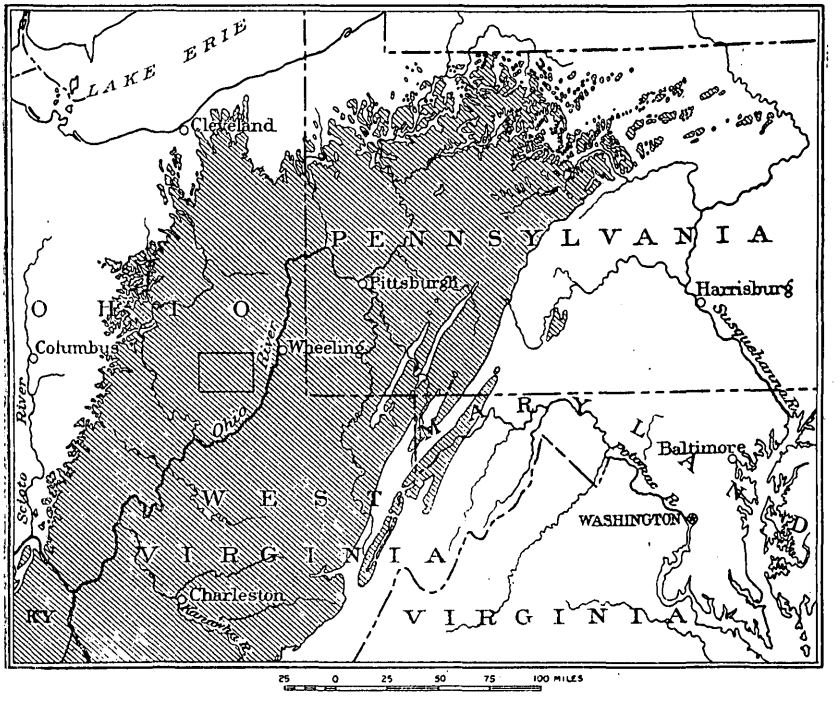


FIGURE 5.—Map of northern part of Appalachian coal field. The location of the Summerfield and Woodsfield quadrangles is shown by the rectangle in eastern Ohio opposite Wheeling, W. Va.

stone, or Pomeroy. Already a number of purchasers have acquired "gold bricks." Some of these transactions have involved lands whose worthlessness for coal is evident from direct field observations of the outcrop alone, and the purchasers could have been spared this mistake through the services of a geologist. Such lands are found in secs. 25, 26, 31, and 32 and part of sec. 33, in the northwest corner of Somerset Township, Belmont County, and in the western part of Malaga Township and possibly all of Summit Township, Monroe County. The disappearance of the coal along the valley west from Temperanceville has long been known. To the south along Rock Creek and its two forks the bed where geologically due

is marked by black shale resting on limestone. About 70 feet higher in the same valley is the Lower Meigs Creek coal, 2 to 3 feet thick, which has been mistaken for the Pittsburgh by some geologists. The same conditions prevail along the outcrop to the south across the county line, in the valleys of Seneca and Paynes forks of Wills Creek.

The township descriptions given in another part of this report set forth fully the evidence as to the thickness and character of the Pittsburgh coal in each township. A number of the measurements are also diagramatically represented on the index map (Pl. V). The coal consists of one principal bed divided into several parts by thin layers of shale or "sulphur," some of which are fairly constant, whereas others are of local extent. Above the principal bench there may be a foot or so of clay overlain by several inches of impure coal commonly known as the roof coal. Elsewhere the roof coal may be missing or replaced by shale or sandstone. As a rule the coal bed is found to vary considerably in thickness where it is directly overlain by sandstone—for example, in parts of Wayne and Goshen townships, as shown by core-drill data, and in parts of the Cochran mine at Baileys Mills.

In southwestern Pennsylvania, where the Pittsburgh coal is at its best, the bed is divided into a number of parts by thin layers of shale that are almost as persistent as the coal itself. The several parts of the coal bed have been given names by the miners, and some of them are recognizable in the following section measured in the Samuel Sayre mine, 1½ miles northwest of Quaker City.

Section of coal bed in Sayre mine.

	Ft.	in.
Shale, unmeasured:		
Bony coal		4
"Breast" coal:		
Coal		9
"Sulphur"		1
Coal	1	8
Shale		½
"Bearing in" coal		3½
Shale		½
"Bottom" coal		11

The heating value and chemical composition of the Pittsburgh coal are shown by analyses of four samples, Nos. 20187, 20188, 20230, and 20178 in the table on page 39. The table also includes for comparison the analysis of a sample from the Connellsville coke region of southwestern Pennsylvania.[10] Evidently the Pittsburgh coal of Belmont County ranks considerably higher in heating value than the

[10] Analyses of coals in the United States, with descriptions of mine and fuel samples collected July 1, 1904, to June 30, 1910: U. S. Bur. Mines Bull. 22, p. 168 (laboratory No. 4411).

Meigs Creek and other coals in the area, but it does not compare so favorably with the Pittsburgh of southwestern Pennsylvania.

LOWER MEIGS CREEK COAL.

The stratigraphic position of the Lower Meigs Creek coal bed, as shown by measurements recorded in the descriptions of townships, is 18 to 35 feet below the Meigs Creek coal. The two beds appear in outcrop in all parts of the Summerfield quadrangle and have been recorded in diamond-drill test holes and in oil wells to the east. In most places the Lower Meigs Creek coal is so insignificant that it has been overlooked or incorrectly identified, even by geologists. Its thickness at best is rarely found to be as much as 3 feet, and it includes numerous shaly, earthy bands and "sulphur." Both on the outcrop and to the east, where it lies far below the surface, this bed is locally 2 to 3 feet thick and with such dimensions extends throughout areas where the Meigs Creek coal is thin or lacking. In such places the Lower Meigs Creek may be mistaken for the Meigs Creek coal.

One of the most promising areas of this coal is in the valleys of westward-flowing tributaries of Wills Creek between Temperanceville and Monroefield. Here the coal lies under a massive sandstone and rests on gray limestone. At a few places the Meigs Creek coal appears about 30 feet higher. The Pittsburgh coal is of no value on the outcrop in this vicinity, although not so reported by some observers who have mistaken the Lower Meigs Creek coal for the Pittsburgh bed.

This coal is also 2 feet or more thick at certain places near Barnesville and northwest of Temperanceville, toward Quaker City. Detailed information concerning the bed in each township is given in the township descriptions.

No recent openings in the Lower Meigs Creek coal were discovered, and therefore no samples were taken for analysis. From numerous measurements and notes given in the township descriptions it is evident that the value of the coal is diminished by the presence of "sulphur" bands and numerous thin shaly partings. In its extent as a minable bed and in quality it can in no way compare favorably with the Meigs Creek coal.

MEIGS CREEK COAL.

The Meigs Creek coal ranks next to the Pittsburgh in value in the Woodsfield and Summerfield quadrangles. Along the outcrop it is best in the ridges westward from Summerfield to Sarahsville and southward for many miles beyond the limits of the area described in this report. From Summerfield northeastward to a point within a few miles of Barnesville is a barren area where the coal is thin or

lacking, but west of this area, in the high ridges, there is a narrow productive belt extending from Mount Ephraim through Batesville and Baileys Mills along the west side of Barnesville.

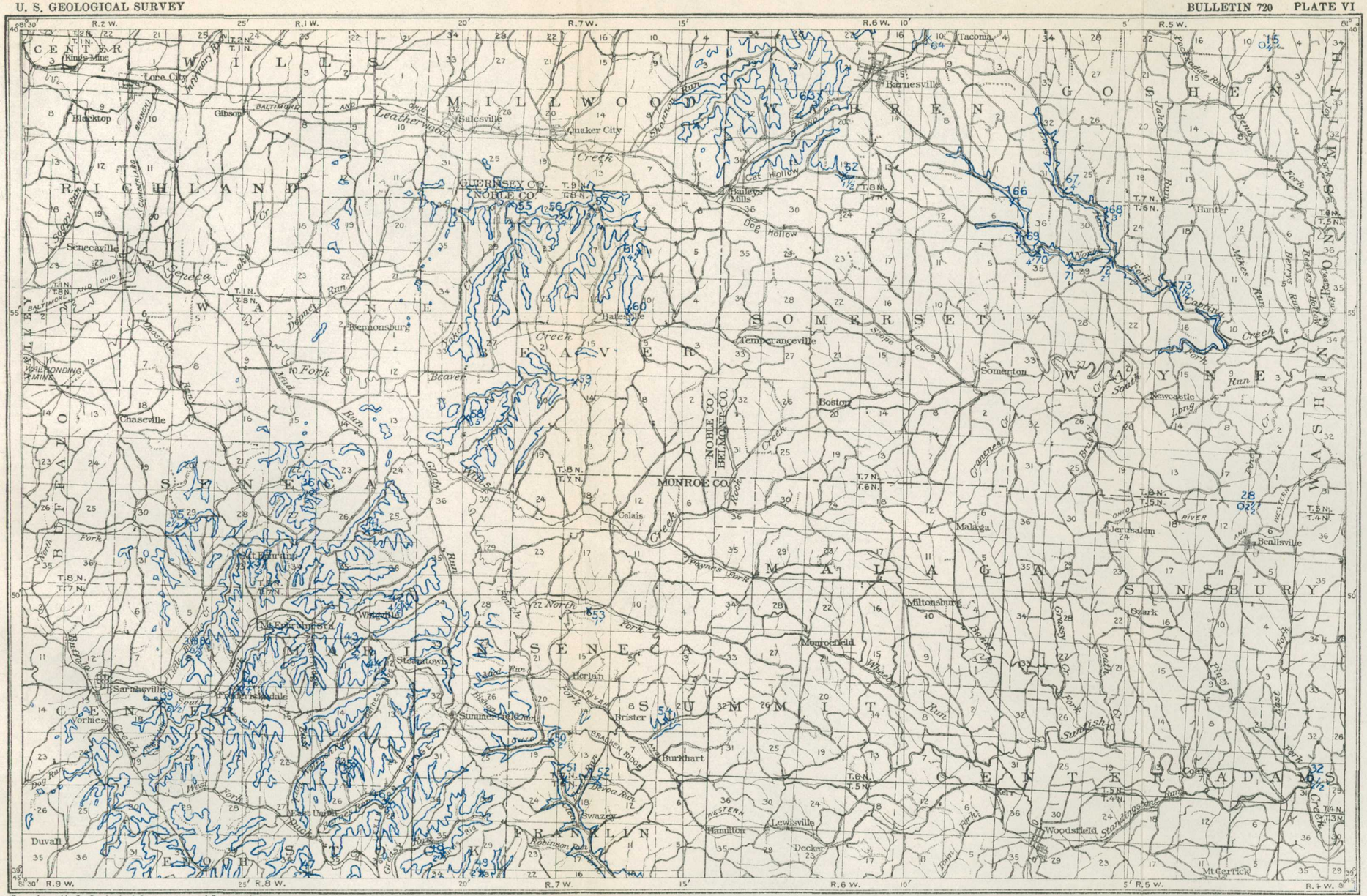
East of Barnesville the coal appears in outcrop low in the valley of Long Run and other tributaries of Captina Creek. Its southeastward dip is at about the same rate as the gradient of the streams, and therefore the coal lies 10 to 40 feet above the creek bed for miles and has been mined in a small way at dozens of places. Near the junction of North and South forks of Captina Creek the bed dips below the valley and is 10 to 20 feet under cover eastward for about 3 miles. According to report the coal has been stripped during low water near the mouth of Piney Creek. About 2 miles farther east, at Alledonia, it is at least 20 feet below the creek bed, but it rises again to the surface about 1 mile north of Alledonia, along and near the mouth of Bend Fork, where the coal has been mined for many years.

Careful search along Sunfish Creek in the southeastern part of the Woodsfield quadrangle failed to reveal an outcrop of the Meigs Creek coal, although its position for several miles should be near the valley floor or only slightly below, as indicated by the position of the Uniontown coal in the hills that border the valley.

The extent of the Meigs Creek coal as a valuable bed under cover in the Woodsfield quadrangle is probably considerable. A careful inspection of the outcrop along Captina Creek shows the bed to be 3 to 4 feet thick at numerous places. It is subject to abrupt variations in thickness and quality along its outcrop, however, and therefore should be carefully prospected by the person who is considering the carrying on of mining operations on a large scale. In structure or the number of partings and shale bands it also shows considerable variation. The bed is evidently in no way comparable to the Pittsburgh coal as to persistence and general reliability.

Detailed information as to the bed on its outcrop in each township is set forth in another part of this report. The variation in thickness is shown roughly by Plate VI and the accompanying sections.

Among oil men the Meigs Creek coal is commonly known as the Mapletown and is so recorded in wells drilled for oil in all parts of the Woodsfield quadrangle. To the west, in the vicinity of Summerfield, it has been mistaken for the Pittsburgh coal by some people. The reliability of the reports of drillers as to the thickness of the Meigs Creek is of course subject to question, for the usual reasons, and also because another coal bed, the Lower Meigs Creek, lies 18 to 35 feet lower and is locally 2 to 3 feet thick where the Meigs Creek is thin or lacking, as on the outcrop south of Temperanceville, in valleys tributary to Seneca Fork, and also in several oil fields to the east where the coals have been recorded.



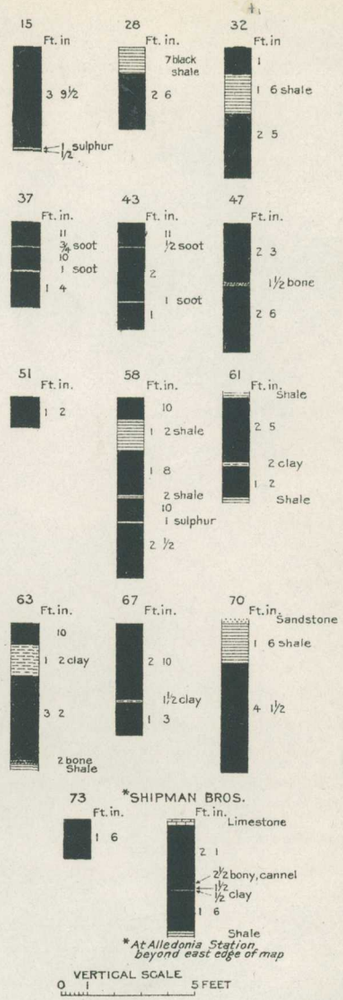
Base from U. S. Geological Survey maps of Summerfield and Woodsfield quadrangles.

A. HOEN & CO. BALTIMORE

INDEX MAP AND SECTIONS SHOWING EXTENT AND THICKNESS OF MEIGS CREEK COAL BED IN SUMMERFIELD AND WOODSFIELD QUADRANGLES

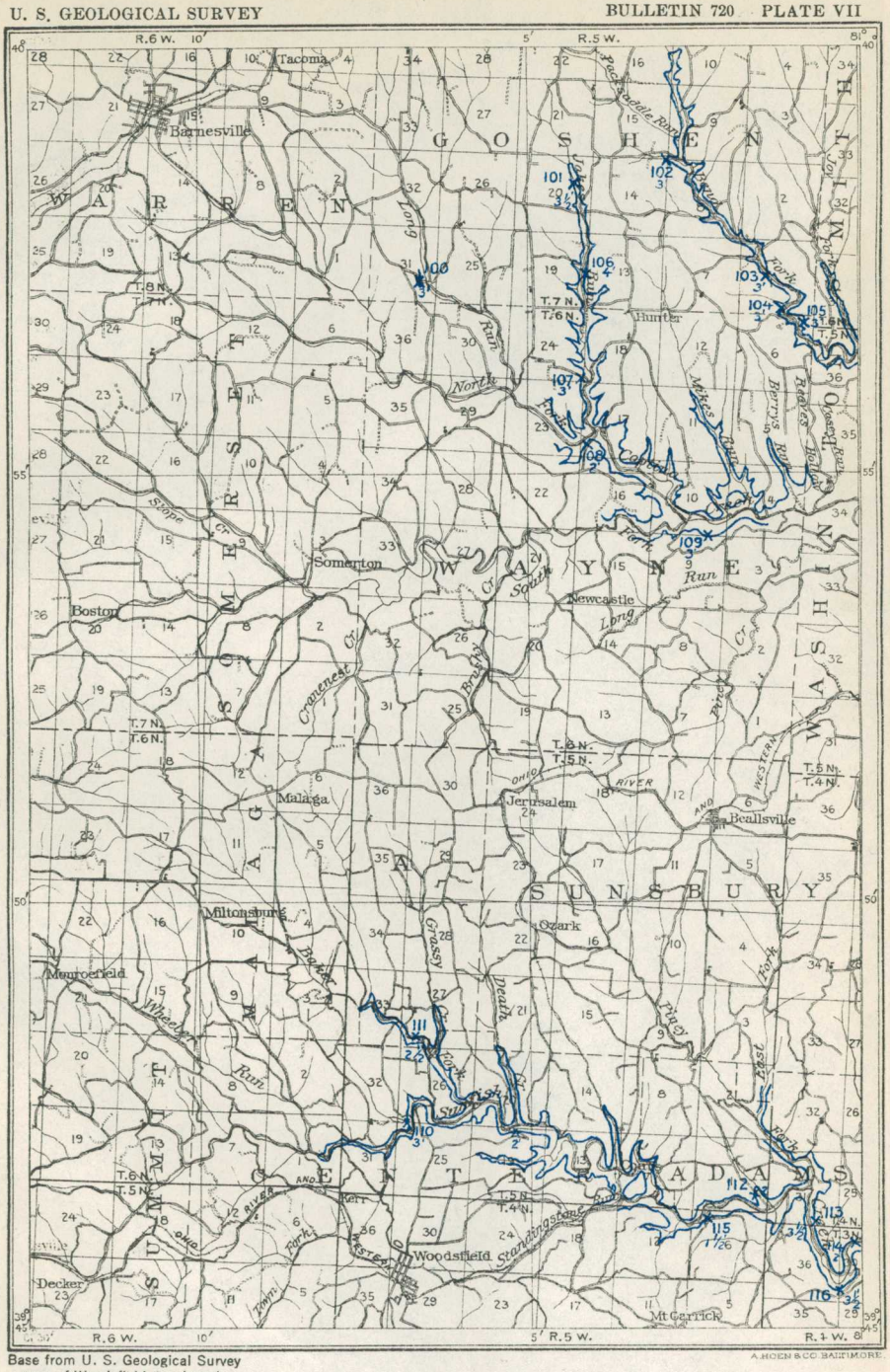
1 0 1 2 3 4 5 MILES

1922



EXPLANATION

- Outcrop of Meigs Creek coal where 1 foot or more thick
- 32 / 0½ Coal test hole where section was measured. Thickness shown to nearest half foot
- 40 / X 4' Locality where section was measured. Thickness shown to nearest half foot



101
Ft. in. Shale
1 1
3 shale
11
3½ shale
9

102
Ft. in. Shale
1 10
4 clay
1 1

103
Ft. in.
2 6
1 shale
⅗ shale
7

105
Ft. in
1 11
1 bone
¾ clay
6

106
Ft. in. Shale
3 11
Shale

108
Ft. in. Sandstone
6
3 3
Shale

111
Ft. in. Shale
½ shale
1
1 1 clay
2
5 clay
9½
5 clay
10
Shale

113
Ft. in.
1 7 coal, upper portion bony
3½ shale
10½
2 shale
6

VERTICAL SCALE
0 1 5 FEET

EXPLANATION

Outcrop of Uniontown coal where 1 foot or more thick

115 / 1½ Locality where section was measured. Thickness shown to nearest half foot

Base from U. S. Geological Survey map of Woodsfield quadrangle.

A. HOEN & CO. BALTIMORE

INDEX MAP AND SECTIONS SHOWING EXTENT AND THICKNESS OF UNIONTOWN COAL BED IN WOODSFIELD QUADRANGLE

1 0 1 2 3 MILES

1922

Samples of the Meigs Creek coal were cut in five mines at widely separated localities. Sections of the coal bed at each locality are given on the index map (Pl. VI). Sections of the beds are also given on pages 45–46, and the calorific values and analyses of the samples on page 40.

UNIONTOWN COAL.

The extent of the Uniontown coal bed in workable thickness along its outcrop is less than that of the Waynesburg, about 60 feet higher, or the Meigs Creek, about 110 feet lower. Although geologically due in nearly all parts of the Woodsfield quadrangle and in much of the Summerfield quadrangle, it is of no economic importance, except along Sunfish Creek eastward from Woodsfield and along Captina Creek and its tributaries Jakes Run, Bend Fork, and Joy Run, in the northeast corner of the area. The coal is soft and earthy and is characterized by shale bands, which vary in thickness and number from place to place and are locally so numerous that they can not be separated from the coal by the miner. The character of the coal is illustrated by sections that accompany the index map (Pl. VII). On this map the extent of the coal where it is 1 foot or more in thickness is represented.

Along the ridge roads in the vicinity of Summerfield the Uniontown coal forms conspicuous "blossoms" that would indicate a good thickness. Where seen in clean exposures in the railroad cuts, however, it is found to consist largely of worthless bone interbedded with coal.

At Barnesville, Temperanceville, and Lewisville there is commonly a few inches of coal at the Uniontown horizon, together with more or less bony coal. Locally there are two thin layers of coal separated by 6 to 10 feet of shale.

The quality of the coal has been determined from samples taken at two localities. The results of the analyses are given in the table on page 40. The calorific value of the two samples as received is 11,660 and 11,540 British thermal units, and the ash content is 15.3 per cent in each sample. The heating value is similar to that of the Waynesburg coal, but considerably less than that of the Pittsburgh.

It is evident that the Uniontown coal will find its chief use as a convenient source of fuel for the farmers. The presence of numerous shale bands and a high ash content will be a serious drawback to its being mined for the market, even where the thickness is as much as 3 feet.

WAYNESBURG COAL.

The Waynesburg coal lies 265 to 285 feet above the Pittsburgh coal as found in the north half of the Woodsfield quadrangle. In that area it has long been mined, especially in the vicinity of Boston,

Somerton, Newcastle, and Hunter, and is designated the Four Foot Hard coal by the farmers. The bed is 2 to 3 feet think throughout nearly all of Somerset Township and 3 feet or more in parts of Goshen and Wayne townships, Belmont County. No exposures as thick as 1 foot were found to the south in Monroe County. The outcrop of the bed where 1 foot or more in thickness is represented on the index map (Pl. VIII).

The coal has been mined in a small way by the farmers for many years. The usual procedure is to drive a drift into the hillside from which the supply necessary for home use is taken out for a few seasons until the roof falls. Then another drift is made, and in this manner the hills have become scarred with numerous prospect holes. Many measurements in natural exposures and small mines were made in each township, and these are given in the township descriptions. Representative sections of the bed are given on Plate VIII.

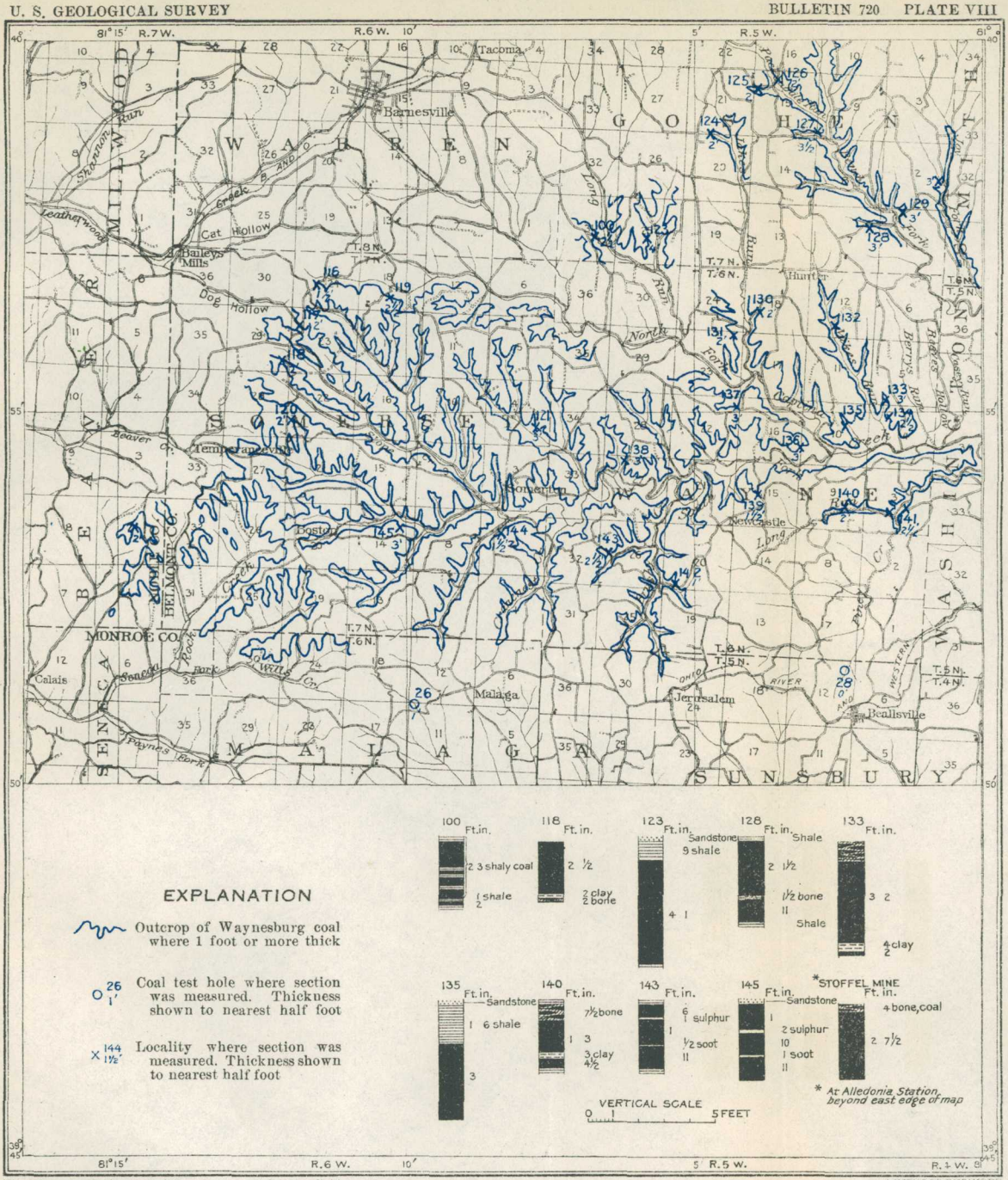
The Waynesburg coal was sampled at four localities, and the results are given in the table on page 41. The coal is high in ash, averaging about 15.2 per cent in the coal as it comes from the mine, but not nearly so high as the Washington coal, which shows 21 per cent. In heating value the coal averages about 11.730 British thermal units, a little more than the Washington coal but considerably less than the Pittsburgh coal.

The Waynesburg coal, as is evident from the sections, varies considerably in thickness from place to place and has no characteristic partings that are persistent throughout wide areas. Numerous sections and local details concerning the coal are given in the township descriptions.

WASHINGTON COAL.

The Washington is the highest coal bed in the geologic column of the area under consideration. There is, it is true, more or less impure bony coal about 140 feet higher at a few localities, but nowhere is it worthy of special attention as coal. The Washington bed almost everywhere on its outcrop consists of a layer 1 to 8 feet thick. It occurs, as shown by the maps (Pls. IX and XII), well up in the hills in the vicinity of Woodsfield, and gradually rises northward to the tops of the highest hills a little beyond the Belmont County line.

There are locally other coal beds 10 feet and 26 feet above the Washington coal, and where these are of any prominence they may be mistaken for the Washington. These "rider" coals were seen in the eastern part of Goshen Township and also in Malaga Township. Their thickness is nowhere as great as that of the Washington coal, and the beds will not be confused except where the exposures are poor.



EXPLANATION

Outcrop of Waynesburg coal where 1 foot or more thick

26 / 1′ — Coal test hole where section was measured. Thickness shown to nearest half foot

144 / 1½′ — Locality where section was measured. Thickness shown to nearest half foot

* At Alledonia Station, beyond east edge of map

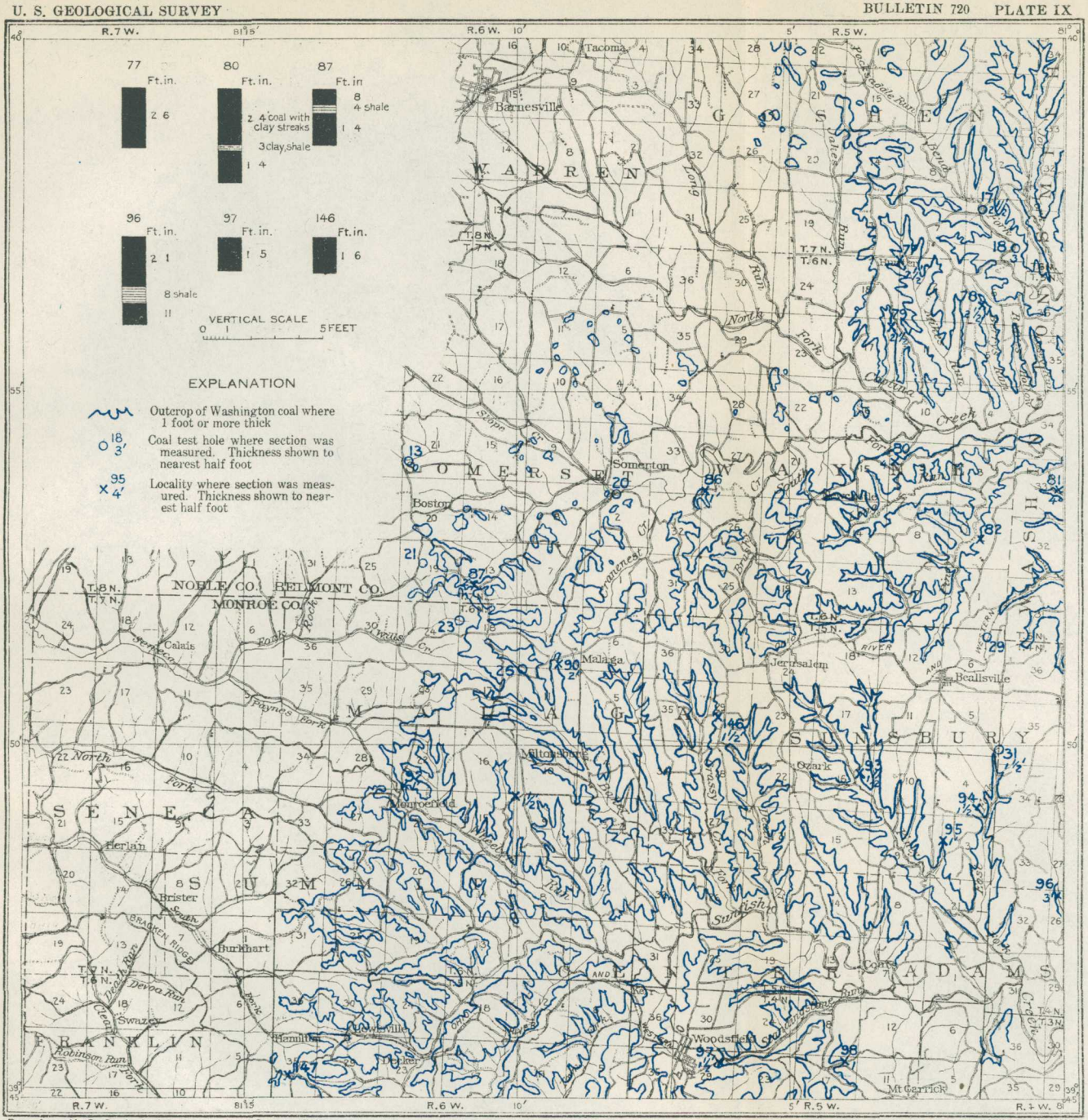
Base from U. S. Geological Survey maps of Summerfield and Woodsfield quadrangles.

A. HOEN & CO. BALTIMORE

INDEX MAP AND SECTIONS SHOWING EXTENT AND THICKNESS OF WAYNESBURG COAL BED IN SUMMERFIELD AND WOODSFIELD QUADRANGLES

1 0 1 2 3 4 MILES

1922



Base from U. S. Geological Survey maps of Summerfield and Woodsfield quadrangles.

A. HOEN & CO. BALTIMORE

INDEX MAP AND SECTIONS SHOWING EXTENT AND THICKNESS OF WASHINGTON COAL BED IN SUMMERFIELD AND WOODSFIELD QUADRANGLES

1 0 1 2 3 4 MILES

1922

The thickness and structure of the Washington coal is shown by numerous measurements given in the township descriptions, a few of which are repeated on Plate IX for the convenience of the reader. The bed where thickest, as seen in Sunbury Township and to the north near Captina Creek, consists of two layers each 1 to 2 feet thick, separated by a foot or so of clay shale. It shows a similar make-up also in other localities to the west.

This coal has been mined entirely by the farmers for their own use, and the method followed has, except at a few small drift mines, been stripping along the outcrop in ravines. The thinness, the shaly partings, and the extremely high ash content (21 per cent) are unfavorable features of the coal. Throughout most of the area there are other more accessible coal beds to supply the local demand, and much coal from commercial mines is also distributed to the villages on the railroads. Therefore the prospective value of the Washington coal is slight.

A sample was taken in the S. A. Moore mine, sec. 33, Washington Township, one of the few places where the coal has been extracted by drift mining. The section of the bed is given on Plate IX, and the analysis of the sample on page 41.

The measurements given on the index map are selected as representative of the coal in the areas mentioned. The bed is evidently at its best at the east side of the Woodsfield quadrangle, where it comprises an upper and a lower bench. In the section measured at Hunter there is a suggestion of the two benches, but the upper bench of coal is decidedly shaly. In the vicinity of Woodsfield and to the east and west for several miles the coal consists of a single layer 14 to 17 inches thick. Before the construction of the railroad and the shipping of fuel from more distant sources, this coal, being almost the only bed of any value in the area, was extensively stripped. The coal as found in the high hills along the county line north of Malaga commonly shows the two benches represented in the section at locality 87. (See Pl. IX.) Roadside and ravine exposures are plentiful, but few of the farmers have found it necessary to use this coal, because they can obtain a more convenient supply from the Waynesburg bed, which has a fair development in the same vicinity.

COMPOSITION OF THE COAL.

COAL SAMPLING.

The method of sampling of coal beds as described by Campbell [11] were followed in the collection of the samples. All samples are collected in mines or prospects at the freshest place available. The

[11] Miscellaneous analyses of coal samples from various fields of the United States: U. S. Geol. Survey Bull. 531, pp. 331-333, 1913.

collector faces up the bed until fresh material is bared and then obtains his sample by making a uniform cut across the bed from roof to floor, including all such benches and partings as an experienced and careful miner would include in commercial coal and throwing out such impurities as would certainly be excluded in practical operation. He cuts sufficient coal to give at least 6 pounds for each foot of coal bed sampled. The sample is pulverized in the mine until it will pass through a ½-inch mesh and then is quartered down until about 4 pounds remains. This is placed in a galvanized-iron can, sealed with adhesive tape or paraffin, and mailed to the laboratory for analysis. The sampling is done on the principle that a coal mine should be sampled as carefully as a gold mine and that the sample should be even more carefully handled after it has been taken. The object of sealing is to prevent change in the moisture content, so that the coal may reach the laboratory in practically the same condition that it exists in the mine. Coal is a very unstable substance, and great care must be exercised to prevent oxidation in the course of preparation and in transit. It is also important that the sample should consist of neither the best nor the poorest coal, but that it should be representative of the output of the mine, if one is in operation, or, if the field is undeveloped, it should represent as nearly as possible the merchantable coal that may be obtained at some time in the future when mining is carried on.

Although the aim of the geologist in obtaining a sample by the method specified above is to obtain coal that is representative of the output of the mine, practical experience has shown that this is seldom or never accomplished. Almost invariably the sample obtained in the mine contains a lower percentage of impurities than the coal which reaches the consumer. This is due largely to carelessness in mining and handling and probably could be largely eliminated were the conditions of mining more nearly ideal.

ANALYSES.

All the analytical work was done by chemists of the Bureau of Mines. In the table the analyses are given in three forms, marked "A," "B," and "C." Analysis A represents the sample as it comes from the mine. Analysis B represents the theoretical condition of the coal after all the moisture has been eliminated. Analysis C represents the coal after all moisture and ash have been theoretically removed. This is supposed to represent the true coal substance, free from the most significant impurities. Forms B and C are obtained from the other merely by recalculation. They should not be used except in theoretical comparisons, for they represent theoretical substances that do not exist.

The coal of this part of Ohio will sooner or later come into direct competition with coal from adjacent States, so it is best for all concerned—the operator as well as the consumer—to understand fully their comparative values. The demand for fuel in this area is perhaps not now sufficient to attract coal from Pennsylvania and West Virginia, but it eventually will be; and as soon as the local coal is shipped out of the area it will come into direct competition with better coal from the areas farther east and south.

The coal of the Summerfield and Woodsfield quadrangles may be able to hold its own indefinitely in the local market, where the demands are not so exacting as they are elsewhere, and the low freight rates on it as compared with those on coal shipped from Pennsylvania and West Virginia may make it really cheaper. But for producing steam, especially in big power or manufacturing plants, it will come into direct competition with better coal, and the tendency now is to select coal for such plants only after a long series of tests has been made to show exactly the comparative values of a number of available coals.

The coal of the Summerfield and Woodsfield quadrangles has four characteristics which should be carefully considered—high moisture, high ash, high sulphur, and low heating value. The low heating value is of course but the logical result of the high percentages of moisture and ash, for as these impurities increase the heating value of the coal diminishes. Another fact to be noted is the general decrease in the efficiency of the coal in the Appalachian trough from its east to its west side, due to the decrease in the effect of metamorphism in that direction, which is shown by the change in the comparative heating value of the Pittsburgh coal from Lore City, in this area, eastward to Frostburg, in Maryland. Thus the heating value of the Pittsburgh coal mined near Barnesville, in British thermal units, is 12,840; near Wheeling W. Va., it is 13,000; at Pittsburgh, Pa., 13,400; at Connellsville, Pa., 13,600; and at Frostburg, Md., 14,000. The best coals of Pennsylvania and West Virginia yield about 14,000 British thermal units and contain not much more than 1 per cent of sulphur and about 6 or 7 per cent of ash.

The exact quantity of sulphur in coal to be used for raising steam or for heating is not of great significance, but tbe quantity in coal to be used for making coke for smelting iron is of paramount importance. Most of the coals in this field contain too large a percentage of sulphur to be used for making coke, except perhaps the Upper Freeport coal which averages about 1½ per cent. The same is true of coal to be used for the manufacture of gas, so that these coals are unadapted to such uses until some inexpensive process of reducing materially their content of sulphur is devised.

Analyses of coal samples from the Summerfield and Woodsfield quardangles, Ohio.

[Made by the Bureau of Mines.]

Upper Freeport coal bed.

	Location.			Laboratory No.	Form of analysis.	Proximate.			Ultimate.						Heating value.	
	Sec.	T.	R.			Moisture.	Volatile matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Blacktop mine, Morris Coal Co., 1 mile west of Lore City, Guernsey County.	8	1 N.	2 W.	20264	A.	6.1	35.2	51.8	6.9	1.62	.....	.....	.....	.....	7,075	12,740
					B.	.....	37.5	55.1	7.4	1.72	.....	.....	.....	.....	7,535	13,570
					C.	.....	40.5	59.5	.....	1.86	.....	.....	.....	.....	8,135	14,650
Do	8	1 N.	W.	20265	A.	6.0	35.7	50.4	7.9	2.15	.....	.....	.....	.....	7,035	12,660
					B.	.....	38.0	53.6	8.4	2.29	.....	.....	.....	.....	7,480	13,460
					C.	.....	41.5	58.5	.....	2.50	.....	.....	.....	.....	8,170	14,700
Composite sample, mixture of Nos. 20264 and 20265	8	1 N.	.....	20266	A.	6.1	35.0	51.6	7.33	1.95	5.37	71.24	1.39	12.72	7,060	12,710
					B.	.....	37.3	54.9	7.80	2.08	5.00	75.84	1.48	7.80	7,520	13,530
					C.	.....	40.5	59.5	.....	2.26	5.42	82.26	1.61	8.45	8,155	14,680
Cleveland mine, Morris Coal Co., Senecaville, Guernsey County.	21	1 N.	2 W.	20261	A.	5.4	35.8	50.8	8.0	1.64	.....	.....	.....	.....	7,100	12,780
					B.	.....	37.8	53.7	8.5	1.73	.....	.....	.....	.....	7,505	13,510
					C.	.....	41.4	58.6	.....	1.89	.....	.....	.....	.....	8,205	14,770
Do	21	1 N.	2 W.	20262	A.	6.4	33.7	52.1	7.8	2.16	.....	.....	.....	.....	7,015	12,630
					B.	.....	36.0	55.7	8.3	2.30	.....	.....	.....	.....	7,495	13,490
					C.	.....	39.2	60.8	.....	2.51	.....	.....	.....	.....	8,175	14,720
Composite sample, mixture of Nos. 20261 and 20262	21	1 N.	2 W.	20263	A.	6.0	34.2	52.0	7.83	1.98	5.38	71.38	1.32	12.11	7,065	12,720
					B.	.....	36.4	55.3	8.33	2.11	5.01	75.93	1.40	7.22	7,520	13,530
					C.	.....	39.7	60.3	.....	2.30	5.47	82.83	1.53	7.87	8,200	14,760
Walhonding mine No. 2, 1 mile east of Hartford, Guernsey County.	11	8 N.	9 W.	20245	A.	6.9	34.1	53.3	5.7	.84	.....	.....	.....	.....	7,105	12,790
					B.	.....	36.6	57.2	6.2	.90	.....	.....	.....	.....	7,630	13,730
					C.	.....	39.0	61.0	.....	.96	.....	.....	.....	.....	8,130	14,640
Do	11	8 N.	9 W.	20246	A.	6.2	36.2	52.3	5.3	.88	.....	.....	.....	.....	7,225	13,000
					B.	.....	38.6	55.8	5.6	.94	.....	.....	.....	.....	7,705	13,870
					C.	.....	40.9	59.1	.....	1.00	.....	.....	.....	.....	8,170	14,700
Composite sample, mixture of Nos. 20245 and 20246	11	8 N.	9 W.	20247	A.	6.5	35.4	52.6	5.53	.88	5.49	73.42	1.37	13.31	7,190	12,940
					B.	.....	37.9	56.2	5.91	.94	5.10	78.51	1.46	8.08	7,690	13,840
					C.	.....	40.3	59.7	.....	1.00	5.42	83.44	1.55	8.59	8,170	14,710

Anderson coal bed.

Prospect of Andy Slovak, 1 mile east of Hartford, Guernsey County.	11	8 N.	9 W.	20243	A.	4.3	40.2	45.1	10.39	3.75	5.37	68.30	1.50	10.69	6,940	12,490
					B.	.....	42.0	47.1	10.86	3.92	5.11	71.39	1.57	7.15	7,255	13,060
					C.	.....	47.2	52.8	.....	4.40	5.73	80.09	1.76	8.02	8,140	14,650

Pittsburgh coal bed.

Small mine of Samuel Sayre, 1½ miles northwest of Quaker City, Guernsey County.	21	9 N.	7 W.	20178	A.	4.4	41.1	45.8	8.74	4.85	5.37	69.30	1.26	10.48	7,060	12,710
					B.	.....	43.0	47.9	9.14	5.07	5.11	72.46	1.32	6.90	7,385	13,290
					C.	.....	47.4	52.6	.....	5.58	5.62	79.75	1.45	7.60	8,125	14,630
Cochran mine No. 2, Bixler Ohio Coal Co., Baileys Mills, 3½ miles southeast of Barnesville, Belmont County.	31	8 N.	6 W.	20187	A.	4.1	42.7	43.9	9.3	4.46	.....	.....	.....	.....	7,075	12,730
					B.	.....	44.6	45.7	9.7	4.65	.....	.....	.....	.....	7,380	13,280
					C.	.....	49.4	50.6	.....	5.15	.....	.....	.....	.....	8,175	14,710
Do	31	8 N.	6 W.	20188	A.	3.7	43.3	44.4	8.6	4.45	.....	.....	.....	.....	7,195	12,950
					B.	.....	44.9	46.1	9.0	4.62	.....	.....	.....	.....	7,470	13,450
					C.	.....	49.3	50.7	.....	5.07	.....	.....	.....	.....	8,205	14,770
Composite sample, mixture of Nos. 20187 and 20188.	31	8 N.	6 W.	20189	A.	3.9	43.1	43.9	9.07	4.36	5.46	69.97	1.27	9.87	7,130	12,840
					B.	.....	44.8	45.8	9.44	4.54	5.23	72.80	1.32	6.67	7,420	13,360
					C.	.....	49.5	50.5	.....	5.01	5.77	80.39	1.46	7.37	8,195	14,750
Jefferies mine, Temperanceville, Belmont County..	33	7 N.	6 W.	20230	A.	3.7	41.0	45.8	9.5	4.57	.....	.....	.....	.....	7,090	12,760
					B.	.....	42.6	47.5	9.9	4.75	.....	.....	.....	.....	7,365	13,250
					C.	.....	47.3	52.7	.....	5.27	.....	.....	.....	.....	8,170	14,700

Analyses of coal samples from the Summerfield and Woodsfield quadrangles, Ohio—Continued.

[Made by the Bureau of Mines.]

Meigs Creek coal bed.

	Location.			Laboratory No.	Form of analysis.	Proximate.			Ultimate.						Heating value.	
	Sec.	T.	R.			Moisture.	Volatile matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Small mine of Wiley Carter, 1 mile north of Mount Ephraim Station, Noble County.	33	8 N.	8 W.	20235	A.	4.5	39.6	45.6	10.32	4.12	5.27	68.00	1.17	11.12	6,845	12,320
					B.	.....	41.4	47.8	10.81	4.32	5.00	71.22	1.23	7.42	7,170	12,910
					C.	.....	46.5	53.5	.....	4.84	5.61	79.85	1.38	8.32	8,040	14,470
Small mine of J. T. Moore, 1 mile west of Steamtown, Noble County.	11	7 N.	8 W.	20240	A.	3.6	41.5	44.4	10.53	4.87	5.25	68.15	1.11	10.09	6,945	12,510
					B.	.....	43.1	46.0	10.92	5.05	5.03	70.67	1.15	7.18	7,205	12,970
					C.	.....	48.4	51.6	.....	5.67	5.65	79.33	1.29	8.05	8,085	14,560
Small mine of G. W. Griffin, 3 miles southeast of Quaker City, Noble County.	11	8 N.	7 W.	20185	A.	4.2	38.4	44.8	12.62	3.61	5.22	66.87	1.20	10.48	6,740	12,130
					B.	.....	40.1	46.7	13.17	3.77	4.97	69.76	1.25	7.08	7,030	12,650
					C.	.....	46.2	53.8	.....	4.34	5.72	80.34	1.44	8.16	8,095	14,570
Small mine of Thomas Davy, 1 mile southwest of Barnesville, Belmont County.	20	8 N.	6 W.	20176	A.	4.3	39.0	45.5	11.21	3.65	5.31	68.17	1.20	10.46	6,890	12,400
					B.	.....	40.7	47.6	11.72	3.81	5.05	71.26	1.25	6.91	7,205	12,970
					C.	.....	46.1	53.9	.....	4.32	5.72	80.72	1.42	7.82	8,160	14,690
Surface prospect of Shipman Bros., 1 mile north of Alledonia, Belmont County, 2 miles east of this area.	22	5 N.	4 W.	20237	A.	3.5	37.2	41.5	17.8	4.05	.....	.....	.....	.....	6,395	11,510
					B.	.....	38.5	43.0	18.5	4.20	.....	.....	.....	.....	6,630	11,930
					C.	.....	47.2	52.8	.....	5.15	.....	.....	.....	.....	8,130	14,630
Uniontown coal bed.																
Prospect of Peter Kamp, 2 miles east of Hunter, Belmont County. Coal weathered.	1	7 N.	5 W.	20775	A.	4.7	34.2	45.8	15.34	2.85	4.95	63.71	1.33	11.82	6,480	11,660
					B.	.....	35.9	48.0	16.10	2.99	4.65	66.85	1.40	8.01	6,800	12,240
					C.	.....	42.8	57.2	.....	3.56	5.54	79.68	1.67	9.55	8,105	14,590
Prospect of Charles Mobley, 5 miles east of Woodsfield, Monroe County. Coal weathe ed.	31	4 N.	4 W.	20259	A.	4.9	35.9	43.9	15.32	3.96	4.87	63.59	1.19	11.07	6,410	11,540
					B.	.....	37.8	46.1	16.10	4.16	4.55	66.83	1.25	7.11	6,740	12,130
					C.	.....	45.0	55.0	.....	4.96	5.42	79.65	1.49	8.48	8,030	14,460

Waynesburg coal bed.

Small mine of George Thomas, 1½ miles east of Boston, Belmont County.	14	7 N.	6 E.	20241	A.	4.5	36.6	44.2	14.75	3.02	5.10	65.32	1.16	10.65	6,555	11,800
					B.	.....	38.3	46.3	15.44	3.16	4.81	68.37	1.21	7.01	6,860	12,350
					C.	.....	45.3	54.7	.....	3.74	5.69	80.85	1.43	8.29	8,110	14,600
Small mine of Howard Brown, 2 miles southeast of Somerton, Belmont County.	26	6 N.	5 W.	20234	A.	4.4	37.1	43.1	15.4	2.90	.....	.....	.....	.....	6,475	11,660
					B.	.....	38.8	45.0	16.2	3.03	.....	.....	.....	.....	6,775	12,190
					C.	.....	46.3	53.7	.....	3.61	.....	.....	.....	.....	8,080	14,540
Prospect of J. D. Milhoan, 1½ miles northeast of Hunter, Belmont County.	7	7 N.	5 W.	20174	A.	4.3	35.3	44.2	16.22	3.53	4.98	64.10	1.20	9.97	6,445	11,610
					B.	.....	36.9	46.1	16.95	3.69	4.70	66.98	1.25	6.43	6,735	12,130
					C.	.....	44.4	55.6	.....	4.44	5.66	80.65	1.50	7.75	8,110	14,600
Small mine of Nathan Davis, 1 mile southwest of Alledonia, Belmont County, 1 mile east of this area.	27	5 N.	4 W.	20236	A.	4.6	36.8	44.2	14.4	2.59	.....	.....	.....	.....	6,575	11,830
					B.	.....	38.6	46.3	15.1	2.71	.....	.....	.....	.....	6,890	12,400
					C.	.....	45.5	54.5	.....	3.19	.....	.....	.....	.....	8,120	14,610

Washington coal bed.

Prospect of S. A. More, 1½ mile southwest of Alledonia, Belmont County.	33	5 N.	4 W.	20238	A.	4.1	33.7	41.2	21.00	2.86	4.76	59.93	1.09	10.36	6,010	10,820
					B.	.....	35.1	43.0	21.89	2.98	4.49	62.48	1.14	7.02	6,270	11,280
					C.	.....	45.0	55.0	.....	3.81	5.75	79.99	1.46	8.99	8,025	14,440

Average of analyses for each coal.

Coal bed.	Sulphur.	Ash.	British thermal units.	Moisture.
Upper Freeport (9 analyses)	1.57	7.0	12,770	6.2
Anderson (1 analysis)	3.75	10.4	12,490	4.3
Pittsburgh (5 analyses)	4.54	9.0	12,800	4.0
Meigs Creek (5 analyses)	4.06	12.5	12,170	4.0
Uniontown (2 analyses)	3.40	15.3	11,600	4.8
Waynesburg (4 analyses)	3.01	15.2	11,730	4.5
Washington (1 analysis)	2.86	21.0	10,820	4.1

MINES FROM WHICH SAMPLES WERE OBTAINED.

In the following descriptions, which are arranged in the same order as the table of analyses, the numbers in black-face type are the laboratory numbers of the samples.

UPPER FREEPORT COAL.

20264, 20265. Blacktop, a shaft mine of the Morris Coal Co. on a spur from the Baltimore & Ohio Railroad, 1 mile west of Lore City, sec. 8, T. 1 N., R. 2 W., Richland Township, Guernsey County. Upper Freeport coal at top of Allegheny formation; thickness variable. The bed was measured and sampled at two points by D. Dale Condit on November 28, 1914, as described below.

Sections of coal bed in Blacktop mine.

	20264	20265
	Ft. in.	*Ft. in.*
Roof, shale.		
Coal	2 6	2 3
Coal, bony	1½	2½
Coal	1 2½	1 7
Bone	[a] 2	[a] 2½
Coal	10	1 9
Floor, clay.		
Thickness of bed	4 10	6
Thickness of coal sampled	4 8	5 9½

[a] Not included in sample.

20264. Entry 23 east off main south entry, 6,200 feet S. 15° E. of shaft. The mine was dry at the point of sampling.

20265. Near end of main south entry, 7,300 feet S. 12° W. of shaft.

The upper bony band in the coal was included in the samples. The lower bone band is excluded in mining. The shaft is about 102 feet deep. The average daily output in 1914 was reported to be 1,000 tons.

20261, 20262. Cleveland, a shaft mine of the Morris Coal Co. on a branch of the Baltimore & Ohio Railroad at Senecaville, sec. 21, T. 1. N., R. 2 W., Richland Township, Guernsey County. Upper Freeport coal; thickness variable. Sandstone roll encountered in workings. The bed was measured and sampled at two points by Frank Reeves on November 28, 1914, as described below.

Sections of coal bed in Cleveland mine.

	20261	20262
	Ft. in.	*Ft. in.*
Roof, shale or sandstone.		
Coal	1 6	8
"Soot"	½	½
Coal	8	1 0
Bone	a 1	
Coal	7	
"Soot"	½	½
Coal	4	7
"Soot"	½	
Coal	8	
Bone	a 2	a¾
Coal	9	6
"Soot"	a ½	½
Coal	4	8
"Soot"	a ½	½
Coal	9	6
Bone		a 2
Coal		4
Bone		a 1
Coal		7
Floor, clay.		
Thickness of bed	5 11¾	5 3¼
Thickness of coal sampled	5 7¾	4 11½

a Not included in sample.

20261. Room No. 5 east, off main north entry, 5,000 feet east of shaft.
20262. 10,500 feet north of shaft.

20245, 20246. Waldhonding No. 2, a shaft mine of the Cambridge Colliery Co. on a spur of the Baltimore & Ohio Railroad, sec. 11, T. 8 N., R. 9 W., Valley Township, 1 mile east of Hartford. Upper Freeport coal; thickness variable. The bed was measured and sampled at two points by Frank Reeves on November 27, 1914, as described below.

Sections of coal bed in Waldhonding No. 2 mine.

	20245	20246
	Ft. in.	*Ft. in.*
Roof, shale.		
Coal	2	1 9
"Soot"	¼	a ½
Coal	8	1 6
"Soot"	a ½	¼
Coal	2 0	4
"Soot"	a ½	a ½
Coal	7	9
"Soot"	¼	
Coal	8	
Clay	a ¾	
Coal	6	
Bone	a 1½	a 1
Coal	1 2	10
Floor, clay.		
Thickness of bed	6 ¾	5 4¼
Thickness of coal sampled	5 9½	5 2½

a Not included in sample.

20245. 600 feet southeast of shaft.
20246. 3,400 feet northwest of shaft.

ANDERSON COAL.

20243. Drift mine operated by Andy Slovak at Waldhonding, a mining village 1 mile east of Hartford, in sec. 11, T. 8 N., R. 9 W., Valley Township, Guernsey County, on branch of Baltimore & Ohio Railroad. Anderson (Bakerstown) coal; thickness averages about 1¾ feet. The coal is mined in a very small way for local use. The bed has a similar thickness throughout a considerable area but has been

mined at only a few places. The sample was cut by Frank Reeves on November 27, 1914, at a point 75 feet from the mine mouth, where the bed consists of 22 inches of coal with a sandstone roof and shale floor.

PITTSBURGH COAL.

20178. Drift mine operated by Samuel Sayre, locality 1, sec. 21, T. 9 N., R. 7 W., Millwood Township, 1½ miles northwest of Quaker City, Guernsey County. Pittsburgh coal; thickness averages about 4 feet. The two shale partings in the lower portion, so characteristic of the bed, are persistent in this region. The other divisions are less uniform. The sample was taken from a fairly dry room at a point 350 feet east of the mine mouth. The vertical cover is about 70 feet. This and other small mines in the neighborhood supply the country demand. The bed was sampled by D. Dale Condit on November 20, 1914, as described below.

Section of coal bed in Samuel Sayre's mine.

	20178
	Ft. In.
Roof, clay shale.	
Coal, bony	[a] 4
Coal	9
"Sulphur"	[a] 1
Coal	1 8
Shale	[a] ½
Coal	3½
Shale	[a] ½
Coal	11
Floor, clay.	
Thickness of bed	4 1½
Thickness of coal sampled	3 7½

[a] Not included in sample.

20187, 20188. Cochran No. 2, a drift mine of the Bixler Ohio Coal Co., locality 8, sec. 31, T. 8 N., R. 6 W., Warren Township, Belmont County, on the Baltimore & Ohio Railroad at Baileys Mills, 3½ miles southwest of Barnesville. Pittsburgh coal; thickness about 4 feet. The bed dips eastward at an an angle of less than 1°. In the mine is a sandstone "roll" which reduces the thickness of the coal in certain entries. The output of the mine is shipped to Columbus and other points west. The coal was measured and sampled at two points by R. V. A. Mills on November 25, 1914, as described below.

Sections of coal bed in Cochran No. 2 mine.

	20187	20188
	Ft. in.	*Ft. in*
Roof, clay or sandstone.		
Coal	9	1 1
"Sulphur"	[a] 1	[a] 1
Coal	2 11	.....
Coal, impure	.....	5
Bone	.....	1
Coal	.....	6
"Sulphur"	.....	¼
Coal	.....	2
Floor, clay.		
Thickness of bed	3 9	4 2¼
Thickness of coal sampled	3 8	4 1¼

[a] Not included in sample.

20187. Face of main north entry, 1 mile north of mine mouth.
20188. Room 6, off No. 15 west entry, three-fourths mile north of mine mouth.

20230. Jefferies wagon mine, Temperanceville, locality 12, sec. 33, T. 7 N., R. 6 W., Somerset Township, Belmont County, 4 miles south of the Baltimore & Ohio Railroad. Pittsburgh coal; thickness fairly uniform, about 3 feet 8 inches. The

thickness of the coal in this mine varies only slightly. In the same vicinity, however, the coal thins toward the south. It is of little if any importance in the hills south of Temperanceville. The bed was measured and sampled at a point 600 feet north of the mine mouth by R. V. A. Mills on November 22, 1914, as described below.

Section of coal bed in Jefferies mine.

	20230
	Ft. in.
Roof, clay.	
Coal	7½
"Soot" streak	a ½
Coal	4½
Bone	a ¾
Coal	1 7
"Sulphur"	a ½
Coal	1
Floor, clay.	
Thickness of bed	3 8½
Thickness of coal sampled	3 7

a Not included in sample.

MEIGS CREEK COAL.

20235. A small mine on the Wiley Carter farm, locality 37, sec. 33, T. 8 N., R. 8 W., Seneca Township, Noble County, 1 mile north of Mount Ephraim Station on Ohio River & Western Railroad. Meigs Creek (Sewickley) coal. The sample was cut in a fairly dry room 300 feet west of the mine mouth. The bed was measured and sampled by Frank Reeves on November 26, 1914, as described below.

Section of bed in Wiley Carter's mine.

	20235
	Ft. in.
Roof, shale.	
Coal	11
"Soot"	a ¾
Coal	10
"Soot"	a 1
Coal	1 4
Floor, shale.	
Thickness of bed	3 2¾
Thickness of coal sampled	3 1

a Not included in sample.

20240. A small mine on the J. T. Moore farm, locality 43, sec. 11, T. 7 N., R. 8 W., Marion Township, Noble County, 1 mile west of Steamtown, the nearest station on the Ohio River & Western Railroad. Meigs Creek (Sewickley) coal. The sample was cut at a point 480 feet south of the mine mouth, where the vertical cover is about 80 feet. The bed was measured and sampled by Frank Reeves on November 26, 1914, as described below.

Section of coal bed in J. T. Moore's mine.

	20240
	Ft. in.
Roof, shale.	
Coal	11
"Soot"	a ½
Coal	2 0
"Soot"	a 1
Coal	1 0
Floor, clay shale.	
Thickness of bed	4 ½
Thickness of coal sampled	3 11

a Not included in sample.

20185. A small mine on the G. W. Griffin farm, locality 61, sec. 11, T. 8 N., R. 7 W., Beaver Township, Noble County, 3 miles southeast of Quaker City, the nearest village on the Baltimore & Ohio Railroad. Meigs Creek (Sewickley) coal. The roof of clay shale is not secure. The sample was cut at a point 350 feet west of the mine mouth, where the vertical cover is about 75 feet. The bed was measured and sampled by D. Dale Condit on November 22, 1914, as described below.

Section of coal bed in G. W. Griffin's mine.

	20185
	Ft. in.
Roof, clay shale.	
Coal	2 5
Clay	a 2
Coal	1 2
Floor, clay shale.	
Thickness of bed	3 9
Thickness of coal sampled	3 7

a Not included in sample.

20176. Thomas Davy's drift mine, locality 63, sec. 20, T. 8 N., R. 6 W., Warren Township, Belmont County, 1 mile southwest of Barnesville, near the Baltimore & Ohio Railroad. Meigs Creek (Sewickley) coal; thickness fairly uniform, about 3 feet 6 inches in this mine, not including the roof coal, which is not minable. The coal is mined at several places near Barnesville for the local market. The mine at the point of sampling was dry. The sample was cut at a point 350 feet southwest of the mine mouth. The bed was measured and sampled by D. Dale Condit on November 20, 1914, as described below.

Section of coal bed in Thomas Davy's mine.

	20176
	Ft. in.
Roof, clay.	
Coal, impure	a 10
Clay	a1 2
Coal	3 2
Bone	a 2
Floor, shale.	
Thickness of bed	5 4
Thickness of coal sampled	3 2

a Not included in sample.

20237. Shipman Bros.' small drift mine, on the bank of Captina Creek in sec. 22, T. 5 N., R. 4 W., Washington Township, Belmont County, 1 mile north of Alledonia, a station on the Ohio River & Western Railroad. Meigs Creek (Sewickley) coal; thickness 3½ to 4 feet. The roof is clay with irregular limestone layers. The mine has extended about 40 feet from the mouth, and the sample was taken at the face. The sample showed little evidence of weathering. The roof of clay and limestone is not secure and falls badly on weathering. The bed was measured and sampled by D. Dale Condit on November 26, 1914, as described below.

Section of coal bed in Shipman Bros.' mine.

	20237
	Ft. in.
Roof, clay and limestone.	
Coal	2 1
Coal, bony cannel	2½
Coal	1½
Clay	a ½
Coal	1 6
Floor, clay shale.	
Thickness of bed	3 11½
Thickness of coal sampled	3 11

a Not included in sample.

UNIONTOWN COAL.

20775. Prospect on Peter Kemp farm, locality 103, sec. 1, T. 7 N., R. 5 W., Goshen Township, Belmont County, 2 miles east of Hunter and 5 miles southeast of Bethesda, the nearest town on the Baltimore & Ohio Railroad. Uniontown coal; thickness variable; one or more shale divisions that vary in thickness, and locally are more prominent than the coal. The roof ranges from sandy shale to sandstone. The floor is commonly clay shale. The sample was taken at a point 20 feet from the mine mouth. It was fairly dry and considerably weathered. The bed was measured and sampled by D. Dale Condit on November 21, 1914, as described below.

Section of coal bed in Peter Kemp's prospect.

	20775
	Ft. in.
Roof, sandy shale.	
Coal	2 6
Shale	[a] 1
Coal	3
Shale	[a] 5
Coal	7
Floor, clay shale.	
Thickness of bed	3 10
Thickness of coal sampled	3 4

[a] Not included in sample.

20259. A small mine on the Charles Mobley farm, locality 113, sec. 31, T. 4 N., R. 4 W., Adams Township, Monroe County, 2½ miles east of Coats Station, the nearest point on the Ohio River & Western Railroad. Uniontown coal. The following section shows the clay bands and bony streaks so prevalent in the Uniontown coal. The sample was weathered and stained with iron rust. The sample was cut at a point 40 feet from the mine mouth by D. Dale Condit on November 27, 1914, as described below.

Section of coal bed in Charles Mobley's mine.

	20259
	Ft. in.
Roof, shale.	
Coal, bony at top	1 7
Shale	[a] 3½
Coal	10½
Shale	[a] 2
Coal	6
Floor, clay shale.	
Thickness of bed	3 5
Thickness of coal sampled	2 11½

[a] Not included in sample.

WAYNESBURG COAL.

20241. George Thomas's drift mine, locality 145, sec. 14, T. 7 N., R. 6 W., Somerset Township, Belmont County, 2 miles east of Boston (Atlas post office) and 7 miles south of Barnesville, the nearest town on the Baltimore & Ohio Railroad. Waynesburg coal; thickness averages about 3 feet. The sample was cut in a dry place 200 feet south of the mine mouth. The bed was measured and sampled by Frank Reeves on November 24, 1914, as described below.

Section of coal bed in George Thomas's mine.

	20241
	Ft. in.
Roof, sandstone.	
Coal	1 0
"Sulphur"	a 2
Coal	10
"Soot"	a 1
Coal	11
Floor, shale.	
Thickness of bed	3 0
Thickness of coal sampled	2 9

a Not included in sample.

20234. Howard Brown's drift mine, locality 143, sec. 26, T. 6 N., R. 5 W., Wayne Township, Belmont County, 2 miles southeast of Somerton and 8 miles southeast of Barnesville, the nearest town on the Baltimore & Ohio Railroad. Waynesburg coal; average thickness about 2½ feet. The sample was cut in the mine at a point 100 feet west of the mine mouth. Although generally less than 3 feet thick and of high ash content, this coal is mined in a small way at numerous places for local use. The bed was measured and sampled by Frank Reeves on November 24, 1914, as described below.

Section of coal bed in Howard Brown's mine.

	20234
	Ft. in.
Roof, shale.	
Coal	6
"Sulphur"	a 1
Coal	1
"Soot"	a ½
Coal	11
Floor, clay shale.	
Thickness of bed	2 6½
Thickness of coal sampled	2 5

a Not included in sample.

20174. J. D. Milhoan's drift mine, locality 128, sec. 7, T. 7 N., R. 5 W., Goshen Township, Belmont County, 1½ miles northeast of Hunter and 5 miles south of Bethesda, a village on the Baltimore & Ohio Railroad. Waynesburg coal; thickness fairly uniform, about 3 feet in this mine but varies considerably in other openings of the neighborhood. The coal is tough and somewhat bony, and although lacking visible clay bands has the appearance of being of high ash content, as is shown by the analysis. The bed was measured and sampled 50 feet south of the mine mouth by D. Dale Condit on November 21, 1914, as described below.

Section of coal bed in J. D. Milhoan's mine.

	20174
	Ft. in.
Roof, shale.	
Coal	2 1½
Bone	1½
Coal	11
Floor, shale.	
Thickness of bed	3 2
Thickness of coal sampled	3 2

20236. Stoffel mine, on the Nathan Davis farm, sec. 27, T. 5 N., R. 4 W., Washington Township, Belmont County, 1 mile southwest of Alledonia, a station on the Ohio River & Western Railroad. Waynesburg coal; thickness in this and neighboring

mines about 2½ feet. This coal is present throughout large areas in similar thickness. Its high ash content is objectionable, but it is a valuable source of fuel for local use. The bed was measured and sampled by D. Dale Condit on November 26, 1914, as described below.

Section of coal bed in Stoffel mine.

	20236
	Ft. *in.*
Roof, shale.	
Bony coal	4
Coal	[a] 2 5½
Floor, clay shale.	
Thickness of bed	2 9½
Thickness of coal sampled	2 5½

[a] Not included in sample.

WASHINGTON COAL.

20238. S. A. Moore's drift mine, extending about 50 feet into the hill at locality 81, sec. 33, T. 5 N., R. 4 W., Washington Township, Belmont County, 1½ miles southwest of Alledonia, a station on the Ohio River & Western Railroad. Washington coal. The bed shows the usual division into two benches separated by clay; the upper bench is the better. The section below is representative of the Washington coal throughout large areas. It is mined to only a slight extent, owing to its inferior quality, better coals being accessible in most places. The sample was taken from a dry room and showed little evidence of weathering. The bed was measured and sampled by D. Dale Condit on November 26, 1914, as described below.

Section of coal bed in S. A. Moore's mine.

	20238
	Ft. *in.*
Roof, shale.	
Coal, bony	[a] 3
Coal, bony in lower part	2 1
Clay	[a] 8
Coal	11
Floor, shale.	
Thickness of bed	3 11
Thickness of coal sampled	3 0

[a] Not included in sample.

LIMESTONE.

The Woodsfield and Summerfield quadrangles are more abundantly provided with limestone than almost any other part of southeastern Ohio. The beds are distributed at varying intervals through all the outcropping formations, thus affording a more or less convenient supply for every township in the area. The extent and accessibility of each bed are set forth in the description of the respective townships.

Uses of limestone.—The limestone beds are, with one or two exceptions, not suitable for the manufacture of Portland cement, being magnesian. By far the most important use to which they can be put is in the surfacing of the roads. Few regions are so favorably situated with reference to a convenient supply of such material, and it is to be hoped that this opportunity for inexpensive construc-

tion of good roads will be used to a great extent in the future. Good roads are of especial importance for the economic development of a region such as that comprising Belmont, Monroe, and Noble counties, where much of the hilly country is far from a railroad and some of it still further isolated on account of rough topography.

Most of the limestone beds have a composition that makes them well suited for agricultural use. This is especially true of the Ames and Cambridge fossiliferous limestones, which appear in outcrop in the Summerfield quadrangle and are represented on Plate XII. The Cambridge is 4 feet thick at Senecaville and at certain points west of Lore City. The Ames is persistently 1 to 2 feet thick. A single analysis of a sample of the Ames limestone obtained near Senecaville is given below. It is noteworthy that the rock contains a small amount of tricalcium phosphate.

Analysis of Ames limestone from point near Senecaville.

SiO_2	12.72
Al_2O_3 (includes about 0.5 per cent Fe_2O_3 and any titanium present)	4.20
MgO	.21
$CaCO_3$	79.10
P_2O_5	.48
	96.71

Loss on ignition, 36.38 per cent.

The most valuable limestone beds occur in the upper part of the Conemaugh formation and the lower two-thirds of the Monongahela formation. They are designated in the generalized section (fig. 2, p. 16), the Lower Pittsburgh, Upper Pittsburgh, Fishpot, and Benwood limestones.

Lower Pittsburgh and Upper Pittsburgh limestones.—Immediately below the Pittsburgh coal is the Upper Pittsburgh limestone, and about 25 feet below that is the Lower Pittsburgh limestone. The Lower Pittsburgh is the thicker of the two, being 3 to 5 feet thick throughout its outcrop in the area. It ordinarily consists of several beds, such as are illustrated in Plate II, and when seen close at hand shows the pebbly surface also illustrated in the view. The texture is amorphous or nearly so, and the rock, as its appearance would indicate, is a fairly pure limestone containing little magnesia, iron, or alumina. Two analyses of the rock are given below:

Analyses of Lower Pittsburgh limestone.

	Baileys Mills.	Near Chaseville.
SiO_2	2.83	1.48
Al_2O_3 (includes Fe_2O_3, P_2O_5, and any titanium that may be present)	1.05	1.10
$MgCO_3$	.87	.42
$CaCO_3$	94.20	95.28
	98.95	98.28

Loss on ignition, 42.95 per cent.

The purity of the Lower Pittsburgh limestone suggests that it would find a good use in the manufacture of building lime. Being low in magnesia it may also be of value in the manufacture of Portland cement, especially when mined and combined with a calcareous clay that is commonly found below it.

Fishpot limestone.—The Fishpot limestone lies beneath the Lower Meigs Creek coal. It is nearly as abundant as the Lower Pittsburgh limestone, being 3 to 6 feet thick throughout nearly all of its outcrop in the area and locally as much as 13 feet thick, as described below. The upper beds are as a rule of gray color and purer than the lower beds, which are commonly buff and not so resistant to weathering. At the Maldine farm, 1 mile north of Barnesville, immediately beneath the Lower Meigs Creek coal is 7½ feet of hard blue or gray limestone with a small amount of shale (sample 1 in the table below). Next lower is 6 feet of buff or gray limestone (sample 2). The following analyses of this limestone are given in a report of the Geological Survey of Ohio.[12]

Analyses of Fishpot limestone from Maldine farm, near Barnesville.

[S. V. Peppel, analyst.]

	1	2
Silica	14.06	16.10
Alumina	4.33	5.74
Oxide of iron	1.13	2.28
Carbonate of calcium	66.31	51.25
Carbonate of magnesium	12.71	23.02
	98.54	98.39

Benwood limestone.—The Benwood includes numerous beds of limestone lying above the Meigs Creek coal and having a combined thickness of about 70 feet. The beds vary considerably in thickness and composition and are interbedded with strata that are more properly termed calcareous shale than limestone. The appearance of some of the beds is illustrated by Plate X, *B*. Another bed illustrated in Plate III, *B*, has a most peculiar aspect, resembling flint clay in texture and presenting everywhere on the outcrop a peculiar blocky surface as shown in the view. This layer is persistent and has a thickness of about 4 feet in nearly all of Belmont County. It lies 15 to 20 feet above the Meigs Creek coal. Its composition, as shown by the analysis of a sample taken at a point on Captina Creek near the east edge of the area, indicates that it should be called a calcareous magnesian clay.

[12] Orton, Edward, jr., and Peppel, S. V., The lime resources and the lime industry in Ohio: Ohio Geol. Survey Bull. 4, 4th ser., pp. 41–42, 1906.

Analysis of clay bed above Meigs Creek coal on Captina Creek.

SiO_2	25.70
Al_2O_3 (includes Fe_2O_3, P_2O_5, and any titanium present)	14.38
$MgCO_3$	21.47
$CaCO_3$	31.79
Loss on ignition 28.11 per cent.	93.34

Samples of the entire Benwood limestone member have been collected by the Geological Survey of Ohio at Armstrongs Mills, Belmont County. The analyses show the limestone to be of magnesian character, the percentage of magnesia ranging from about 13 to 17.[13]

The section and analyses are given below.

Section of limestone strata sampled at Armstrongs Mills.

		Ft.	In.
	Sandstone.		
	Shale interstratified with about one-fourth limestone	47	
	Limestone (roof)	3	
Sample 1	Shale, hard and calcareous	2	6
	Blue limestone, not very hard	1	
	Blue limestone, hard	3	
Sample 2	Shale	1	
	Limestone, impure and shaly	4	
	Blue limestone, hard	5	
	Shale		6
	Blue limestone	1	
	Shale		9
	Limestone	1	
	Green shale	4	
Sample 3	Gray limestone	3	
	Shale		6
	Buff limestone	4	
	Brown limestone, shaly	1	
	Dark-gray limestone	1	
	Blue shale	1	
	Gray limestone	2	6
Sample 4	Blue limestone	1	6
	Dirty limestone, hard, but laminated		6
	Light-brown limestone	2	
	Brown limestone	3	
	Blue limestone	6	
	Dark-brown slaty limestone	1	
	Soft slate	1	
	Coal, Meigs Creek	4	
	Interval, containing shale with a little sandstone	23	
	Limestone (roof)	2	
Sample 5	Blue limestone, hard, in four courses	8	
Sample 6	Hard fine-grained shale, bleaching to a light color on outcrop	5	
	Hard, fine-grained shale, very dark color		

[13] Ohio Geol. Survey Bull. 4, 4th ser., p. 43, 1906.

Sample 7..	Blue limestone	4
	Shale, brown in part	1
	Blue limestone	3 6

Thus it is seen that for about 50 feet above and below the Meigs Creek coal, the strata are predominantly calcareous. Whether a different grouping of the members would have made a materially different or better showing of the character of the materials is of course open to conjecture.

Analyses of limestone from Armstrongs Mills.

[S. V. Peppel, analyst.]

	1	2	3	4	5	6	7
Silica	29.16	25.88	17.10	25.46	10.20	26.10	17.02
Alumina	8.43	7.06	4.90	10.11	2.41	9.64	4.56
Oxide of iron	2.69	1.84	1.24	1.25	1.13	1.30	1.74
Carbonate of calcium	44.23	47.70	58.93	45.40	73.57	45.70	59.78
Carbonate of magnesium	13.56	15.84	16.87	15.53	12.19	15.45	15.98
	98.07	98.32	99.04	97.75	99.50	98.19	99.08

The proportions of lime and magnesia versus silica and alumina fluctuate reciprocally with the inclusion of more or less of the shaly strata, but in the case of sample 5, which contains no shale, the character of the limestone is clearly shown to have no field of usefulness in either white lime or Portland cement manufacture, though it might be of value for agricultural purposes. That it could be used for the Roman or natural cement is beyond doubt. Also other sections in the locality can undoubtedly be found in which limestone of good quality for Roman cement can be obtained, by exclusion of the shale intercalated with the stone beds. The introduction of the Roman cement industry into this section is, however, a question of economics rather than of mineral resources.

The information at hand indicates that the uses to which the limestones of the Monongahela formation may be put are few. None of the beds can be of much use for building. Most of the rock when burned for lime gives an undesirable gray color. The material does not seem promising for use in the manufacture of Portland cement. Hydraulic lime and Roman cement were at one time manufactured at Barnesville. These products are inferior to Portland cement for many purposes but are serviceable for foundations and rough stone masonry.

BUILDING STONE.

The only rock in this area of any value for building is sandstone. The principal sandstone members are in ascending order the one between the Lower Meigs Creek and Meigs Creek coals, the sandstone over the Uniontown coal, correlated with the Gilboy sandstone of the West Virginia Geological Survey, and the sandstone over the Waynesburg "A" coal, correlated with the Mannington sandstone of the West Virginia Survey. All these sandstones occur

locally in massive form and present numerous exposures suitable for quarrying. The rock is as a rule too friable to be regarded as superior material for building and on weathering readily wears away. The texture in massive exposures is fairly coarse, and the rock is as a rule a freestone well suited to easy quarrying. In the finer-textured sandstones the bedding is so commonly irregular or the lamination so pronounced that the rock shows a too ready tendency to break along the bedding.

The sandstone that has been most extensively quarried is the bed over the Waynesburg "A" coal along Standingstone Run near Woodsfield. The sandstone over the Uniontown coal has been used near Miltonsburg in the construction of a church. (See Pl. X, *A*.) Descriptions of these and other localities are given under the respective township headings.

CLAY AND SHALE.

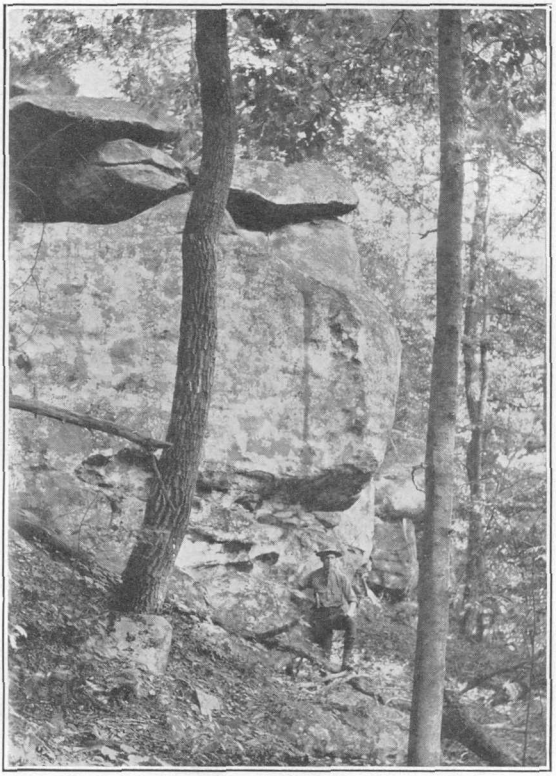
Both clay and shale are present in great quantity in this area. So far as known they have not been utilized in the ceramic industry. It is certain, however, that material suitable for the manufacture of bricks and paving blocks can be obtained in almost any part of the area.

Numerous outcrops of the Washington formation near Woodsfield show clay that may upon investigation be found suitable for the manufacture of refractory wares. Two beds of clay were observed, one about 20 feet above and the other immediately below the Washington coal. They are of greenish-gray or gray color and apparently contain little lime or iron.

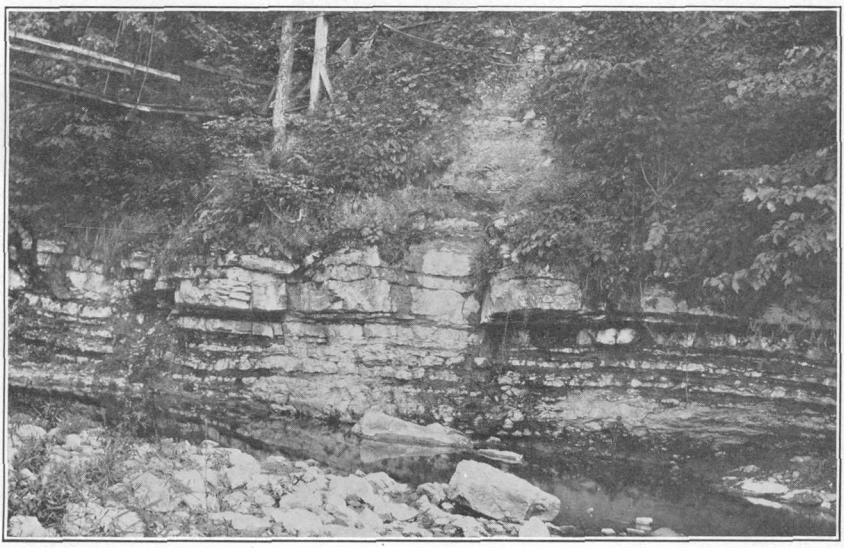
The alluvial silt so plentiful along Seneca Fork and other branches of Wills Creek will probably be found upon investigation to be suited to the manufacture of brick. The material varies in texture, being almost a clay in some places and of sandy composition in others. No attempt has been made to use such material in this area, but it has been successfully used in a small way at the village of Cumberland, near the center of the Cumberland quadrangle, to the west.

WATER RESOURCES.

The Woodsfield and Summerfield quadrangles contain no streams of large size. The largest are Captina and Sunfish creeks and their branches and Leatherwood Creek, Seneca Fork, and other tributaries of Wills Creek, all of which rise near the center of the area. The volume of even the largest streams is too small to make them of much value for power. In dry seasons they are reduced to mere trickles or water holes. It is probable that with the growth of communities in this area it will become more and more necessary to construct reservoirs for the storage of water.



A. SANDSTONE OVERLYING UNIONTOWN COAL HORIZON 2 MILES WEST OF MILTONSBURG.



B. TYPICAL EXPOSURE OF BENWOOD LIMESTONE ALONG BEND FORK NEAR CAPTINA CREEK.

Both Barnesville and Woodsfield obtain their water supply from springs. The flow is caught in reservoirs and pumped to tanks on hilltops within the towns. The supply of Woodsfield is obtained from a ravine 2 miles north of the town and about 200 feet lower, from which it is pumped to a tank on a high hill at the north side of the town and 100 feet higher thus giving a good head.

The water supply of the farming communities is derived largely from springs, which are numerous and for the most part persistent even in periods of drought. The springs were chosen as convenient home sites by the early settlers, and therefore nearly every farm house except those on the ridges has its spring close at hand.

In digging or drilling water wells in the valleys it is rarely necessary to go deeper than 10 or 20 feet in order to obtain a good supply. A few wells penetrate to a considerable depth in bedrock. A well drilled near the station at Lore City obtains a sulphurous water in black shale at a depth of about 60 feet. In the valley near Hall School, 1 mile southwest of Quaker City, a supply of excellent water is obtained at several farmhouses by digging to the Ames limestone, which is found at depths ranging from 10 to 30 feet. The sandstone and other strata almost without exception contain salty water where encountered at a depth of 75 feet or more in the valleys, thus furnishing evidence as to the shallow depth of circulation of ground waters.

Water in quantity sufficient for domestic use can be obtained at moderate depth on almost any of the ridges. It is usually associated with a coal or limestone bed or occurs in a sandstone underlain by clay. It is exceptional to find on the ridges a well as deep as 75 feet, and the greater number are 50 feet or less in depth.

GEOLOGY BY TOWNSHIPS.

GUERNSEY COUNTY.

MILLWOOD TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Millwood Township lies at the east side of Guernsey County, adjacent to Warren Township, Belmont County. Leatherwood Creek, which heads in Warren Township near Barnesville, flows westward across Millwood in a direct route to Cambridge and its valley is utilized by the Baltimore & Ohio Railroad. Quaker City and Salesville are the principal villages. Baileys Mills, a coal-mining community at the Belmont County line, is rapidly increasing in size. The number of inhabitants in the township in 1920 was 1,742, and in Quaker City, the largest village, 732.

The surface of Millwood Township is more rugged than that of areas to the east or west. Its hilltops agree in elevation with those of the highlands to the east, along the divide separating the waters of the eastward-flowing Captina Creek from those of streams that flow westward into Tuscarawas River. The surface is, however, dissected by deep valleys with numerous tributary ravines. Leatherwood Creek is joined by a number of creeks from the north which are longer and larger and more numerous than those from the south. The elevation of the principal valleys ranges from 840 to 900 feet above sea level, and that of the ridges from 1,150 to slightly more than 1,300 feet.

GEOLOGIC SECTION.

The Pittsburgh coal bed is the principal geologic horizon marker in Millwood Township, and the name is a household term because of the extent to which the bed has been mined by the farmers. At Quaker City it lies about 205 feet above the railroad, or 1,080 feet above sea level, but it gradually descends eastward to 1,030 feet at Baileys Mills. Another coal bed about 100 feet higher, the Meigs Creek, is seen in the hills in the east side of the township north of the railroad.

From Spencers Station westward along the valley the Ames ("Crinoidal") limestone, with its abundant fossil shells, appears in outcrop. In the railroad embankment at the east side of Quaker City it is a few feet above the railroad track, and 2 miles west, in the vicinity of Salesville, it crops out along the sides of the hills 40 feet above the railroad. It is a single brownish-gray layer about 2 feet thick and can not be mistaken, because of its fossil-scarred surface and the absence of other limestone beds in this part of the geologic section. Below the Ames limestone is clay or shale of olive-green and brownish-red to chocolate color, with scattered nodules of limestone and "ironstone" concretions. The strata above the Ames for about 50 feet consist of sandy shale and thin-bedded sandstone, which are in turn overlain by alternating beds of clay and shale of variegated color and sandy beds.

The interval between the Ames limestone and Pittsburgh coal is about 188 feet. In the upper part of the interval, about 25 feet below the Pittsburgh coal, is the Lower Pittsburgh limestone, a mottled ochreous-yellow and gray rock about 4 feet thick. A less prominent bed, the Upper Pittsburgh limestone, lies immediately beneath the coal.

The strata in the interval of 100 feet between the Pittsburgh and Meigs Creek coal beds consist largely of sandstone or sandy shale with two or three prominent limestone beds. Sandstone commonly occurs a little above or in contact with the Pittsburgh coal and also

about 80 feet above. This upper sandstone member in its most prominent development in the hills north and east of Quaker City is a massive bed 30 to 40 feet thick which extends above the usual position of the Meigs Creek coal. In such areas that bed is of little value and where present consists of an impure shaly coal 125 to 140 feet above the Pittsburgh coal and resting on the sandy beds.

STRUCTURE.

There is little regularity in the direction of dip of the beds in Millwood Township. In general it is southward, but there are local flexures that produce considerable variation. The rate of dip also varies, ranging from only a few feet to 40 feet in a mile. The rocks, as shown by the contour map (Pl. XII, in pocket) have the greatest dip east of Spencers Station, northwestward to Quaker City and beyond they lie nearly flat. At the east side of the township the rocks rise in a true anticlinal fold within which is the Barnesville oil and gas pool.

MINERAL RESOURCES.

COAL.

PITTSBURGH COAL.

The Pittsburgh coal lies well up in the long, narrow ridge of Millwood Township 150 to 200 feet above the valley and therefore will not be in great demand for exploitation in a commercial way except possibly in the eastern part of the township. The coal, although of fair thickness, is higher in sulphur and ash than the same bed where mined to the east along Ohio River and is therefore less desirable for certain purposes. Its chemical properties and heating value have been determined from samples taken in the Sayre mine, 1½ miles northwest of Quaker City (locality 1, sample 20178), and in the Cochran No. 2 mine, at Baileys Mills (locality 8, samples 20187, 20188). The results are tabulated on page 39. The thickness of the bed at these localities is shown by sections on Plate V.

In the vicinity of Baileys Mills and also farther west, near Quaker City, sandstone or clay "horses" locally reduce the thickness of the coal and give considerable trouble in mining. Where the coal is immediately overlain by sandstone the quality of the coal is noticeably poorer, there being an increased amount of "sulphur" and bony impurities, especially in the upper portion of the bed.

In the hills south of Spencers Station mines have been opened in a number of places, and the thickness of the bed is similar to that found on the north side of Leatherwood Valley. To the west, however, opposite Quaker City (locality 2), the bed thins from 4 feet to a few inches within a distance of half a mile. The bed is of doubtful

value in the hill above Hall School, but to the northeast, across the ridge (locality 3), it has a good thickness and has been mined for many years. Although geologically due in secs. 25 and 31, the coal is represented there by only a faint carbonaceous streak.

MEIGS CREEK COAL.

The Meigs Creek coal, so far as known, has not been mined in Millwood Township. Its thickness near the east township line is 2 to 3 feet for 2½ miles north of Baileys Mills and becomes increasingly greater nearer Barnesville, where the coal has been mined at several places. In the northeast corner of the township the coal is impure and deserves the name of bone rather than coal where seen in roadside outcrops at several places on the east-west ridge road. The bed lies in sandy shale above a thick sandstone, and its position is about 135 feet above the Pittsburgh coal.

The record of a well drilled on the J. K. Rose farm, 1 mile north of Salesville, is of interest on account of the several coal beds recorded. Their thicknesses as given must of course be regarded as rough approximations. The Upper Freeport coal, which should appear about 255 feet below the Ames limestone, is missing. Of the lower coal beds recorded, the first two may be the Lower Kittanning and the Clarion.

Log of well drilled for oil on J. K. Rose farm, 1 mile north of Salesville.

[Well head 25 feet below Ames limestone and 215 feet below Pittsburgh coal. Well nonproductive.]

	Thickness.	Depth.
	Feet.	*Feet.*
Shale, red	50	50
Sand, Cow Run		75
Limestone, Cambridge		95
Coal [probably Brush Creek]	1½	175
Shale, sandy		375
Coal [Lower Kittanning]	4½	379
Sand, Second Cow Run		390
Coal	3½	400
Coal	5	440
Coal	1½	510
Shale, sandy		600
Sand, stray		700
Sand, Keener		850
Sand, Big Injun		980
Sand, Berea	50	1,330-1,380

LIMESTONE AND SANDSTONE.

The Ames limestone appears in outcrop along the sides of Leatherwood Valley at Spencers Station and westward. Although 2 feet or less in thickness, the rock has been used for road metal where it is easily accessible. This rock, together with the limestone below the Pittsburgh coal, has been used in the construction of a pike between Salesville and Quaker City and also southward from Quaker City toward Batesville.

The most valuable beds are the Upper Pittsburgh and Lower Pittsburgh limestones, which lie 1 and 24 feet respectively below the Pittsburgh coal. The lower bed is the thicker, being 3 feet thick in Millwood Township and increasing southward to 5 feet or more in adjoining areas. The rock is brownish gray to nearly white and of suitable composition for making lime for use in agriculture.

A massive coarse-grained bed of sandstone 25 to 40 feet thick is conspicuous north and east of Quaker City to the township line. It lies about 75 feet above the Pittsburgh coal, near the hilltops. The rock has been quarried in a small way at numerous places for foundations, and years ago was taken out near Barnesville for railroad ballast. It is apparently sufficiently durable to have prospective value as a building stone, and favorable quarry sites can be found in almost every ravine.

Other sandstone beds of finer texture and not so massive are found 25 to 100 feet above the Ames limestone. The rock is in beds 1 to 3 feet thick, with even horizontal partings that give it a flaggy character.

RICHLAND TOWNSHIP.

Richland Township, in addition to being rich agriculturally, as its name implies, is an important mining region, commercial mines being in operation at Senecaville and Blacktop. The main line of the Baltimore & Ohio Railroad crosses its northeast corner, and a branch extends from Lore City southward across the township to Senecaville and other places to the west. The population of Senecaville in 1920 was 947 and of Lore City, part of which is in this township, 784. The total number of inhabitants in the township is given at 2,322.

SURFACE FEATURES.

Both Leatherwood Creek and Seneca Fork, the principal streams, have broad bottoms in which they flow in meandering courses. The Seneca Fork valley is along much of its course, half a mile or more wide, but for a short distance in the vicinity of Senecaville it is constricted by a thick layer of sandstone that forms the valley walls. The gradient of the valley downstream from Senecaville is about 3 feet to the mile, and that of the stream channel along its complicated meanders probably less than 1 foot to the mile.

The elevation of Seneca Valley at the southwest side of the township is about 800 feet above sea level. The neighboring hills rise 100 to 200 feet above the valley, and a few isolated summits rise slightly more than 300 feet. Eastward there is an increasing number of high hills, and near the township line east of Fairview School the general elevation along the ridges is from 1,100 to about 1,250 feet above sea level.

GEOLOGIC SECTION.

The strata that crop out in Richland Township for the most part belong to the Conemaugh formation. The higher hills in the eastern part of the area consist of basal beds of the overlying Monongahela formation. There are no coal beds of more than local importance, and the rocks for the most part consist of sandy shale, brownish-red clay, sandstone, and thin beds of limestone. The Upper Freeport coal, mined by shafting, is 100 feet or more below the bottoms of the valleys.

The Cambridge limestone crops out along the valley of Leatherwood Creek. At Blacktop its position is about 60 feet above the valley, or 877 feet above sea level. In this vicinity the bed is about 3 feet thick and consists of one layer. The freshly broken rock is bluish-gray and smooth textured. Fossil shells are abundant, the most characteristic one being a form called *Chonetes verneuilanus*. At Lore City the limestone is less prominent, being an impure yellowish nodular rock, but the fossils are as abundant as elsewhere. The Cambridge limestone is most prominent at Senecaville, where it is 4 feet thick. It may be seen near the railroad station and also at the abandoned shaft a few hundred yards north, where the bed is 148 feet above the Upper Freeport coal. Westward, down Seneca Fork, the bed is only slightly thinner, but to the north, along Soggy Run, it loses its prominent character and consists of limestone nodules that are seldom seen in good exposure. The position of the bed is everywhere indicated by the Anderson coal, 10 feet higher.

The Ames limestone, although nowhere as thick as the Cambridge, is remarkably persistent and appears as a single bed 1 to 2 feet thick throughout the region. As shown in the general section, it lies about 110 feet above the Cambridge limestone; therefore the extent of its outcrop, as represented on the map (Pl. XII, in pocket), is much greater. Being so easily recognized, it is useful in determining the geologic structure—that is, the direction and rate of dip of the rocks. The contours on the structural map (Pl. XII) are drawn from hundreds of elevations obtained on the Ames limestone and other key strata.

The succession of strata below the surface at Gibson is shown by the following excellent well record, furnished by John Shane, the driller. The well head is 77 feet below the Ames limestone. The coal at a depth of 123 feet is probably the Brush Creek, and that at 262 feet is probably the Middle Kittanning.

Log of well No. 65 on Z. Tennant farm at Gibson.

[Nonproductive.]

	Thickness.	Depth.
	Feet.	*Feet.*
Surface material and clay	40	40
Sand	10	50
Rock, red	10	60
Lime	15	75
Slate, dark	30	105
Sand	17	122
Coal [Brush Creek?]	1	123
Sand	13	136
Clay	7	143
Sand	2	145
Slate, white	5	150
Slate, dark	10	160
Sand	19	179
Shale	11	190
Sand	70	260
Coal [Middle Kittanning?]	2	262
Clay	4	266
Sand; show of oil	154	420
Lime	30	450
Slate	7	457
Sand	13	470
Shale	70	540
Lime	35	575
Sand	75	650
Shale	5	655
Sand	10	665
Shale	68	733
Coal	4	737
Sand	26	763
Shale	130	893
Sand	45	938
Shale	274	1,212
Shale, black	45	1,257
Sand, Berea, hard, compact	46	1,303

STRUCTURE.

The dip of the strata in Richland Township is in general southeast, but there are numerous local cross flexures or folds that cause variation in the direction of dip and produce synclinal "embayments" and anticlinal "noses." The most unusual structural feature is the depression at the east side of Lore City. The evidence upon which it is mapped consists of elevations of the Cambridge limestone. That bed is 846 feet above sea level at the road forks half a mile north of the village, 847 feet on the main street 700 feet south of the railroad, and 802 feet on the railroad half a mile east of the station. In adjacent hills to the north and south of this place the limestone lies 45 to 50 feet higher.

MINERAL RESOURCES.

Among the mineral products of Richland Township are oil and gas, coal, limestone, and sandstone. Oil has been found in small quantities, and most of it comes from the Mahoning sandstone, overlying the Upper Freeport coal. In fact, that bed is saturated with oil, which runs into some of the mine workings and has been pumped and sold as crude oil. In other places the sand contains little oil and a large amount of salty water.

COAL.

UPPER FREEPORT COAL.

The Upper Freeport coal bed is mined by shafts at Senecaville and Blacktop. A mine formerly operated at Kings, north of Blacktop, has been abandoned for many years. At Blacktop the bed is about 100 feet below the valley, and at Senecaville about 170 feet.

The Blacktop mine, 1 mile west of Lore City, is operated by the Morris Coal Co. The average daily output of run-of-mine coal is reported to be 1,000 tons. The coal was sampled at two points (analyses 20264, 20265, p. 38). Sections of the coal bed measured at two points in the mine are given on page 42. The mine workings have extended to the southeast, south, and southwest, a distance of a little more than 1 mile. To the north and northwest the coal has been tested at a number of places and is believed to be a continuous thick bed. In the valley of Leatherwood Creek there is some question as to the possibility of extracting the coal, owing to an insecure roof. The alluvium is many feet thick, and in Center Township, a short distance downstream from the vicinity of Blacktop, it rests directly on the coal.

The Cleveland mine of the Morris Coal Co. is at the southeast side of Senecaville on a spur from the Baltimore & Ohio Railroad. The bed was measured and sampled at two points (analyses 20261, 20262, p. 38). Measurements of the bed are given on page 43. The mine workings extend northeast and south from the shaft a distance of about 1 mile. A little more than half a mile to the southwest is a sandstone "roll," which has checked development in that direction. The sandstone roof abruptly slopes down, entirely replacing the coal along a front bearing nearly northwest.

East of the mine workings at Senecaville many diamond-drill holes have been put down, and there is assured a considerable area of valuable coal. In one of the test holes so much oil was found in the sandstone above the coal that it was pumped out and sold for crude oil.

ANDERSON COAL.

The Anderson coal ranges from a mere blossom to a bed about 2 feet thick. Almost the only exposures available for measurement in this township are natural outcrops on the roads, but at a few places the bed has been mined by stripping or drifting into the hillsides. The principal places where it may be as much as 2 feet thick are half a mile west of Blacktop and about 3 miles to the south, on Soggy Run. Near the Waldhonding mine, just across the Valley Township line, where the bed is mined for local use by Andy Slovak, it is 1 foot 10 inches thick. The results of an analysis are given on page 39 (analysis 20243).

SANDSTONE AND LIMESTONE.

The only sandstone of probable value for building in Richland Township lies above the Cambridge limestone. It ranges from shaly to massive and coarse grained and in the latter form is prominently shown at Senecaville and eastward for 2 miles. The rock is conspicuous northward from Senecaville along the railroad and also between Lore City and Gibson, on the south side of the valley. Here and there small amounts of sandstone have been quarried for use in foundations.

None of the roads of Richland Township have been surfaced with limestone. About 1 mile of limestone pike has been built along the valley east from Lore City, and this is the only improved road in the region. Limestone that is easily available is somewhat scarce, the Ames and Cambridge beds being the only source in the western half of the township. The Ames limestone is persistently 1 to 2 feet thick, and by stripping on the outcrop large quantities can be obtained. The Cambridge limestone is of local importance, being 4 feet thick west of Blacktop and in the vicinity of Senecaville, but elsewhere it is simply a layer of nodular clayey limestone. The outcrops of the Ames and Cambridge limestone beds are represented on the map (Pl. XII, in pocket), and their positions in the geologic column are shown in the general section.

About 170 feet above the Ames, at the base of the prominent terraced slopes that extend to the tops of the hills in the eastern part of the township, is the Lower Pittsburgh limestone, a bed 2 to 4 feet thick, of light-gray color and smooth texture, probably suited for burning for building lime and certainly useful for agriculture.

WILLS AND CENTER TOWNSHIPS.

A strip of land slightly more than 1 mile in width at the south sides of Wills and Center townships is included within the Summerfield quadrangle. The valley of Leatherwood Creek lies parallel to the south boundaries of these townships and is followed by the Baltimore & Ohio Railroad. At the adjoining south corners of the two townships is Lore City, the principal village. A branch railroad line was built from Lore City northeastward a distance of 4 miles to Washington and operated for a short time but is now idle.

GEOLOGIC SECTION.

The rocks exposed in the southern parts of Wills and Center townships consist almost entirely of rusty brown or brownish-red clay, shale and sandy shale, with sandstone beds of irregular extent and thickness, and a few thin layers of coal and limestone.

One of the lowest horizon markers in the area is a coal bed known as the Anderson (Bakerstown). Where seen in a ravine at Kings

Mine it is about 1 foot thick and has a roof of irregular-bedded sandstone. Its position is about 80 feet above the railroad and 155 feet above the coal at the bottom of the shaft. About 10 feet beneath the Anderson coal is the Cambridge limestone, a bed about 3 feet thick, containing many fossils. Its outcrop was seen at numerous places on both sides of Leatherwood Valley near Blacktop and Kings Mine. To the east near Lore City, however, the bed is much less prominent, being made up of nodular lumps of impure limestone embedded in calcareous clay.

Near Lore City and northward is a coal bed about 25 feet above the position of the Anderson coal. Where seen at the forks of the road half a mile north of the village and to the northeast along the abandoned railroad it is about 1 foot thick and lies in the midst of an irregular bedded sandstone. In the same vicinity the Cambridge limestone was found 35 feet lower.

In the southern part of Wills Township the Ames fossiliferous limestone bed is 109 feet above the Cambridge. It lies at the top of a bed of brownish-red clay and is overlain by light greenish-gray shale. This bed is persistent throughout the region, being absent at only a few places. Although only 1 or 2 feet thick, it is conspicuous in roadside and ravine outcrops, owing to its association with soft shale and clay. The strata for more than 100 feet above the Ames limestone are of variable character but consist largely of sandy shale, thin-bedded sandstone, and greenish-gray or chocolate-colored clay.

MINERAL RESOURCES.

COAL.

The only coal of economic importance in the portions of Center and Wills townships here described is the Upper Freeport bed, which lies about 50 feet below the valley of Leatherwood Creek at the extreme northwest corner of the Summerfield quadrangle. It is probable that the coal is persistently 5 feet or more thick throughout large areas west and north of Lore City. Considerable coal has been mined at Kings Mine, but the site was abandoned years ago, after a fire had destroyed the buildings about the shaft. Westward from Kings Mine along Leatherwood Valley mining operations will be impossible, at least in places, owing to the thickness of alluvium which extends down to the coal.

Many coal test holes have been drilled in the northern part of Wills Township, in the Antrim quadrangle, near Washington and eastward along Salt Fork. The results have almost without exception proved unfavorable, the coal being thin or lacking. A record of the strata penetrated on the G. M. Coen farm, near the center of sec. 20, 1 mile south of Washington, furnished by Prof. F. A. Ray, is given below:

Record of core-drill boring on G. M. Coen farm, sec. 20, Wills Township.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Surface	4	4
Lime	2	6
Shale, blue	28	34
Slate, dark	38	72
Coal	1	73
Clay	3	76
Shale, sandy	22	98
Slate, black	1	99
Coal	6	99 6
Clay	6	100
Lime	30	130
Slate, light	6	136
Clay	4	140
Lime	33	173
Coal	8	173 8
Clay	5 4	179
Lime, sandy	39	218
Slate, dark	22 7	240 7
Slate, black	6	241 1
Coal, "No. 6" or Middle Kittanning	3 3	244 4
Clay	1 1	245 5

LIMESTONE AND SANDSTONE.

The principal limestone beds are the Ames and Cambridge, which have already been described. Neither is more than 2 or 3 feet thick, but the amount of rock that can be obtained by stripping in ravine outcrops is considerable and should go far toward surfacing the principal roads of the townships.

The only sandstone bed of possible value for quarrying is the one above the Anderson coal. The rock is as a rule irregularly bedded and friable, but in a few favored localities it has been found suitable for foundations. The stone has been quarried to a slight extent on the abandoned railroad about 1 mile northeast of Lore City.

NOBLE COUNTY.

WAYNE TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Wayne Township, Noble County, is an irregular area lying in the north-central part of the Summerfield quadrangle. A portion of the township is within the bounds of an early United States military reserve. Kennonsburg, the only village, has a population of a few dozen people, and the total number of inhabitants in the township according to the census of 1920 was 438. This township, like most other rural communities, is decreasing in population, the number in 1910 (479) being 32.3 per cent less than in 1890, when it had 708 people. The west end of the township extends almost to the railroad at Senecaville, and the north side is about 1½ miles from Salesville, on the Baltimore & Ohio Railroad.

The most unusual feature of the surface of Wayne Township is the abnormally broad valley of Seneca Fork of Wills Creek, a comparatively small stream whose flood plain is nearly as broad as that of the Ohio at Wheeling. The stream has so slight a fall and its course is so meandering that the run-off after heavy rains is slow, and as a result the bottomlands are frequently flooded and are therefore of limited agricultural value. The lowlands and gently sloping hillsides are generally covered with a mantle of sandy loam which covers most rock exposures up to an elevation of about 920 feet. The sandy loam contains stream-rounded pebbles, even where it lies 100 feet above the flood plain of Seneca Fork. The depth to bedrock in the valley is probably many feet, and the alluvium, together with the mantle of similar material on the hillsides, probably denotes a former silting up of the valley to a depth of 150 feet or more. A similar condition is found throughout this drainage system. In the Tuscarawas Valley, about 40 miles to the northwest, the rock floor is buried several hundred feet below the river channel.

The land rises in gentle slopes 300 to 400 feet above the valleys and forms rounded ridges that show little concordance in elevation. The highest hilltops, which are along the north side of the township, are 1,240 to 1,280 feet above sea level. The hillsides consist of a number of terraces that vary in steepness according to the hardness of the underlying strata. Sandy shale is more resistant to weathering and wear by streams than clay or shale, which in addition to easy erosion are much given to landslides.

GEOLOGIC SECTION.

There are two strata which deserve first consideration in a description of the rocks of Wayne Township, owing to their easy identification, economic value, and use in the mapping and study of other geologic features. They are the Ames limestone, which crops out low in the hills in the western part of the township, and the Meigs Creek coal, which lies in the higher hills in the eastern part. The vertical interval between these beds is about 315 feet. The gentle southeasterly dip carries the Ames limestone below the bed of Seneca Fork of Wills Creek opposite Kennonsburg, as shown on Plate XII, in pocket. In its westward outcrop the bed is everywhere 1 to 2 feet thick and contains crinoid stems and fossil shells, which serve to distinguish it from all other limestone beds.

The strata for 150 feet above the Ames limestone consist chiefly of sandy shale, a few sandstone layers, and beds of greenish-gray or brownish-red shaly clay. The succeeding 150 feet upward to the Meigs Creek coal contains several masses of tough sandy shale 30 to 40 feet thick, between which are thin beds of limestone and clay.

STRUCTURE.

The general southeastward dip of the rock beds of this region is varied in the western part of Wayne Township by a low up-fold called the Chaseville anticline, which trends northeast. It is paralleled on the northwest by a shallow depression, and on its southeast side the normal southeasterly dip of 20 to 40 feet to the mile is resumed. Other flexures of less prominence appear in the northern part of the township. These structural features are represented on Plate XII.

MINERAL RESOURCES.

Wayne Township is unimportant as a producer of oil, gas, or coal. A few oil wells at the north end of the Chaseville field lie within the township, and oil has been found in small amounts at other places.

COAL.

The Meigs Creek coal, which is the only bed of minable thickness in the rocks that crop out, is of slight extent, lying in the tops of the hills in the eastern part of the township. The coal bed of greatest value is the Upper Freeport, which is mined by shafts to a depth of about 200 feet at Senecaville.

UPPER FREEPORT COAL.

The mine workings of the Cleveland mine at Senecaville extend into the west end of Wayne Township. The thickness of the coal, as shown by the section on page 43, measured 5,000 feet east of the shaft about 2,000 feet north of the Wayne Township line, is nearly 6 feet. The southward extension of the mine workings has demonstrated the presence of a sandstone "roll," which replaces the coal along a front extending in a southeasterly direction across sec. 6. The bed is missing in many wells drilled for oil and gas to the south, in the Chaseville pool. Little is known concerning its character in the eastern part of Wayne Township. It has been tested by core drilling at several points, as shown on Plate XII, but no records were obtained

MEIGS CREEK COAL.

The Meigs Creek coal appears as a roadside blossom at many places near Longs School, in the northeast corner of the township, and has been mined in a small way at several places. Its thickness is a little more than 3 feet, and a thinner rider coal lies above it, separated by 1 foot of clay. In the C. Long mine (locality 55, Pl. VI), a quarter of a mile east of the township line, a thickness of 4 feet 5 inches of coal was measured. To the south, in the ridge near the township line, the bed has been mined at a few places, and the thickness is reported to be 4 feet.

SANDSTONE AND LIMESTONE.

There is a little sandstone suitable for building or rough foundations in Wayne Township. The principal bed lies below the Meigs Creek coal, and is of some prominence in the vicinity of Longs School and elsewhere in the eastern part of the township, where it is 20 to 30 feet thick, but so friable that it is easily crumbled into sand. Another sandstone bed occurs a little above the Lower Pittsburgh limestone, but it is as a rule shaly and thin bedded.

The Ames limestone, a bed 1 to 2 feet thick, crops out in the valley of Depue Run north of Kennonsburg and gradually rises in the hills on the west. The bed constitutes almost the only limestone supply in that area, with the exception of several layers near the hilltops in the vicinity of Miley School.

The amount of limestone in the eastern part of the township is greater, there being three beds 2 to 3 feet thick distributed in the section 30 to 130 feet below the Meigs Creek coal. The principal layer is the Lower Pittsburgh, whose outcrop forms a conspicuous band of white nodules along the hillsides. It is everywhere 2 to 4 feet thick. Its prominent outcrops in the ravines furnish easily accessible supplies of material for road surfacing.

BUFFALO AND VALLEY TOWNSHIPS.

LOCATION AND SURFACE FEATURES.

The eastern third of Buffalo Township and about 1 square mile of Valley Township lie within the Summerfield quadrangle. The Cleveland and Marietta branch of the Pennsylvania Railroad crosses the western part of these townships, in the Cumberland quadrangle, and on it are the villages of Glenwood, Ava, and Pleasant City.

The waters of the two townships are carried off by Buffalo Creek, Seneca Fork of Wills Creek, and their tributaries. Those streams flow northwestward and empty into Wills Creek. Their valleys, like those of all streams of this drainage system are unusually wide and the streams are sluggish. The elevation is about 790 feet in the valley of Buffalo Creek at the north edge of Buffalo Township. The hilltops are generally 1,000 to 1,100 feet in elevation, there being many flat areas at 1,000 to 1,040 feet. Some of the highest summits in the northeastern part of Buffalo Township rise as high as 1,180 feet.

GEOLOGIC SECTION.

The outcropping strata mostly belong to the Conemaugh formation and consist largely of brownish-red shale and clay with nonpersistent sandstone beds and a few layers of limestone. Limestone and sandy shale of the Monongahela formation form the conspicuous terraced hilltops in the eastern part of Buffalo Township.

The Ames limestone is the lowest outcropping stratum worthy of note. It is a fossiliferous brownish-gray layer 1 to 2 feet thick. Elevations obtained on its outcrop at numerous places furnish evidence regarding the attitude of the rocks. The outcrop of the limestone is a prominent spring line, owing to the impermeable clay associated with it. The overlying strata consist of sandy shale of olive-green color. Beds to a height of 150 feet above this shale consist largely of rusty-brown sandy shale and brownish-red clay which form gentle hillside slopes.

In Valley Township the Cambridge limestone, 109 feet below the Ames, is exposed. The bed is not as thick here as to the northeast, near Senecaville. About 10 feet above it is the Anderson coal, which has been mined in the village near the Waldhonding coal mine.

The several limestone beds that appear in the hilltops at the east side of Buffalo Township lie 150 to 250 feet above the Ames limestone. None of them are more than 2 to 4 feet thick, and each is separated from the next by 25 to 40 feet of tough sandy shale to which in large part are due the conspicuous steepened hillside slopes.

MINERAL RESOURCES.

A portion of the Chaseville oil and gas pool lies in the northeastern part of Buffalo Township. The outcropping strata include no coal beds of considerable economic value, the only one being the Anderson, which is 1½ to 2 feet thick in Valley Township. The township is, however, underlain by a considerable area of minable Upper Freeport coal, the same bed as that mined at Senecaville and at several places on the Cleveland and Marietta branch of the Pennsylvania Railroad. Its depth below the Ames limestone is about 265 feet. The bed is recorded in some of the wells in the Chaseville oil field and has also been found in several hollow-rod drill holes in secs. 12 and 13. It is extremely variable in thickness and subject to abrupt changes; therefore no areas in which it occurs can be considered as of proved value until thoroughly tested with the drill.

The principal limestone and sandstone beds lie in the high hills in the eastern part of Buffalo Township. The sandstone may be of more or less value locally for use in foundations. The limestone furnishes an easily accessible source of material in moderate quantity for road building.

SENECA TOWNSHIP.

Seneca Township includes all but the two north rows of sections of T. 8 N., R. 8 W., as designated in the original land survey. Mount Ephraim and Chaseville are the only villages. The nearest place on the Ohio River & Western Railroad is Mount Ephraim Station, 1½ miles south of the village of Mount Ephraim. Senecaville, on a

branch of the Baltimore & Ohio Railroad, is 3 miles north of Chaseville. The population of the township according to the census report for 1920 was 616. The mineral resources include an oil and gas field at Chaseville and a bed of coal mined by shafts at numerous places in the township.

SURFACE FEATURES.

The principal valleys of the township are broad and of low gradient, the fall being only 2 or 3 feet to the mile. This general character of the valleys of the trunk streams also marks those of the numerous small tributaries, which rise in the ridge that forms the principal divide, extending from Chaseville to Mount Ephraim and thence southeastward to Summerfield. The hilltops are rounded and have summits of varying elevation, there being no level upland. The altitude on the divide ranges from 1,100 to 1,260 feet above sea level, and the highest point is in the vicinity of Mount Ephraim. The lowest valley bottoms along the north side of the township have an elevation of about 830 feet. The rocks of the area consist largely of sandy shale alternating with clay and limestone beds, which constitute the higher hills. Below these are red clay and shale with few sandstone layers, which are so weak that landslides are prevalent. Such strata form gentle slopes that steepen abruptly at the beginning of the overlying tough sandy shale, whose resistant character produces the terraces so typical of this region.

GEOLOGIC SECTION.

The lowest easily recognized stratum at the surface in Seneca Township is the Ames limestone. Its outcrop is limited to the valleys of North Fork of Buffalo Creek in sec. 30 and Opossum Run east of Chaseville, as shown on Plate XII (in pocket). The limestone is only 1 foot or so thick but has abundant fossil shells.

Above the Ames limestone are sandy shale, nonpersistent sandstone, and red clay, with nodules of white limestone and hematite. The beds, with the exception of the basal 50 feet, are as a whole weak and much given to landslides. About 150 feet above the Ames limestone is the Lower Pittsburgh limestone, a gray rock 2 to 3 feet thick, of smooth, homogeneous texture, lacking fossil shells such as are found in the Ames. Higher strata consist of other limestone beds at intervals of 25 to 40 feet, between which are resistant sandy shale. The coal bed mined at many places in the area is the Meigs Creek. Its position is 120 to 140 feet above the Lower Pittsburgh limestone, or 270 to 290 feet above the Ames limestone. Over the coal is sandy shale, sandstone, or locally clay shale and limestone.

STRUCTURE.

The dip of the rocks is in general southeastward at a rate ranging from 10 to 40 feet to the mile. The axis of the Chaseville anticline, a low fold, extends in a northeasterly direction through Chaseville, and along it is the Chaseville oil and gas field. The oil and gas produced here are derived largely from the Berea sand, which has also recently proved to be productive in sec. 22, 1½ miles northeast of Mount Ephraim.

MINERAL RESOURCES.

Coal, oil, and gas are the most valuable mineral products in Seneca Township. The township also contains sandstone for use in building and limestone for surfacing the roads.

COAL.

The Meigs Creek is the only minable coal bed at the surface in this township. The Pittsburgh coal, whose position is about 108 feet lower, or 25 feet above the Lower Pittsburgh limestone, is lacking here and in adjoining townships.

UPPER FREEPORT COAL.

The Upper Freeport coal, mined at Senecaville by shafts, may underlie parts of Seneca Township in minable thickness, but this fact can only be determined by extensive testing with the core drill. The bed is reported in a few wells in the vicinity of Chaseville, but is lacking in most of the oil and gas field.

MEIGS CREEK COAL.

The outcrop of the Meigs Creek coal bed is shown on Plates VI and XII. The bed is about 1,050 feet above sea level in the southeast corner of the township and rises northwestward to the tops of the highest hills a mile or so beyond Mount Ephraim. The thickness of the bed is illustrated by the following sections:

Sections of Meigs Creek coal bed in Seneca Township.

Mine on H. Morgan farm, SE. ¼ sec. 26 (locality 41).

	Ft.	in.
Shale.		
Coal, shaly		11
Clay		5½
Coal	1	7
Clay		1
Coal	1	3
Clay shale, unmeasured.		
Thickness of coal bed	4	3½

Ditto sheet #9

Mine on Mendenhall farm, SE. ¼ sec. 22 (locality 36).

	Ft.	in.
Shale.		
Coal		5½
"Sulphur"		1
Coal	1	2
Bone		2
Coal	1	5½
Clay shale.		
Thickness of coal bed	3	4

Roadside exposure in south-central part of sec. 29 (locality 35).

	Ft.	in.
Shale, sandy.		
Coal, shaly		9
Clay	1	
Coal	2	6
Clay shale.		

A sample of the core in the Wiley Carter mine, half a mile south of Mount Ephraim (locality 37), was taken for analysis (No. 20235, p. 40). A section of the coal in this mine is given in Plate VI.

The thickness of the bed at the extreme southeast corner of the township is indicated by a measurement made on the J. S. Sparling farm, across the township line, 1 mile east of Whigville (locality 42), where the bed from top to bottom shows coal, 2 feet 3 inches; shaly coal, 5 inches; and coal, 1 foot 10 inches; total thickness, 4 feet 6 inches.

From the above sections it is evident that the bed is of less value in Seneca Township than to the south, the thickness being only a little more than 3 feet in most places. The bed is, however, of good quality and ample in quantity for the needs of the farmers.

SANDSTONE AND LIMESTONE.

One bed of sandstone suitable for buildings and foundations is found in this township. It lies between the Lower Pittsburgh limestone and Meigs Creek coal. This rock, with associated beds, forms the conspicuous terrace about 150 feet above the valley in the western part of the township. The outcrop of the sandstone remains wooded because the slopes are too steep and rocky for cultivation. The sandstone has been quarried at a few places northeast of Riches School, in secs. 20, 29, and 30. The beds are in layers 2 to 4 feet thick in convenient attitude for quarrying. Similar exposures are found in the valleys at the south side of the township. In the northeastern part the beds are shaly and less massive.

The important limestone beds of this township are three in number and occupy positions 30, 90, and 125 feet below the Meigs Creek coal. The Lower Pittsburgh limestone, the lowest of the three, is 2 to 3 feet thick in all but the western part of the township, where

it is nodular and less conspicuous than the Upper Pittsburgh limestone, about 25 feet higher. The limestones beneath the Pomeroy coal and the Fishpot limestone (beneath the Lower Meigs Creek coal) are persistently 1½ to 3 feet thick.

These limestone beds are so widely distributed through the township that they offer a ready supply of material for surfacing the roads. Nevertheless no limestone pikes have been built in this township, and only a few miles of pike in adjoining ones.

CENTER TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Center Township occupies the southwestern part of the Summerfield quadrangle and narrow areas along the borders of adjacent quadrangles. The eastern part of the township lies within T. 7 N., R. 8 W., as designated by the original land survey, and the western part includes two north-south rows of sections within T. 7 N., R. 9 W. Sarahsville, the only village, is in the north-central portion on the Ohio River & Western Railroad, about 6 miles northeast of Caldwell, the county seat. The number of inhabitants in Sarahsville, according to the census of 1920, was 186, and in the entire township 1,083. The mineral resources include a coal bed in the hills of the eastern half of the township, possibly some minable coal below the surface, and three small oil pools.

Nearly all of Center Township is drained by Buffalo Creek, which flows northwestward and unites with Wills Creek at Hartford. A small area in the southwestern part is drained by branches of Duck Creek. The valley of Buffalo Creek widens into bottom lands of unusual extent a few miles from its source. Along the valley are low benches 30 to 40 feet above stream level, the tops of which are formed of a layer of sandy silt. These benches with their deposits are remnants of a former valley floor that has been largely worn away in the deepening of the valley to the modern flood plain. From them the slopes rise in terraces of moderate steepness to the summits of the ridges, which are 300 to 400 feet above the valley floor, or 1,150 to 1,250 feet above sea level. Terraced slopes are developed to an unusual degree in the northwestern part of the township, and their undulating profiles add to the beauty of the landscape. They are caused by rocks of varying resistance to weathering, such as tough shaly sandstone alternating with beds of clay, shale, and limestone. The resistant sandy beds are effective in retarding the tendency to "creep" of the softer beds, but landslides are fairly prevalent on slopes that have been without timber for a number of years.

GEOLOGIC SECTION.

The general direction of dip of the rocks in Center Township is southeast at an average rate of about 25 feet to the mile; therefore strata that lie low in the hills at the east side of the township rise westward to much higher positions and may be lacking even in the ridge tops. In like manner strata that crop out on Buffalo Creek at the northwest corner of the township lie far below the bottoms of the deepest valleys at the southeast corner. The thickness of beds thus exposed is in columnar section about 500 feet. Their stratigraphic sequence is illustrated by figure 2 (p. 16). The Conemaugh beds, constituting the lower part of the section, consist largely of sandy shale of light olive brownish-gray color, interbedded with reddish-brown shale and clay containing nodules of limestone and hematite. The few coal beds are thin and nonpersistent. Beds of limestone are likewise few and inconspicuous, with the exception of the Ames and Lower Pittsburgh. The Ames limestone is a brownish-gray impure rock stained with iron rust and containing abundent remains of fossil shells. This limestone, together with nonpersistent beds 15 to 60 feet higher, also fossiliferous, records the last invasion of the ocean into this region in "Coal Measures" time, and higher beds carry no fossil forms of known marine types.

The strata of the Monongahela formation differ from those below in that they lack the reddish-brown color and contain several beds of coal and of gray limestone. The coal beds, except the Meigs Creek, are thin or absent in Noble County, but to the northeast in Belmont County they are of great importance.

The principal hillside terraces in Center Township occur above the Ames limestone, above the Lower Pittsburgh limestone, and a little below the Meigs Creek coal. The lowest one appears along Buffalo Creek downstream from Sarahsville. It is controlled by sandy shale of pale greenish-yellow color. At the base are numerous springs which are led to the surface by clay associated with the Ames limestone.

Above the Ames terrace is a long, gentle rise to the level of sandy beds about 190 feet higher which overlie the Lower Pittsburgh limestone and form the terrace so conspicuous west and north of Sarahsville at an elevation of 1,000 to 1,050 feet above sea level. Still higher clay and limestone beds alternating with sandstone and sandy shale form other terraces that are only slightly less prominent.

STRUCTURE.

The prevailing dip or slope of the strata, as shown by elevations of the Meigs Creek coal and other beds determined by spirit leveling, is southeast, at 10 to 50 feet to the mile. No well-marked anticlines

or synclines are present, but there are minor flexures which cause considerable local variation in the direction of dip and form anticlinal "noses" and synclinal "embayments" such as those in the vicinity of Mount Ephraim Station shown on the structural map (Pl. XII, in pocket).

MINERAL RESOURCES.

COAL.

MEIGS CREEK COAL.

The Meigs Creek is the only important coal bed that crops out in Center Township. In the western half of the township it lies in the tops of the highest hills, where the cover is so slight that the coal is of little value. Eastward from a north-south line passing through Sarahsville there are so many small mines that it is safe to conclude that the bed is everywhere 4 feet or more in thickness. There is commonly a layer of clay a little above the middle dividing the coal into two benches. The rock overlying the coal is sandy shale or sandstone.

Sections of Meigs Creek coal bed in Center Township.

Mine on J. H. Young farm, 1 mile east of Sarahsville (locality 39).

	Ft.	in.
Sandstone.		
Coal	2	6
Clay		9
Coal	1	9
Shale		1
Coal	1	5
Clay shale.		
Thickness of bed	6	6

Mine on C. Hague farm, half a mile east of Fredericksdale (locality 40).

Clay shale.		
Coal	1	1
Clay	1	
Coal	4	
Clay shale.		

Mine on H. Carter farm, sec. 8, 2 miles northeast of Sarahsville (locality 38).

Clay, carbonaceous		1
Clay, gray		6
Coal, with irregular bony bands	3	4
Clay, unmeasured.		

3 data sheets #9

Where seen in openings in the vicinity of Mount Ephraim Station the bed is a few inches less than 4 feet thick and is overlain by shale, which in turn is overlain by a thick bed of sandstone. In the southeast corner of the township, near East Union, the coal is divided into two benches by the usual clay bed. The upper bench, which is 1 to 2 feet thick, is seldom used and is left up in the rooms as a roof. The lower bench ranges from 3½ to a little more than 4 feet in thickness.

COAL BEDS BELOW THE SURFACE.

The Upper Freeport coal mined at Senecaville and near Caldwell is about 570 feet below the Meigs Creek coal. In the valley of Buffalo Creek at the northwest corner of the township it is about 180 feet below the surface. Several coal test holes have been drilled in the valley, but the results are not available. A coal that is possibly the Upper Freeport is reported in the logs of some of the wells drilled for oil between Sarahsville and Caldwell.

SANDSTONE AND LIMESTONE.

The principal sandstone bed of Center Township lies about 60 feet below the Meigs Creek coal bed. It ranges from tough shaly beds to moderately massive layers that are well suited for building. The rock has been quarried by the farmers in a small way in the northeastern part of the township.

A sandstone bed overlies the Meigs Creek coal along much of its outcrop. The rock is of little use on account of its soft, friable texture. At one place east of Sarahsville it has been pulverized and used for building sand.

The principal limestone bed of Center Township is the Lower Pittsburgh, which lies about 145 feet below the Meigs Creek coal at the base of the prominent terraces in the western part of the township. This limestone is persistently 3 to 4 feet thick in all but the northern part of the township and is exposed in conspicuous outcrops along the hillsides. Where measured in the railroad cut 1½ miles south of Sarahsville the beds are 3½ feet thick. (See Pl. II, p. 16.) The weathered surface is invariably lumpy, and the rock is a limestone conglomerate. It is so firmly cemented that when broken the fracture passes indiscriminately through the pebbles as well as the matrix. The rock is well suited for various purposes, the most important being for road metal.

From 43 to 50 feet above the Lower Pittsburgh limestone is another dark bluish-gray laminated limestone about 2 feet thick. About 60 feet higher, or 20 feet below the Meigs Creek coal, is a gray resistant limestone 2 to 3 feet thick, the Fishpot, which is probably second in abundance to the Lower Pittsburgh. The total supply of limestone easily available in Center Township is ample for the building of many miles of good pike, but little work of that kind has been done.

The Ames limestone is of little or no value because of its slight thickness in Center Township. In typical exposure it is a single layer of brownish color, 1 foot or less thick. In the southern part of the township it consists of many thin beds of shaly limestone and calcareous shale 10 to 15 feet thick.

MARION TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Marion Township occupies an area of about 24 square miles in the south-central part of the Summerfield quadrangle. It includes the villages of Summerfield and Whigville, on the Ohio River & Western Railroad. The township is one of the richest in mineral resources in Noble County. The population, as given in the Census report for 1920, was 1,246 people, 484 of whom lived in Summerfield.

The township, with its present boundaries, is made up of parts of three townships of the early system of surveys, and for this reason some section numbers are used twice in different parts of the township. In the two eastern tiers the sections are numbered from south to north and in the remaining portion from east to west and then back and forth, beginning with the northeast corner of the township, according to the system now in use by the General Land Office.

Marion Township consists of a highland greatly dissected by deep ravines that have their sources on the principal divides in the central portion, separating northward-flowing branches of Wills Creek from the southward-flowing waters of Duck Creek. The elevations on this principal divide and its lateral extensions range between 1,150 and 1,250 feet above sea level. The lowest valley in the southern part of the township is that of East Fork of Duck Creek, about 780 feet in elevation, and the lowest in the northern part is that of Seneca Fork of Wills Creek, about 840 feet in elevation. The valleys of Seneca Fork and its tributaries are markedly broad. The Seneca Fork Valley, with its marshy bottomlands nearly half a mile wide, is occupied by a sluggish stream that follows a meandering course among numerous abandoned oxbows and sloughs. The slight fall, less than 5 feet to the mile, makes the run-off so slow that floods are common.

GEOLOGIC SECTION.

The Meigs Creek coal is the one coal bed that appears in minable thickness in Marion Township. It has been so extensively mined by the farmers that almost every farm is scarred with one or more prospect pits. In opening a mine the entrance is seldom securely timbered, and as a result it falls sooner or later, after coal has been extracted for a few seasons. Frequently, therefore, one may see from any good point of view on a hill a number of abandoned mine dumps with their car tracks and posts at the mine entrance.

The strata overlying the Meigs Creek coal consist of either shale and sandstone or clay and limestone, the latter being most prevalent in the eastern part of the township. There is commonly a bed of olive-

green clay about 14 feet above the coal. The character of the beds above and below the Meigs Creek coal, as seen near the railroad 1 mile northwest of Summerfield, is illustrated by the following section:

Section of beds at horizon of Meigs Creek coal near railroad 1 mile northwest of Summerfield.

	Feet.
Limestone, white, in several beds, unmeasured.	
Clay shale, olive-green	4
Limestone and clay shale	10
Coal, Meigs Creek	5±
Sandstone and sandy shale, unmeasured.	

About 120 feet above the Meigs Creek is another coal, the Uniontown, which appears as a blossom at numerous points on the ridges. Where seen in fresh exposures in railroad cuts and ravines it consists largely of bony coal with black shale. The strata above it are either sandy shale or thin-bedded sandstone about 50 feet thick, at the top of which is a bed of green clay and a few feet higher a coal blossom which marks the position of the Waynesburg coal, a bed of considerable value to the east, in Belmont County. (See Pl. IV, *B*, p. 18.)

The strata below the Meigs Creek coal consist of several limestone beds alternating with sandy shale and clay, with faint "markers" of coal beds that are of importance in other townships.

A record of strata penetrated in well No. 544 drilled on the F. L. Craig farm, half a mile south of Steamtown, is given below. This record, although incomplete, is of interest because it shows the positions of the principal sands with reference to the Meigs Creek coal and the names applied to them by oil men.

Log of well No. 544 on F. L. Craig farm.

	Thickness.	Depth.
	Feet.	*Feet.*
Coal, Meigs Creek		75
Rock, red	100	240– 340
Sand, 80-foot	60	340– 400
Rock, pale red	45	400– 445
Sand, 140-foot	60	445– 505
Sand, 300-foot	100	595– 695
Sand, 500-foot	14	812– 826
Sand, Stray	25	875– 900
Sand, Schramm	23	945– 968
Lime, Big	17	1,063–1,080
Sand, Keener	15	1,165–1,180
Sand, Big Injun	183	1,188–1,371
Sand, Berea; gas at 1,742–1,750 feet	9	1,741–1,750

STRUCTURE.

The dip of the strata in Marion Township varies considerably both in direction and degree. In general it is southeastward at a rate ranging from a few feet to 50 feet to the mile. In the northwest corner of the township the rocks lie nearly flat in an area of more than a square mile, and to the southeast in the succeeding half mile they

dip 40 feet. At the east side of the township north of Summerfield the rocks dip gently westward from the crest of a small anticlinal fold near the township line.

The structural map (Pl. XII, in pocket) is constructed from elevations determined on the Meigs Creek coal, and therefore the direction and degree of dip of that bed at any point can readily be ascertained by an inspection of the map. In opening coal mines it is desirable that the site for the entry be selected on a hillside where the rocks dip toward the mine entrance, in order that the water may drain from the mine workings and that the coal may be delivered at the mine mouth by gravity. The structural map will therefore be useful in the selection of locations for mines.

MINERAL RESOURCES.

The principal mineral products of Marion Township are coal, oil, and gas. The Summerfield gas field, one of the most valuable ever discovered in which the gas is obtained from the Berea sand, lies within the township. In the southern part of the township small quantities of oil are derived from the 500-foot sand and also the Berea sand.

COAL.

BEDS THAT CROP OUT.

The Meigs Creek coal is the only coal bed of minable thickness included in strata that crop out in Marion Township. The Uniontown coal bed, 115 to 140 feet above the Meigs Creek, forms a conspicuous blossom at a few places, but the coal is so shaly and bony as to be of little use. Its thickness where exposed in the railroad cut at Whigville (Pl. IV, *B*) is as follows:

Section of Uniontown coal bed at Whigville.

	Ft.	in.
Shale, sandy.		
Coal		6
Clay		2½
Coal	1	
Clay shale	1	6
Shale, bony	2	6
Coal		8
Shale, unmeasured.		

The extent of the Meigs Creek coal is shown on Plate VI, and its importance as a local source of fuel is evident from the numerous mines. The bed was formerly mined near Steamtown for railroad shipment, but the workings have been abandoned. In an area about 1 mile in width along the east side of the township the coal bed is little more than 2 feet thick. This is probably its thickness on the hills on the east side of Glady Run north of Summerfield and also

along the railroad southeast of the village. To the west the bed is believed to be uniformly 4 feet or more thick.

Sections of Meigs Creek coal bed in Marion Township.

Van Dyne Bros. mine, on J. S. Sparling farm, 1 mile east of Whigville (locality 42).

	Ft.	in.
Shale, unmeasured.		
Shale, black		10
Coal	2	3
Coal, bony with "sulphur"		5
Coal	1	10
Clay shale.		
Thickness of coal bed	4	6

T. C. Hague mine, southwest of railroad at Steamtown (locality 44).

	Ft.	in.
Clay shale.		
Coal		5
Clay	1	1
Bone		2
Coal	3	3
Clay		1½
Coal	1	3½
Clay shale.		
Thickness of coal bed	4	10

Where measured on Lexington Ridge at the south township line the bed is 4 feet 9 inches thick and contains no clay partings. A mile farther west, on the King farm, in the SE. ¼ sec. 23 (locality 45), the bed shows a thickness of 5 feet, with 1 foot of clay above and 1 foot of roof coal. At the northwest corner of the township the bed is as a rule 4 feet thick and is overlain by black shale with or without a layer of roof coal.

COAL BEDS BELOW THE SURFACE.

One or more coal beds are recorded in a number of wells drilled for oil and gas in Marion Township. The positions of the beds range from 300 to 800 feet below the Meigs Creek coal. There is little reliable evidence as to the thickness of these beds, and their identification is difficult owing to their seeming lack of agreement as to position with reference to the Meigs Creek coal. The Upper Freeport coal, which is mined at Senecaville and near Caldwell, if present n Marion Township, probably lies about 560 feet below the Meigs Creek coal.

LIMESTONE AND SANDSTONE.

The limestone beds of Marion Township, although not of great thickness, are so distributed as to furnish a ready source of material for road building throughout the township. A pike leading north from Summerfield along the ridge toward Batesville is the only road that has been improved in this or adjoining townships.

One of the most useful limestone members is the Lower Pittsburgh, which is persistently about 3 feet thick. It lies 50 to 100 feet above the valleys in the northern part of the township, and its white beds form a conspicuous outcrop on the hillsides. The same limestone is also seen along East Fork of Duck Creek and its tributaries in the western part of the township. Other limestone beds are found about 30 feet below the Meigs Creek coal and also above it, some of which are suitable for road metal.

Sandstone in thick beds suitable for quarrying operations is not plentiful in Marion Township. The most promising exposures occur in the western part of the township, where beds lying about 50 feet below the Meigs Creek coal form a prominent terrace, with local outcrops of massive character.

ENOCH TOWNSHIP.

A narrow strip along the north margin of Enoch Township is included in the Summerfield quadrangle. Fulda, the only village in the township, lies on a ridge 1½ miles to the south, in the Macksburg quadrangle. The portion of the area here described is probably best known on account of the Salt Run and Low Gap oil pools, in which the oil is derived from the Buell Run sand.

The Meigs Creek coal lies well up in the ridges at elevations ranging from 1,050 to 1,080 feet above sea level, or 100 feet above the valley of Buffalo Creek at the north edge of the township. It is present in minable amount throughout the township, and the thickness ranges from 5 to 7 feet or more. The value of the bed is somewhat lessened by a clay layer near the middle, which is commonly 1 foot thick. The character of the coal bed is illustrated by the following section:

Section of Meigs Creek coal bed in Lawrence Schaffer mine, near Fulda.

	Ft.	in.
Shale and sandstone.		
Coal	2	6
Clay		10
Coal	4	
Clay.		
Thickness of bed	7	4

In Enoch Township the Meigs Creek coal is overlain by sandstone or sandy shale instead of limestone, agreeing in this respect with rocks in townships to the east.

STOCK TOWNSHIP.

LOCATION AND SURFACE FEATURES.

The north end of Stock Township is included within the Summerfield quadrangle. It is drained by East Fork of Duck Creek and its tributaries, which follow in general a southeasterly direction. East

Union and Carlisle, situated in the valley, are the only villages. The number of inhabitants in the township, according to the census report of 1920, was 934, of whom 105 lived in Carlisle.

The surface is moderately rugged, and the valleys are narrower and bounded by steeper slopes than those of most valleys in the county, especially those to the north and west, in Seneca and Center townships. The valley of Duck Creek lies 720 to 770 feet above sea level in this township and is bordered by ridges whose summits are about 400 feet higher. The highest ridges are slightly more than 1,200 feet above sea level.

GEOLOGIC SECTION.

The most conspicuous bed in the township is the Meigs Creek coal, which is mined in all but the eastern part of the township. Its elevation in the vicinity of East Union ranges from 1,026 to 1,045 feet above sea level, or about 270 feet above the village. The coal dips gently to the southeast, and at the south edge of the quadrangle, where mined in the hill west of Duck Creek, it lies 992 feet above sea level.

The beds above the Meigs Creek coal consist of either clay and limestone or sandstone. The sandstone is most prevalent. About 15 feet above the coal is locally a bed of olive-green clay, which is so peculiar in appearance that it can not be mistaken for any other bed in the region. The only trace of coal in rocks above the Meigs Creek coal bed is about 138 feet higher, at the horizon of the Uniontown, which is marked by 1 foot or so of bony coal or black shale. The higher strata consist largely of sandstone and sandy shale with a few clay beds.

The succession of strata usually found below the Meigs Creek coal is shown below.

Section of strata below Meigs Creek coal, in Stock Township.

	Feet.
Coal, Meigs Creek	2–4
Shale of sandstone	28
Limestone, with coal marker above	3
Shale, sandy, with one or more beds of clay or limestone	48
Limestone, dark, shaly	2
Shale, sandy	27
Clay, calcareous, with coal marker above at place of Pittsburgh coal	2
Shale	19
Limestone, Lower Pittsburgh beds	4
Clay and shale, greenish gray to brownish red, with sandstone beds; thickness to bottom of valley	100±

The Lower Pittsburgh limestone probably ranks second to the Meigs Creek coal in its prominence as an easily recognized stratum.

The gray boulders form conspicuous outcrops on the hillsides and at waterfalls in the ravines. There are higher beds only slightly less prominent, and the township is therefore supplied with an abundance of easily accessible limestone material for surfacing its roads. There are, however, no pikes, and little attempt has been made to improve the roads.

COAL BEDS.

The only coal bed of economic importance in Stock Township is the Meigs Creek. It has been mined by the farmers at dozens of places and maintains a thickness of 4 to 5 feet throughout the township except in a strip at the east side less than 2 miles wide, where it thins to about 2 feet. The thickness in a hollow at the north edge of sec. 28 (locality 49), and also half a mile farther north, in a valley east of Curtis Church, is about 2 feet. On the hillside a few hundred feet west of the church, in sec. 35 (locality 48) the bed is a little less than 2 feet thick.

Half a mile to the west the bed is several feet thick and locally consists of two benches, each of which is minable, separated by a few inches to a foot or more of bony coal or clay. A measurement at the mine on the Martha Curtis farm, in sec. 25 (locality 46), shows that the bed is without partings and is 4 feet 9 inches thick. In sec. 3 the bed is much broken by partings, as shown in the following section:

Section of Meigs Creek coal bed at mine on J. H. Bates farm, NW. ¼ sec. 3, 2 miles west of Carlisle, about one-quarter mile south of Summerfield quadrangle.

	Ft.	in.
Sandstone.		
Coal		11
Bone.		
Clay		8
Coal	1	1
"Soot"		¼
Coal	2	1
Bone		¼
Coal	1	10
Clay.		
Thickness of bed	5	½

BEAVER TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Beaver Township occupies all but a narrow strip at the west side of T. 8 N., R. 7 W., as designated in the original land survey. Batesville, the only village, is near the center, about 3½ miles from the Baltimore & Ohio Railroad, which touches the northeast corner. The population of the township in 1920 was 1,190. The land is fairly fertile,

and tobacco is the principal crop. Coal is the most important mineral product. The northeast corner of the township is underlain by the Pittsburgh bed in minable thickness, and the northwest half by the Meigs Creek bed.

Beaver Creek, flowing westward through the central portion, is the principal drainage line and is joined by a number of parallel tributaries from the north. Those from the south are few and small. This unsymmetrical arrangement of drainage lines is true not only of Beaver Creek, but also of many other east or west flowing streams in this region, which have a number of long tributaries from the north and only a few short ones from the south. Less than 1 mile south of Beaver Creek is a divide separating its waters from these of southward-flowing branches of Seneca Fork of Wills Creek.

The valleys are bordered by fairly steep hills, whose summits are 1,200 to 1,300 feet above sea level. They are considerably higher than those to the west, in Wayne Township, and the surface is on the whole more rugged than that of townships on the west and east.

GEOLOGIC SECTION.

The principal members of the geologic section in the northeastern part of the township are the Pittsburgh coal bed in minable thickness and a prominent sandstone about 70 feet higher, at the base of which is the Lower Meigs Creek coal bed, 1 to 2 feet thick. The Meigs Creek coal is missing in this vicinity, but its position is near the top of this sandstone, or about 35 feet above the Lower Meigs Creek coal. When followed in a southwesterly direction the sandstone gives place to sandy shale and the Meigs Creek coal assumes a minable thickness. In the same vicinity the Pittsburgh coal abruptly thins to a mere blossom, and where geologically due farther southwest it is missing altogether.

The Pittsburgh coal thins southwestward from a bed 4 feet thick to a carbonaceous streak, within less than 1 mile. The overlying and underlying strata are much the same where the coal is present and where it is lacking, and there is seemingly little evidence as to the cause of the change. The principal difference is a thickening of the underlying limestone beds in the barren area. There may have been a deepening of the great swamp in Pittsburgh time which resulted in the formation of a great open lake that afforded favorable conditions to the accumulation of thick limy muds but not for the uninterrupted acccumulation of plant materials into peat beds.

The irregularity of the Meigs Creek coal bed is obviously to be ascribed to a different cause. The formation of a peat bed of uniform thickness at that time was hindered and locally prevented by the contemporaneous deposition of quantities of sand, possibly at the deltas of several rivers.

The succession of strata below the surface is illustrated by the following well record:

Log of well No. 96 on Roe farm, in the NW. ¼ sec. 19, Beaver Township.

[Well head 100 feet below Meigs Creek coal.]

	Thickness.	Depth.
	Feet.	*Feet.*
Surface	10	10
Limestone		20
Rock, red		124
Shale, sandy	21	124–145
Rock, red	35	145–180
Coal, Brush Creek (?)	4	400
Coal, Upper Freeport (?)	4	470
Sand, salt (gas)		560
Sand, Keener (oil)	5	903

STRUCTURE.

The general southeastward dip in this region is varied in Beaver Township by several minor flexures, which produce considerable variation in the direction of dip. At the west side of the township is a shallow synclinal embayment extending northward from Summerfield. To the east this is paralleled by an anticlinal nose extending southward from Quaker City. The direction of dip therefore varies from east or southeast to south, southwest, and even west. The dip is at most 40 or 50 feet to the mile, and locally as little as 10 feet.

MINERAL RESOURCES.

Oil and gas have long been produced from the Temperanceville pool, a portion of which extends into Beaver Township. The productive oil sand here, as well as in the Barnesville pool, to the north, is the Berea. A small amount of oil has been obtained from the Keener sand 2½ miles southwest of Batesville. Coal, limestone, and sandstone are also important mineral products in the township.

COAL.

Of the coal beds that crop out in this township, the Pittsburgh, Lower Meigs Creek, and Meigs Creek are the only ones of sufficient value to be worthy of description. Other coals far below the surface have been recorded in a few oil wells, but the information available is meager. A bed, probably the Upper Freeport, is found in wells drilled on the Roe farm, in sec. 19, as shown in the record above.

PITTSBURGH COAL.

The Pittsburgh coal bed crops out in minable thickness in only a few square miles in the northeast corner of the township. (See Pl. V, p. 28.) The limiting line extends roughly from Temperance-

ville northwestward toward a point half a mile south of Quaker City. Southwest of this line the Pittsburgh coal is represented by a marker of black shale resting on the Upper Pittsburgh limestone.

Half a mile west of Temperanceville, on the C. E. Wilson farm, at the south line of sec. 4 (locality 11), the coal as indicated by a ravine exposure is only a few inches thick. The following section was measured at this point:

Section showing strata at horizon of Pittsburgh coal on C. E. Wilson farm.

	Feet.
Coal blossom, Pittsburgh, thin.	
Limestone, bluish gray, weathering to light gray with yellowish mottlings	5
Clay shale	20
Limestone, gray, with ocherous yellow patches and brecciated structure	4

Along the valley in the N. ½ sec. 4 are small mines from which the Pittsburgh coal has been taken, and the thickness of the bed is about 4 feet. Several openings have been made on the Douglass farm, at the north side of sec. 10, and farther north up the valley. The coal is reported to be thin in the ravine west of the crossroads, but to be 3 to 4 feet thick about 600 feet farther north. It is reported that coal 3 feet thick was once dug from the creek bed at the east side of sec. 17 (locality 5). A good thickness is found at the head of the valley at the southeast corner of sec. 12, where the bed has been mined on the Flood farm. To the west, along the south side of sec. 12 and across the border of sec. 18, there is some uncertainty whether the bed is of minable thickness. The same is true in the NW. ¼ sec. 18. In sec. 6 near the railroad and to the south along the township line the bed is about 4 feet thick and is overlain by sandstone which in places forms an undulating contact with the coal. The sandstone masses extending down into the coal are called "rolls" or "horses" by the miners.

LOWER MEIGS CREEK COAL.

The Lower Meigs Creek coal is persistent throughout large areas in thicknesses of 1 foot or less. Locally it thickens to 2 feet and has been stripped for home use at a few places. Its position is 75 to 85 feet above the Pittsburgh coal and 30 to 40 feet below the Meigs Creek. In sec. 11, near Tuckyho School, the bed is slightly more than 2 feet thick. Where seen at numerous places in the hills southeast of Batesville the thickness ranges from 1 foot 2 inches to 1 foot 7 inches, but toward the west it decreases to less than 1 foot.

MEIGS CREEK COAL.

The Meigs Creek coal bed in minable thickness is limited to the northwest half of Beaver Township. The line marking the limit of minable coal extends approximately along the road leading from

Summerfield to Batesville, thence east 1 mile, north through the center of secs. 10 and 11, and northwest toward Quaker City. East of this line the bed is generally less than 1 foot 6 inches thick and in places is a mere carbonaceous streak. West of the line the thickness increases to about 4 feet. "Clay veins" and "horses" that give considerable trouble in mining are common.

North of Beaver Creek a number of measurements were made, as follows:

At the C. W. Long mine, in sec. 30 (locality 55), the bed has a thickness of 4 feet 5 inches, at a roadside exposure in the SE. ¼ sec. 24 (locality 56) it is 4 feet 3 inches thick, and at a roadside exposure in the S. ½ sec. 18 (locality 57) it is 3 feet 3 inches thick.

A section of the G. W. Griffin mine, in sec. 11 (locality 61), is given on Plate VI (p. 32) and also on page 46. A sample for analysis was taken in this mine (analysis 20185, p. 40).

Where seen in a slip at the top of a hill half a mile east of Batesville (locality 60) the coal is about 3 feet thick. In the hills west of Batesville its thickness is in most places about 4 feet. In a few places there is an upper layer of coal separated from the main bed by a foot or so of clay.

About 1 mile east of Palestine Church, in the NW. ¼ sec. 14 (locality 59), the coal, where exposed at the forks of the road, is 1 foot 3 inches thick. The Lower Meigs Creek coal, with a thickness of nearly 2 feet, appears along the road 28 feet lower, underlain by limestone. Half a mile to the west, in sec. 20, the Meigs Creek coal is 2 to 3 feet thick, and farther west it thickens to about 4 feet. Over the coal is a massive bed of coarse-grained sandstone.

Section of Meigs Creek coal in Joseph Morris mine in the SW. ¼ sec. 26, Beaver Township (locality 58).

	Ft.	in.
Shale.		
Coal, impure		10
Shale, soft	1	2
Coal	1	8
Shale		2
Coal		10
Clay and "sulphur"		1
Coal	2	½
Clay shale.		
Thickness of lower bench	4	9½

At the center of sec. 19 there is a faint blossom of the Meigs Creek coal, and it is a safe conclusion that the coal is not present in minable thickness in this vicinity. Exposures seen in the hills to the west across the valley indicate a thickness of 3 to 4 feet.

UNIONTOWN AND WAYNESBURG COAL BEDS.

The Uniontown and Waynesburg coals are present in the highest ridges in the southeastern part of the township. So far as known, the Uniontown is no thicker than 1 foot at any point. It was seen at a number of places on the ridge north of Calais. The Waynesburg coal is reported to be almost 2 feet thick near the east township line in sec. 2, where at one time it was mined for use on the Carpenter farm.

LIMESTONE AND SANDSTONE.

Beaver Township probably has a greater quantity of limestone in easily accessible outcrops than any other township in this region. A fair limestone pike has been built the greater part of the distance from Summerfield through Batesville to Quaker City, but aside from this almost no use has been made of the limestone. Most of the roads are poor, especially those along the valleys, which become almost impassable in rainy weather.

The positions of the principal beds are evident on any hillside, owing to the prominent outcropping white layers that are freshly exposed each year through the slipping of the loose soil cover. The Lower Pittsburgh and Upper Pittsburgh limestones are the most conspicuous. Their positions, together with those of other beds, are illustrated by the following section measured along the road at the south side of sec. 9:

Section showing limestone beds in sec. 9, Beaver Township.

	Feet.
Coal blossom, Lower Meigs Creek.	
Limestone, Fishpot, gray; weathers to chalky white	2
Shale, sandy; forms steep slopes	50
Limestone, dark blue, laminated	2
Shale, sandy	30
Limestone, Upper Pittsburgh, gray	3
Shale, sandy	24
Limestone, Lower Pittsburgh, in several layers forming waterfalls in ravine	7

The Fishpot limestone is possibly of sufficient purity to be burned for building lime. Other beds, although somewhat ferruginous, are burned by the farmers for agricultural lime.

Coarse sandstone in thick layers occurs below the Meigs Creek coal in the eastern part of the township. It is conspicuous north and south of Temperanceville, where its great blocks are distributed along the hillsides and cliffs, and are conspicuous in the ravines. A similar sandstone is present above the Meigs Creek coal in a small area in the northwestern part of the township.

The sandstone in the vicinity of Temperanceville and northward is rusty brown or yellowish gray in color and of coarse texture. It has

been used principally for foundations and bridges, but will probably be found of some value for building. Like most other beds of the region, however, it is soft and loosely cemented and therefore does not resist weathering to the extent desired.

BELMONT COUNTY.

The portion of Belmont County included in the Woodsfield quadrangle is the southwest corner, comprising Wayne and Somerset townships and parts of Warren, Goshen, Smith, and Washington townships. All these townships are regular in shape and the sections 1 mile square, into which they are divided, are numbered in north-south rows, beginning at the southeast corner, as was customary in the earliest surveys of this region.

WARREN TOWNSHIP.

SURFACE FEATURES.

Warren Township, the southern half of which is included in the Woodsfield quadrangle, has a greater population than any other township in the area here described, the census of 1920 showing a total of 6,770. Barnesville, a town of 4,865 inhabitants, lies in the south-central portion, on the Baltimore & Ohio Railroad, which follows a northeastward route across the township. The principal divide of the area, separating eastward-flowing tributaries of Ohio River from branches of Tuscarawas River, extends in a north-south direction, and on it the hilltops range from 1,250 to 1,350 feet in elevation. The least elevation is about 900 feet on Leatherwood Creek at the southwest corner of the township. At this point the railroad track is about 1,025 feet above sea level, and in the distance of about 4 miles to Barnesville it climbs to about 1,240 feet, giving a difficult grade up which heavily loaded trains must be helped by a second engine.

The surface is least rugged in the eastern part of the township, where there is considerable rolling upland that is broken only by shallow valleys occupied by the headwaters of Captina Creek and its tributary Long Run. This portion is best suited to farming both on account of its gentle topography and also for the reason that the soil is enriched by the decomposition of many limestone beds. The western portion has a more rugged surface, being cut by many deep ravines with steep slopes.

GEOLOGIC SECTION.

The rocks that crop out in Warren Township have a thickness of about 400 feet and include in ascending order the upper portion of the Conemaugh formation, all of the Monongahela, and about 100

feet of the Washington. The rocks of the Conemaugh formation, as shown by the geologic map, crop out only along Leatherwood Creek and its branches and in the valley in sec. 33. The ridges between these valleys and all the upland to the east consist of strata in the Monongahela and Washington formations. The stratigraphic sequence is illustrated by the following section, which is a generalization of observations made throughout the township:

Generalized section in descending order of strata outcropping in Warren Township.

	Feet.
Washington formation:	
Sandstone, coarse-grained, friable, capping the ridges east and south from Barnesville, correlated with Mannington sandstone of West Virginia Geological Survey	40
Coal, Waynesburg "A," commonly in two parts, separated by 4 to 8 feet of shale. Both beds thin.	
Shale or shaly sandstone	45
Monongahela formation:	
Coal, Waynesburg; too thin to be of value in Warren Township.	
Shale or shaly sandstone	48
Coal, thin, Uniontown.	
Shale	7
Limestone, dark, nodular, containing minute fossils	1
Shale, sandy	20
Limestone, Benwood, in many beds interlain with clay shale. In the northwest half of the township the limestone is missing, and in its place is sandy shale or sandstone	68
Coal, Meigs Creek; of workable thickness in nearly all of township	4
Sandstone or sandy shale	18–30
Coal, Lower Meigs Creek; of variable thickness; contains shale and "sulphur" bands	1–3
Limestone, Fishpot, in one or more layers	1–3
Shale and sandstone with one or more beds of limestone	60–75
Coal, Pittsburgh; workable throughout the township; mined at Baileys Mills	4
Conemaugh formation:	
Clay and limestone	4
Shale, sandy	19
Limestone, Lower Pittsburgh, grayish, with rusty-brown spots	3
Shale and sandstone and beds of reddish-brown clay	75

Of the strata represented in the above section probably the best known are the coals, especially the Pittsburgh and Meigs Creek. The Pittsburgh coal is mined for railroad shipment by two companies at Baileys Mills. Thence northeastward along the valley toward Barnesville the roadside is bordered by dozens of old openings. The openings in the Meigs Creek coal, which is about 100 feet higher than the Pittsburgh, are fewer, and at present only one mine is in active operation on Leatherwood Creek. The sandstone, so prominent in hollows 2 miles west of Barnesville, locally occupies the position of the Meigs Creek coal and associated strata.

Good exposures are not plentiful in the eastern part of the township, where the gentle slopes have a covering of soil that obscures outcrops. Much of the section is washed bare along the roadsides, and most of the geologic evidence available is obtained in such places. The Meigs Creek coal lies in the bottom of the valley of North Fork of Captina Creek; this coal and a thick sandstone, probably the Mannington sandstone of West Virginia reports, which caps the ridges, are the most noteworthy strata. The knowledge concerning the rocks below the surface is obtained from records of oil wells. The position of the Upper Freeport coal, which is mined near Lore City and other points to the west, is about 440 feet below the Pittsburgh coal. Its presence in Warren Township has not been proved.

STRUCTURE.

The direction and amount of inclination of the rock beds in Warren Township are expressed on the map by means of contours representing the "lay" of the Pittsburgh coal. The general dip is southeast, with local variations. West of Barnesville is a low fold trending northeast, known as the Barnesville anticline. The Pittsburgh coal lies at an altitude of about 1,080 feet above sea level along its crest and dips southeastward to 920 feet on the south township line. The dip is locally arrested in terrace-like forms, such as are illustrated by the alternate spreading and close grouping of the contours on the structural map (Pl. XII, in pocket).

MINERAL RESOURCES.

The principal mineral products of Warren Township are coal, oil and gas. The oil and gas field lies on an anticline west of Barnesville and the product is derived from the Berea sand, which is about 1,600 feet below the Pittsburgh coal.

COAL.

The stratigraphic positions of the principal coal beds are shown in the geologic section on page 16.

PITTSBURGH COAL.

The Pittsburgh coal bed maintains a thickness of at least 4 feet through nearly all of Warren Township. The only exception known is a small area at Baileys Mills, where the coal is probably reduced in thickness by a sandstone "roll." Its character along the outcrop on Leatherwood Creek and branches is evident in dozens of openings, and there is no reason for believing that it is not equally good under cover farther east. At a few points along the foot of the hill southwest of Barnesville the coal is overlain by sandstone, which forms an uneven contact with the coal. Records of core drilling beyond the south-

eastern limits of Warren Township, in Wayne and Goshen townships, also show that at two places the value of the coal is somewhat impaired by an uneven contact of the overlying sandstone.

There are in the vicinity of Baileys Mills two coal mines whose output is shipped by railroad—the Cochran mine No. 2 of the Bixler Ohio Coal Co. and the mine of the Media Coal Co. In 1916 these were the only shipping mines operating in the Pittsburgh coal within the Summerfield and Woodsfield quadrangles. Samples were taken in the Cochran mine No. 2, and the results of the analyses are given on page 39. Sections of the bed are given on page 44. The average make-up of the coal bed is illustrated by the following measurement:

Section of Pittsburgh coal bed in G. Wellen mine, 1 mile west of Barnesville (locality 7).

	Ft.	in.
Coal	1	1
"Sulphur"		½
Coal	1	9
"Sulphur"		½
Coal		11
Coal, bony		3
Clay.		
Thickness of bed	4	1

LOWER MEIGS CREEK COAL.

The Lower Meigs Creek coal bed is 2 feet thick in the greater part of Warren Township. It is seldom found free from "sulphur" and shale bands and has never been mined. It is of little importance, owing to the accessibility of the much more valuable Meigs Creek and Pittsburgh beds.

In the valley 1 mile northeast of Barnesville, where the Lower Meigs Creek coal has been exposed in the quarrying of the limestone that underlies it, a thickness of 2 feet 6 inches was measured. A shale band 4 inches thick is present 13 inches above the base. "Soot" streaks and "sulphur" impurities are also conspicuous. The Meigs Creek coal, lying 20 feet higher, has been mined here.

On both sides of Leatherwood Valley southwest of Barnesville the Lower Meigs Creek coal lies under sandstone and has been taken out for local use where exposed in hillside ravines. The following measurement was made below the railroad in the NE. ¼ sec. 20:

Section of Lower Meigs Creek coal on J. T. Forbes farm, sec. 20, Warren Township.

	Ft.	in.
Sandstone, coarse, massive	10	
Clay, bluish drab	1	2
Coal, bony	1	1
Coal, with thin streaks of bone and clay	1	11
Shale, dark blue	1	
Limestone	3	

A section similar to that just given was seen half a mile to the west, on the other side of Leatherwood Creek. The same coal is present in Cat Hollow, in sec. 19, where it is thicker than the Meigs Creek coal. It also appears as a blossom on the road 1 mile west of Barnesville but was not seen farther west, where the overlying sandstone becomes unusually prominent.

MEIGS CREEK COAL.

The Meigs Creek coal, which is second in value to the Pittsburgh, is present in workable thickness on the greater part of its outcrop in Warren Township. The principal exceptions are the south side of Cat Hollow and the extreme northwest corner of the township, where the value of the coal is doubtful. It occurs in workable thickness along Leatherwood Creek, northeast and north of Barnesville, and westward from Barnesville for about 2 miles. The coal is not so good as the Pittsburgh coal, and the bed is less accessible, especially in the ridges in the western half of the township; hence it has not been mined except in a small way, and few mines are now open. In the southeast corner of the township this coal is the only convenient source of fuel for the farmers and has been mined at numerous places along branches of Captina Creek. Its thickness is far from uniform and ranges from 2 to 4 feet.

The Meigs Creek coal has been mined for years in sec. 20 near the head of Leatherwood Creek to supply the Barnesville market. The minable portion of the bed as shown by the section (p. 46) is 3 feet 2 inches thick in the Thomas Davy mine (locality 63), on the west side of the valley. A sample was taken here for analysis, and the results appear on page 40.

In the Elmer Hoag mine, 1 mile northeast of Barnesville, in the valley west of Tacoma, the Meigs Creek coal consists of one bench 2 feet 8 inches thick, lacking persistent bands of "sulphur" or other impurities. A similar thickness is found in the hollow north of Barnesville. Near the head of Cat Hollow (locality 62), at the south side of the township, the coal is less than 2 feet thick.

OTHER COAL BEDS.

The Uniontown, Waynesburg, and Waynesburg "A" coal beds are all seen in roadside exposures in the eastern part of Warren Township but are everywhere too thin to be of present or prospective value. A few miles to the south, however, the Waynesburg coal attains a workable thickness, and to the east, in Goshen Township, both the Waynesburg and Uniontown coals are minable.

The Uniontown and Waynesburg coals are both exposed along the railroad within the limits of Barnesville. The Uniontown may be

seen in a cut a quarter of a mile southwest of the station, where it consists of 10 inches of bony coal overlain by carbonaceous shale and sandstone. The Waynesburg crops out at the east end of the tunnel near the station and consists of 13 inches of impure coal overlain by 8½ inches of bony coal.

LIMESTONE.

The principal limestone beds of this township are shown in the geologic section for Warren Township on page 90. The Lower Pittsburgh limestone is separated from the Pittsburgh coal by about 25 feet of sandy shale and clay with a thin limestone bed (Upper Pittsburgh limestone), at the top, close beneath the coal. A typical exposure of these beds may be seen in the railroad cut at the mine of the Media Coal Co., half a mile northeast of Baileys Mills, where the limestone consists of a single massive layer 4 feet thick, underlain by clay and nodular limestone.

The Lower Pittsburgh limestone is valuable chiefly for road metal and has been stripped for this purpose where accessible in the ravines. The bed is persistent, and a thickness such as that near Baileys Mills can be relied upon throughout the greater part of Belmont County.

The Fishpot limestone, below the Lower Meigs Creek coal is likewise of considerable value for road metal, although only a few feet thick. It has been extensively used on the roads near Barnesville. Where quarried at the Elmer Hoag coal mine, in the valley 1 mile northeast of Barnesville, it consists of several layers, the combined thickness of which is about 5 feet. The composition of the rock in this vicinity is shown by analyses on page 51. Similar exposures may be seen in the ravines on both sides of Leatherwood Creek. West of Barnesville, in secs. 27 and 33, the limestone has an ocherous yellow appearance and is too thin to be of value.

The Benwood limestone consists of numerous layers interbedded with clay and calcareous shale. The aggregate thickness of the beds is 60 to 70 feet. Some of the layers are sufficiently firm and durable to be used as road metal, but much of the limestone is argillaceous and on weathering decomposes to calcareous clay. Throughout the greater part of Warren Township the position of the Benwood limestone is occupied by sandy shale and locally by sandstone, especially in the western portion. Toward the east there is a gradual decrease in sandiness and the beds become more calcareous. The sandy shale and thin-bedded limestone commonly have ripple-marked surfaces and fossil sun cracks, indicating deposition in water of slight depth and temporary exposure to the air. The Benwood limestone is most prominent in the extreme southeast corner of the township, along North Fork of Captina Creek, where it is present in nearly typical form.

SANDSTONE.

The most conspicuous sandstone beds in Warren Township are the one below the Meigs Creek coal horizon and the one overlying the Waynesburg "A" coal. The positions of these beds are shown in the general section (fig. 2, p. 16).

Between the Meigs Creek and Lower Meigs Creek coals is locally a massive coarse-grained sandstone 25 to 40 feet thick. This is prominent on the south edge of the township and also in the hills 2 miles west of Barnesville. It has been used to a slight extent for bridge abutments and foundations and is well suited for such purposes. The sandstone overlying the Waynesburg "A" coal is conspicuous on all ridge roads leading south and east from Barnesville. It is loosely cemented and too friable to be well adapted for construction. It has been crushed and used for plastering sand and would probably be suited to use as a glass sand after washing.

GOSHEN TOWNSHIP.

SURFACE FEATURES.

The north boundary of the Woodsfield quadrangle is formed by the fortieth parallel of latitude, which extends through the north-central part of Goshen Township. The northern portion of the township, lying within the Flushing quadrangle, is crossed by the Baltimore & Ohio Railroad, on which are the villages of Bethesda and Belmont. The southern, more hilly portion has no villages but supports a fairly large rural population. In 1920 the township had 3,430 inhabitants.

The run-off of the portion within the Woodsfield quadrangle is carried by four principal streams—Long Run, Jakes Run, Bend Fork, and Joy Fork—all of which flow a little east of south and empty into Captina Creek. Their valleys, although only moderately deep and narrow, are followed by little-used wagon roads on which there are few houses, and the land is largely abandoned to brush and second-growth timber. Here and there are small clearings where tobacco is grown. On the ridges are numerous well-kept farms that form a marked contrast to those in the valleys. The least elevations on the floors of the valleys are about 960 to 1,000 feet above sea level. On the intervening ridges the elevation is generally 1,200 to 1,300 feet. Exceptionally high knobs are in secs. 14 and 9. The one in sec. 14 is marked "1364" at the triangulation station on the summit. The one in sec. 9, shown by the topographic map to be 1,380 feet above the sea, is occupied by a schoolhouse.

GEOLOGIC SECTION.

The direction of the drainage lines and their gradient in Goshen Township agree fairly closely with the direction and magnitude of dip of the rocks; hence the strata exposed along the valleys are much the same from localities near the sources of the streams southward across the township. In the valley of Long Run are exposed the lowest outcropping strata. The thickness of all the strata that crop out in the township is about 450 feet.

The beds at the surface in Goshen Township include the upper two-thirds of the Monongahela formation and about 250 feet of the overlying Washington. The stratigraphic sequence is illustrated by the following section, compiled from observations and measurements made at several places:

Geologic section in descending order of strata exposed in Goshen Township.

	Feet.
Washington formation:	
Shale or shaly sandstone, commonly reddish brown.	
Limestone, nodular, gray	3
Clay, shale, or sandy shale	57
Limestone, nodular or in continuous courses	2
Shale	39
Coal, Washington, in two layers with shale or clay between	2–3
Shale, sandy, grading into massive sansdtone in western part of township	55
Coal, Waynesburg "A," commonly consisting of two parts separated by 8 to 12 feet of shale; both beds thin.	
Clay shale, reddish brown, with nodular limestone or locally a thin bed of limestone	3
Shale, containing sandy layers and locally beds of massive sandstone; Waynesburg sandstone member	45
Monongahela formation:	
Coal, Waynesburg, present in minable thickness along outcrop in eastern part of township	1–4
Shale, sandy, or locally massive sandstone	50
Coal, Uniontown, mined on Jakes Run and Bend Fork	1–3
Clay shale with nodular limestone	6
Shale, sandy	27
Limestone, Benwood; many beds of limestone with interbedded clay and calcareous shale	68
Coal, Meigs Creek	2–4
Shale or shaly sandstone, unmeasured.	
Coal, Pittsburgh, not exposed in township; lies 100 feet below Meigs Creek coal.	

Many of the beds recorded in the above section change greatly in appearance from place to place. The coals are not persistent, sandstone occupies the place of limestone beds, and shale grades laterally into sandstone. In the western part of the township coarse sandstone overlies the Waynesburg "A" coal; farther east this sand-

stone gives place to red shale, clay, and limestone beds such as are typically exposed at the village of Hunter. Along Bend Fork the sandstones over the Waynesburg and Uniontown coals appear and disappear in a confusing manner.

STRUCTURE.

The dip of the strata, as shown by the contour map of the Pittsburgh coal (Pl. XII, in pocket), is a little south of east at a rate ranging from 15 to 60 feet to the mile. The amount of dip across Goshen Township is about 220 feet, the Pittsburgh coal being 970 feet above sea level at the greatest elevation and 750 feet at the least. The terrace-like undulations of the coal are shown by the alternate close spacing and spreading of the contour lines on the map.

MINERAL RESOURCES.

The principal mineral product in Goshen Township is coal. There are also sandstones that may be considered as of prospective value. No oil or gas of consequence has been discovered, but the township has by no means been thoroughly tested, and there is a possibility that valuable pools may be found here.

COAL.

The outcropping coals recorded in the general section (p. 16) vary considerably in thickness from place to place, and the limits of minable areas can be determined only by careful prospecting. The Pittsburgh coal, which lies below the surface, is far more reliable, and there is good reason for believing that it holds a thickness of at least 4½ feet throughout nearly all the township.

PITTSBURGH COAL.

The Pittsburgh coal is about 60 feet below the surface on Long Run, in the southwest corner of the township, and 160 to 180 feet below in the valley of Bend Fork. It has been tested by core drilling at five points and is recorded in a number of wells drilled for oil The records, except that of well No. 14, drilled on Long Run in section 31, indicate that the coal is of uniform thickness, approximating 5 feet. Additional information from adjacent areas leads to the belief that the Pittsburgh coal is a valuable bed throughout Goshen Township with the possible exception of the southwest corner. Core-drill record No. 14 shows the coal to be only 3 feet 4 inches thick and overlain by sandstone. About 1½ miles to the southeast, in sec. 23, Wayne Township, the bed is even thinner, being only 2 feet 5½ inches thick and overlain by sandstone as recorded in test hole No. 16.

A record of diamond-drill hole No. 17, on the T. J. Hatcher farm, in the valley of Bend Fork, in the NW. ¼ sec. 1, is given below. The elevation of the surface is 990 feet, and the depth to the coal 188 feet. The record was obtained from Prof. F. A. Ray, of Columbus, Ohio.

Record of core-drill hole No. 17, on T. J. Hatcher farm, Goshen Township.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Surface	11		11	
Limestone	7		18	
Soapstone	2		20	
Limestone	2		22	
Soapstone	2		24	
Limestone	5		29	
Soapstone	1		30	
Limestone	3		33	
Soapstone	1	6	34	6
Limestone	7	6	42	
Soapstone		6	42	6
Limestone		6	43	
Soapstone	1		44	
Limestone	22		66	
Soapstone	1		67	
Limestone	0	6	67	6
Soapstone	1		68	6
Limestone	26	8	95	2
Shale, dark	1		96	
Soapstone	3	1	99	1
Slate		1	99	2
Coal [Meigs Creek]	2	6	101	8
Limestone	12	2	113	10
Shale, gray	5	6	119	4
Slate	1	6	120	10
Coal [Lower Meigs Creek]	1	8	122	6
Fireclay	1	4	123	10
Limestone	13	6	137	4
Soapstone	1		138	4
Limestone	4	6	142	10
Soapstone		6	143	4
Limestone	3	6	146	10
Shale, light	5		151	10
Limestone	4		155	10
Slate, dark	3		158	10
Limestone	1		159	10
Shale, light	1		160	10
Limestone	7	6	168	4
Soapstone	1		169	4
Limestone	7		176	4
Soapstone	2		178	4
Limestone	1		179	4
Soapstone	4	3	183	7
Coal		9	184	4
Clay [Pittsburgh coal]		10½	185	2½
Coal	5	4½	190	7
Limestone		3	190	10

The thickness of the Pittsburgh coal in the other coal test holes drilled in Goshen Township is as follows:

	Ft.	in.
Hole No. 18, SE. ¼, sec. 1	5	1
Hole No. 15, SE. ¼, sec. 16	6	1
NE. ¼, sec. 6	5	4½

MEIGS CREEK COAL.

The Meigs Creek coal, lying about 100 feet above the Pittsburgh, appears in outcrop in the valley of Long Run in secs. 25, 31, and 32. It has been mined temporarily at several places for country use, and

there are now two small mines in operation (Pl. III, *A*). The following section was measured in an opening on the A. H. Peddicord farm (locality 67), in the SW. ¼ sec. 25:

Section of Meigs Creek coal bed in Peddicord Mine, Goshen Township (locality 67).

	Ft.	in.
Clay, unmeasured.		
Coal	2	10
Clay		½
Coal	1	3
Clay shale.		
Thickness of bed	4	1½

A section similar to the above is reported a short distance north on Long Run. About 1½ miles downstream the thickness is somewhat less. The thickness of the Meigs Creek coal under cover on Bend Fork, as shown by several diamond-drill test holes, is represented in the following tabulation:

	Ft.	in.
Hole No. 18, SE. ¼, sec. 1	3	2
Hole No. 17, NW. ¼, sec. 1	2	6
Hole No. 15, SE. ¼, sec. 16	3	10

UNIONTOWN COAL.

The Uniontown coal bed crops out low in the valley of Bend Fork and Jakes Run and lies 100 to 130 feet above the valley floor of Long Run. It has been mined at numerous places on the first two streams, but is not believed to be present in minable thickness at any point along Long Run or its tributaries, and at several places where observed it consists largely of carbonaceous shale. The most promising exposure is at locality 100, in sec. 31 (see measurement, p. 101), where the coal is about 3 feet thick and contains three layers of shale each several inches thick.

The Uniontown coal is called the "Three-Foot soft coal" by the miners, in order to distinguish it from the Waynesburg, which is known as the "Four-Foot hard coal." It is as a rule high in ash and contains one or more shale partings 1 to 3 inches in thickness, which may be so intimately intercalated with the coal that their exclusion in mining is difficult. This feature is illustrated in the following section measured in the C. J. Van Fossen mine in the NE. ¼ sec. 20, a view of which is given in Plate IV, *A*:

Section of Uniontown coal bed in C. J. Van Fossen mine, Goshen Township (locality 101).

	Ft.	in.
Shale.		
Coal	1	1
Shale		1–4
Coal		11
Clay shale		3½
Coal		9
Shale.		
Thickness of bed	3	4½

In a drift recently opened on the Ewars farm, in sec. 13 (locality 106) nearly 1 mile downstream from the Van Fossen farm, the coal differs from its usual appearance in that it is a bed 3 feet 11½ inches thick, free from shale bands. No such favorable showing was seen elsewhere.

The Uniontown coal has been mined in a small way at numerous places on Bend Fork, and its character is illustrated by the section given below.

Section of Uniontown coal bed on John Wharton farm, in sec. 15, Goshen Township (locality 102).

	Ft.	in.
Sandstone, coarse, irregular bedded.		
Shale	4	
Coal, with shale streaks	1	10
Clay shale		4
Coal	1	1
Shale.		
Thickness of bed	3	3

In the Peter G. Kemp property, in sec. 1 (locality 103), the make-up of the bed is similar to that shown above, but the thickness is only 2 feet 10½ inches. The measurements and results of analysis of a sample are given on pages 47 and 40, respectively.

On Bend Fork, especially in the southeast corner of Goshen Township, cross-bedded sandstone lies close above the Uniontown coal and has locally affected the thickness and quality of the coal bed, which is far from uniform. A measurement in the Gatten mine (locality 104), near the south township line, gives a section similar to that in the Kemp mine, but at several places less than 1 mile farther downstream the bed is too thin to be of value. It is likewise lacking where the road crosses Packsaddle Run in sec. 15, where there is at its horizon only a layer of dark clay overlain by cross-bedded sandstone.

WAYNESBURG COAL.

The area of minable coal in the Waynesburg bed in Goshen Township is considerably less than that of the Uniontown, which lies 50 feet lower. The Waynesburg, like the Uniontown, is invariably high in ash, an analysis showing 16 per cent; but it differs from the Uniontown coal in that shale bands are not common in the midst of the coal bed. The Waynesburg coal is also hard and tough, and for this reason is called the "Four-Foot hard coal" by the people who mine it. The bed has a workable thickness along the greater part of Bend Fork in its course across Goshen Township and is also known to be of slight value near the head of Jakes Run and on Long Run and its branches in secs. 25 and 31. In the H. S. Phillips mine, at the center of sec. 25 (locality 123), the coal is 4 feet 1 inch thick and has no shale impurities. The roof is massive sandstone about 12 feet thick. No

other exposure of the Waynesburg coal was found in this vicinity. Where seen to the southwest, west, and north, at points about 1 mile distant, the coal is somewhat thinner. On the hill road leading west from the valley in sec. 31 the following section was measured:

Section of coal beds on road in sec. 31 (locality 100).

	Ft.	In.
Shale.		
Waynesburg coal:		
Coal, with earthy bands	2	3
Shale		1
Coal		2
Shale, sandy	40	
Uniontown coal:		
Coal, with earthy bands		6
Shale		4
Coal		2½
Shale		2
Coal		7½
Shale		3
Coal		10½
Clay.		

On the Mead farm, on a branch of Jakes Run in the SW. ¼ sec. 21 (locality 124), the Waynesburg coal has been stripped, and a thickness of 2 feet is reported. No workable thickness was discovered elsewhere on this stream except to the south, beyond the township line, where the bed has been mined near Hunter.

The Waynesburg coal is probably of minable thickness throughout its outcrop on Bend Fork, except in a portion of sec. 1 and in secs. 16 and 22, near the head of Packsaddle Run. On the roadside in the NW. ¼ sec. 15 (locality 126) a thickness of about 2 feet was observed. At the south edge of sec. 1, on the road leading west up the hill, the coal shows only a thin blossom. An unsuccessful search for the coal was made in the north-central part of the same section. Near the northwest corner there is an old opening (locality 129) in which the thickness is reported to be 3 feet. Westward in the hollow in sec. 7 (locality 128) a section measured in the J. D. Milhoan mine shows a thickness of 3 feet 2 inches. The analysis of a sample taken at the Milhoan mine is given on page 41 (No. 20174) and the detailed section on page 48. The heating value is similar to that of samples of Uniontown coal, being 11,610 British thermal units, but considerably less than that of the Pittsburgh coal, which averages about 12,800 British thermal units in this region.

Another measurement of the Waynesburg coal made in the Ross Gregg mine, in sec. 15 (locality 127), gives a thickness of 3 feet 6 inches of clear coal. No openings were found farther north on either branch of Bend Fork and information as to the thickness as represented on the map (Pl. VIII, p. 34) is based on roadside and ravine exposures, none of which permit accurate measurements of the bed.

On the east edge of the township, in the valley of Joy Fork, the coal has been mined both by stripping and by drifting, and the thickness is reported to be about 3 feet.

WASHINGTON COAL.

The Washington coal is far more persistent than either the Uniontown or the Waynesburg, being 1½ to 2½ feet thick throughout nearly all its outcrop in the township. It is of little value, however, on account of its high ash content and also because the bed is commonly divided into two benches by a layer of shale 6 to 18 inches thick. There are few places where the coal has been taken from underground workings, but it has been stripped where the cover is slight in dozens of ravines, and there is hardly a farm where it has not been prospected.

The principal evidence as to its thickness is obtained in roadside and ravine exposures. On the hillside at the south edge of sec. 13 (locality 77), east of Hunter, the coal is 2 feet 6 inches thick, and beneath it is 5 feet of clay shale, underlain in turn by 10 inches of coal. The Waynesburg "A" coal, exposed on the same road 50 feet lower, has a thickness of 1 foot 1 inch. Few opportunities were found elsewhere for measurement of the Washington coal, but it seems probable that the thickness of 2½ feet at Hunter is somewhat above the average and that the coal is 2 feet or slightly less in thickness in the northeastern part of the township. Its only use will be as a fuel for the farmers living on the ridges remote from other sources of supply.

Another coal 12 to 18 inches thick occurs 20 to 25 feet above the Washington coal in the northeastern part of Goshen Township. To the east, in Washington Township, this higher coal is in places more prominent than the Washington.

LIMESTONE AND SANDSTONE.

The principal limestone exposures in Goshen Township are in the valley of Long Run, where the Benwood limestone, overlying the Meigs Creek coal, crops out. Many of the beds are too argillaceous to be durable and hence are not well suited for use as road metal. There are, however, more resistant layers, especially near the top, which are excellent for this purpose. These uppermost beds form the valley floors of Jakes Run and Bend Fork, where they would furnish large quantities of easily obtainable material.

The strata above the Benwood limestone consist largely of sandstone, shale, and clay, with little limestone. Almost the only beds of limestone are above the Washington coal, one being 40 feet and another 100 feet higher. These limestones are conspicuously exposed in the vicinity of Hunter and in the ridges to the northeast. They consist of nodular limestone embedded in clay, or of one to three

continuous layers, each about 1 foot thick. These beds by their decomposition enrich the soil, but otherwise they are of little importance.

The most widespread sandstone members of this township overlie the Uniontown and Waynesburg coals. These are locally massive and favorable for quarrying and suited for use in bridge foundations and other structures. The less massive sandstone is so irregularly bedded that it does not favor easy quarrying. Small quantities of the rock are taken out from time to time for local use.

The sandstone overlying the Uniontown coal has its most prominent development along Bend Fork. It is as a rule cross-bedded and made up of lenticular layers which closely overlie the coal or are separated from it by a few feet of sandy shale. Few exposures show rock suitable for quarrying.

The Waynesburg sandstone in massive form is not present throughout large areas. At the Phillips coal mine, in sec. 25, it has a thickness of about 12 feet. A similar thickness was seen on Bend Fork and its branches in secs. 9 and 15.

SOMERSET TOWNSHIP.

SURFACE FEATURES.

Somerset Township is an area 6 miles square which in terms of the early land surveys is designated T. 7 N., R. 6 W. All the sections except those in the west and north rows have each an area of approximately 1 square mile. The principal villages are Temperanceville and Somerton, in the west and east central portions, respectively. The extreme northwest corner of the township is crossed by the Baltimore & Ohio Railroad, which follows the valley of Leatherwood Creek.

The time is not remote when one or more railroads will be built across the township for the exploitation of the Pittsburgh coal which underlies all but the extreme southwest corner. A favorable route would be from the west up Beaver Creek to Temperanceville, thence up the valley to the northeast, and through the divide into the Slope Creek valley by a short tunnel. The route down the Slope Creek valley past Somerton is direct and furnishes an excellent grade. From Somerton eastward in Wayne Township along South Fork of Captina Creek there would necessarily be numerous cuts, tunnels, and bridges, owing to the exceeding crookedness of the valley. North Fork of Captina Creek is less objectionable in this respect and could be reached by a route up Cat Hollow or Dog Hollow from Baileys Mills.

Somerset Township contains the dividing ridge which separates eastward-flowing tributaries of Captina Creek from westward-flowing

streams that empty into Wills Creek and eventually into Tuscarawas River. All the valleys west of this divide have a mature aspect that is lacking in those east of the divide. The valleys of the westward-flowing streams have been cut to a moderate gradient almost to their sources, and the streams flow in wide bottoms bordered by high ridges. These valleys at points 1 mile from their sources are uniformly about 1,000 feet above sea level, whereas across the divide to the east points on streams at similar distances from the sources are 100 to 150 feet higher. The 1,000-foot contour is not reached in branch valleys of Captina Creek within the township, being 5 to 6 miles from its headwaters.

All points on the principal divide are higher than 1,200 feet in elevation, and numerous summits extend above 1,300 feet. The ridge near the township line in sec. 30 is 1,360 feet above sea level, and several hills southeast of Boston reach about 1,350 feet.

The valley slopes have been terraced, as a result of the unequal hardness of the rocks, and this feature not only adds to the beauty of the hills, but aids in farming the land. Rain water in its downward percolation through sandy strata is interrupted by clay beds associated with coals, and the water is led to the surface along the terraces, forming springs that furnish a clue to the position of such beds. Certain sandstone members have locally attained great prominence, and several of these border the deep valleys in the western part of the township, producing shelving cliffs and massive blocks which contribute a picturesque beauty.

GEOLOGIC SECTION.

The deep valleys near the western edge of the township have been cut below the position of the Pittsburgh coal, which is mined in the vicinity of Temperanceville and in Dog Hollow. Its elevation at those places is a little more than 1,000 feet above sea level. The general southeastward dip carries the bed below 850 feet in elevation in the southeast corner of the township. In the valley at Somerton it is about 170 feet below the surface and the Meigs Creek and Lower Meigs Creek coals are also below the valley. The Waynesburg coal is mined in the neighboring hills, and the Washington, a still higher bed, crops out on the highest ridges. Its position is about 380 feet above the Pittsburgh bed. If the strata above the Washington coal and those outcroping below the Pittsburgh are included, the total thickness of rocks exposed in Somerset Township is about 530 feet.

An illustration of the nonpersistence of sandstone members is found in the beds lying between the Lower Meigs Creek and the Meigs Creek coals. In Dog Hollow, at Temperanceville, and farther south on the headwaters of Rock Creek massive, cliff-forming sandstone

occupies this horizon and extends above the position of the Meigs Creek coal, which is thin or lacking. Still farther south and west the sandstone gives place to shaly sandstone and shale and the Meigs Creek coal again appears in its normal position, 25 to 30 feet above the Lower Meigs Creek coal. The sandstone over the Uniontown coal shows a similar variation in character, being a prominent massive bed in the southwestern part of the township and thin-bedded to shaly in the vicinity of Somerton.

The thinning of the Pittsburgh coal from a bed 4 feet thick to a carbonaceous streak takes place abruptly, as is evident at Temperanceville. In several mines on the north and east sides of the village the coal maintains a uniform thickness of nearly 4 feet. To the southwest and west, however, at points less than half a mile distant, the coal is too thin to be of value, and in valleys to the south it is lacking. The usual limestone beds immediately beneath and about 20 feet lower are continuous and even more prominently developed where the coal is lacking than where it is of minable thickness.

STRUCTURE.

The direction and rate of dip of the Pittsburgh coal is represented on the structural contour map (Pl. XII, in pocket), which shows that there is considerable variation in Somerset Township. In the vicinity of Temperanceville and to the north the beds lie nearly flat, but a short distance to the east they dip nearly 90 feet in 1 mile toward a shallow depression southwest of Somerton. North of Somerton there is a flat promontory-like terrace bordered on the northwest by a synclinal embayment and depression. South of Somerton the rocks lie nearly flat for about 2 miles, beyond which there is another increase in rate of dip.

In mapping the geologic structure the elevations of certain key beds whose positions with reference to the Pittsburgh coal are known were determined. The principal key beds are the Waynesburg and Uniontown coals and the limestone beneath the Lower Meigs Creek coal. Elevations were obtained on these and other beds and also on oil-well drill holes at about 180 points in the township. The higher coals and other strata lie so nearly parallel to one another, and also to the Pittsburgh bed that a map showing the "lay" of any one of them indicates also that of the others.

MINERAL RESOURCES.

Coal, petroleum, and natural gas are the principal mineral products of Somerset Township and the only ones that have been exploited to any extent. The numerous sandstone beds afford convenient material for bridge foundations and are quarried in small quantities as

needed. Limestone is not present in large quantities, but the amount in parts of the township is probably sufficient for putting most of the roads in good condition.

COAL.

The valuable coal beds of Somerset Township are in ascending order the Pittsburgh, Lower Meigs Creek, Meigs Creek, and Waynesburg.

PITTSBURGH COAL.

The Pittsburgh coal bed crops out in Dog Hollow in the northwest corner of the township and also in valleys occupied by the branches of Beaver Creek at Temperanceville. It may also be seen along the two branches of Rock Creek in the southwest corner of the township, where the coal is thin and of no value.

The bed has been mined at a number of places in Dog Hollow, but all the openings have been abandoned and most of them have fallen in. The following section measured at the south side of sec. 30 near the schoolhouse is believed to be representative of the neighborhood.

Section of Pittsburgh coal bed on the Judkins farm, in sec. 30, Somerset Township (locality 10).

	Ft.	in.
Sandstone, unmeasured.		
Clay shale	3	
Coal, no persistent partings seen	3	11
Clay and limestone	2	

The quality of the Pittsburgh coal is shown by analyses of samples taken in the Cochran No. 2 mine at Baileys Mills (Nos. 20187, 20188, p. 39).

The Pittsburgh coal was measured and sampled in the Jefferies mine, a quarter of a mile southeast of the crossroads at Temperanceville. The analysis (No. 20230) is given on page 39. The coal compares favorably with that at Baileys Mills, being only slightly lower in calorific value and a little higher in ash. A detailed section of the bed, about 3 feet 8½ inches thick, is given on page 45.

On the outcrop map (Pl. V, p. 28) is shown the approximate line dividing the valuable Pittsburgh coal to the north from the barren portion to the south. This line can readily be traced by numerous old openings where the coal is good and unsuccessful prospects where it fails. The coal is of doubtful value on the south side of the valley west of Temperanceville and is also lacking in the hills bordering the valley of Beaver Creek on the north, except in the immediate vicinity of Temperanceville. From Temperanceville the line of division bears northwestward to the vicinity of Quaker City.

South of Temperanceville on the two branches of Rock Creek the position of the Pittsburgh coal is marked by a little carbonaceous shale or a thin coal streak overlying several beds of bluish limestone.

The Lower Pittsburgh limestone is a prominent bed and can be traced continuously westward along the valley to its junction with Beaver Creek, thence eastward to the point where the Pittsburgh coal again appears as a valuable bed.

The bed at the Pittsburgh horizon is exposed in the valleys of Seneca Fork and Paynes Fork, the latter of which is 4 miles due south of Temperanceville, and is of no value in these valleys. To the east and south the bed is everywhere below the surface for many miles. Under cover it thickens to a valuable bed extending under Belmont County and the greater part of Monroe County to Ohio River and into West Virginia. The line of division between the thin and thick coal can be determined only by test drilling. The evidence at hand does not permit sharp definition of the limit, but it may be represented by a line drawn southeastward from Temperanceville to Boston, thence a little east of midway through sec. 19 to the county line. This approximate boundary is shown on the map by a broken line. It is drawn from evidence furnished by diamond-drill and oil-well (churn-drill) records. The latter are, for well-known reasons, far from reliable in proving the thickness of coal beds, but the combined data furnished by them are of considerable value. The Pittsburgh coal is reported in oil wells on the ridge 1 mile east of Temperanceville and also in wells drilled near the county line in sec. 13, 1½ miles southeast of Boston. The coal is reported in all the available records of wells east of this line. In core-drill hole No. 21, south of Boston, in sec. 19, the coal is 1 foot 9 inches thick, and in No. 22, half a mile down the valley to the southwest, there is no Pittsburgh coal. At that point the bed, if present, would lie about 80 feet below the surface. A partial record of drill hole No. 21 follows:

Partial record of core-drill hole No. 21 on Higginbotham farm in sec. 19, Somerset Township.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Sandrock	11 3	180 9
Shale, gray	2 7	183 4
Pittsburgh coal: Slate, coal, and limestone	1 9	185 1
Pittsburgh coal: Coal	1 10	186 11
Limestone.		

The record of a diamond-drill test hole, No. 20, drilled at Somerton, in sec. 2, is given below.

Record of core-drill hole near Somerton.

[Surface 1,011 feet above sea level.]

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Surface	11		11	
Shale, soft yellow	1	6	12	6
Sandstone, gray	61	2	73	8
Clay, limy		4	74	
Slate and coal, Meigs Creek	1	9	75	9
Shale, limy, dark		5	76	2
Limestone	2	10	79	
Shale, hard dark		3	79	3
Limestone		6	79	9
Rock, cement	1	6	81	3
Limestone		7	81	10
Limestone with fossils		6	82	4
Shale, dark, hard		2	82	6
Limestone	3		85	6
Shale, black, hard		3	85	9
Limestone	1	3	87	
Rock, cement	3	6	90	6
Shale, greenish, sandy, with lime nodules	1	6	92	
Shale, clay	14		106	
Shale, greenish, sandy, with little lime	4		110	
Lime or iron nodules		3	110	3
Shale, gray, sandy	5		115	3
Sandstone, gray, place of Redstone coal	30		145	3
Shale, dark gray, with thin sandstone bands	2	9	148	
Sandstone, gray	1	3	149	3
Shale, dark gray		3	149	6
Sandstone, gray	2	3	151	9
Slate, dark, with fossils	3	4	155	1
Coal, slaty		3	155	4
Slate dark	2	11	158	3
Coal, Pittsburgh or No. 8	4	7	162	10
Slate, dark		2	163	
Shale, hard dark limy, fire clay	3	3	166	3
Shale with limestone nodules		9	167	
Limestone	1		168	

LOWER MEIGS CREEK AND MEIGS CREEK COAL.

The Lower Meigs Creek coal ranges from 1 foot to nearly 3 feet in thickness on its outcrop in the western part of Somerset Township. The Meigs Creek bed, which normally lies 20 to 30 feet higher, is of little or no value. Near the forks of Rock Creek in secs. 25 and 31 it is shaly and less than 18 inches thick, and also in the vicintity of Temperanceville it is no thicker. There is commonly a thick sandstone bed between the two coals, and where this sandstone is most prominent the upper coal is missing.

The Lower Meigs Creek coal has been mined to a slight extent at several places. In an old opening in sec. 25 the bed is about 30 inches thick and has seven to ten "sooty" bands. In spite of its unfavorable appearance, the coal is praised by the farmers who have used it. Close beneath the coal is invariably a bed of gray limestone.

Years ago the citizens of Somerton attempted to sink a shaft to the Lower Meigs Creek coal, which lies at a depth of about 75 feet in the valley. Funds were exhausted before the work was completed, and

the project was abandoned. The bed would have proved disappointing both in thickness and in quality, as indicated above in the record of coal test No. 20, drilled in the same vicinity.

The Meigs Creek coal lies low in the valley of Captina Creek in the extreme northeast corner of the township, where it is present in valuable thickness but varies greatly from place to place. The coal was formerly mined on the McVey farm, near the north township line, where, as reported, it is about 3 feet thick. Half a mile to the south, at the creek forks east of the township line, the bed is much thinner, but it thickens to 4 feet a short distance farther east, near the bend of the creek.

UNIONTOWN COAL.

The Uniontown coal bed is of no value in Somerset Township. Its position is marked by a few inches of carbonaceous shale and little or no coal.

WAYNESBURG COAL.

The Waynesburg coal bed crops out along valleys in all parts of the township and has been prospected at dozens of places. It is generally not more than 3 feet thick and is of poor quality, but at a number of places it is mined each winter to supply the local needs. The outcrop of the bed where it is believed to be of minable thickness is indicated on the maps (Pls. VIII and XII). The coal is probably of more or less value throughout the township except at the north and northwest borders.

Where mined on the N. Carter farm, in sec. 18 (locality 119), the coal is 2 feet 6 inches thick and has a roof of sandstone. At the center of sec. 24 (locality 116), on the roadside, it is a little less than 1½ feet thick. Toward the south it increases slightly in thickness, and at the head of Dog Hollow, in sec. 23, it measures about 20 inches, including several clay streaks. A measurement half a mile farther south on the road (locality 118) gives 2 feet, and a mile farther south, in the SW. ¼ sec. 22 (locality 120), the bed is 2 feet 2 inches thick.

The coal has been mined at a number of places near Boston and to the east. A section measured in the George Thomas mine, in sec. 14 (locality 145), shows the coal to be 3 feet thick, a little thicker than the average. The bed was sampled for analysis at this place (analysis 20241, p. 41), and a detailed section is given on page 48.

In the vicinity of Somerton and farther south the Waynesburg coal is thinner than in the Thomas mine. Numerous openings have been made, but few of them are now accessible for measurement. In an old opening in the NW. ¼ sec. 2 (locality 144), the thickness is a little less than 2 feet. North of Somerton, in an opening in the SE. ¼ sec. 4 (locality 121) the bed measures about 3 feet.

WASHINGTON COAL.

The Washington coal lies near the hilltops in the southern part of the township. It appears in numerous roadside exposures, most of which show the bed in two benches, with a layer of clay between. The following measurement is representative:

Section of Washington coal bed in the S W. ¼ sec. 13, Somerset Township (locality 87).

	Ft.	in.
Clay.		
Coal		5½
Clay		4
Coal	1	5
Clay.		
Thickness of bed	2	2½

SANDSTONE AND LIMESTONE.

The local demand for sandstone is slight, for its only use is for bridge and building foundations. There are in nearly all parts of the township materials suited for this purpose, and in small areas some of the beds could be quarried on an extensive scale for building stone.

The most valuable sandstone is found above the Uniontown coal in the southwestern part of the township, where it occurs in a thick massive ledge lacking the irregular bedding lines so prevalent at other places. This rock was quarried to the south, in Malaga Township, and used in the construction of the stone church near Miltonsburg.

Two other sandstone beds deserve mention. One lies above the Meigs Creek coal and is conspicuous in the hills at Temperanceville and to the south along the branches of Rock Creek. The other is the sandstone lying under the Washington coal and about 60 feet above the Waynesburg coal. This sandstone, which is correlated with the Mannington sandstone of West Virginia reports, appears in massive form in the ridges in the northern part of the township. It is less durable than the Uniontown sandstone, and its friable beds readily crumble into sand.

Somerset Township, like most other parts of Belmont County, contains limestone in numerous thin layers between sandstone, clay, coal, and other beds. The greatest quantity occurs in the deep hollows of Rock Creek west of Boston. The thickest beds lie near the horizon of the Pittsburgh coal; a thinner layer occurs beneath the Lower Meigs Creek coal. The same beds are prominent on Beaver Creek near Temperanceville.

The Benwood limestone, which is so prominent along Captina Creek in Wayne Township, is of less value at Temperanceville and other places in the western part of Somerset Township. Its uppermost layers crop out in the valley slopes near Somerton and have been used in surfacing the road. The same limestone occurs in consider-

able quantity in the northeast corner of the township. Many of the beds are clayey and lack durability.

WAYNE TOWNSHIP.

SURFACE FEATURES.

Captina Creek and its branches have carved deep valleys in the plateau of Wayne Township, making its surface one of the most hilly in eastern Ohio. North and South forks unite in the east-central portion, forming the main creek, which flows eastward to Ohio River. Captina Creek and its branches follow meandering courses in narrow flood plains bordered by steep hills that rise 300 feet or so above the valley floors. The slopes of the hills are largely controlled by thick sandstone beds that appear as sheer walls along the rims of the valleys, forming numerous picturesque shelving caverns and "rock houses." The course of South Fork is extremely meandering. Terraces border the valley at elevations of 920 to 950 feet, or about 70 feet above the present flood plain, and some of them are covered with gravel. The terraces suggest that the course of the ancient higher valley was considerably less tortuous than that of the modern valley.

The hills away from the valley rise to a general elevation of a little more than 1,200 feet, and a few isolated summits are above 1,300 feet. The summit occupied by the triangulation station near Newcastle is 1,367 feet above sea level.

GEOLOGIC SECTION.

The Meigs Creek coal crops out along North and South forks of Captina Creek. Its northwestward rise is about the same as that of the valley, and in no place is it more than 40 feet above drainage level. Near the junction of the two forks the coal dips below the bed of the creek, and thence eastward to the township line it is 10 to 15 feet below drainage level. About 100 feet lower is the Pittsburgh coal, which will at some future date support a great mining industry. The beds above the Meigs Creek coal to the tops of the highest hills comprise a thickness of about 400 feet, and their sequence is illustrated in the following section, compiled from measurements made in various places in the township.

Generalized section, in descending order, of strata exposed in Wayne Township.

	Feet.
Washington formation:	
Limestone, dark gray, nodular or in layers	2
Shale, sandy, or reddish-brown clay	55
Limestone, nodular or in layers	1½
Shale, carbonaceous, with clay and nodular limestone below	9

	Feet.
Washington formation—Continued.	
Shale, sandy, with one or more limestone layers and locally red clay	70
Clay shale, reddish brown	10
Limestone in two or more layers	2–4
Shale, sandy	26
Shale, carbonaceous, thin.	
Limestone, dark, shaly, with fragments of minute fossils	1
Shale	15
Coal, Washington, commonly in two benches separated by a layer of clay	2±
Clay and shale	15
Sandstone from thin bedded and irregular to coarse and massive, locally missing and sandy shale instead	45–50
Coal, Waynesburg A	1±
Limestone, yellowish, nodular in clay	2
Shale, sandy or clay shale with one or more layers of nodular limestone	45
Monongahela formation:	
Coal, Waynesburg	3±
Shale, sandy	16
Coal thin.	
Limestone, yellowish, in numerous layers	5
Shale or shaly sandstone	30
Coal, Uniontown, locally absent	3±
Clay shale	9
Sandstone, shaly	18
Shale, greenish gray and dark red	9
Limestone and calcareous clay, lower portion locally replaced by sandstone	67
Coal, Meigs Creek	3±
Sandstone or sandy shale	23
Coal thin.	
Limestone, well suited for use as road metal	5
Interval rocks not exposed to Pittsburgh coal	75

For purposes of geologic study a rugged topography such as is found in Wayne Township usually offers advantageous conditions The narrow canyonlike valleys of Captina Creek and its branches present numerous excellent rock exposures, which permit detailed study of all the 400 feet of strata exposed in the township. In the upper portion of the section is the great sandstone that borders the scenic valleys of Long Run and Piney Creek east of Newcastle, forming sheer walls 40 to 50 feet high and numerous overhanging ledges along the smaller ravines. Access to such valleys is not easy from the hills, and the narrow bottoms are followed by trails unworthy of the name roads, which lead to the few cabins that have been built on them. The sandstone in massive form is prominent only in the southeast quarter of the township and grades into finer, bedded, sandy layers toward the west and north, there being sandy shale of reddish-brown color at this horizon in parts of the township.

The Waynesburg coal, about 50 feet below the sandstone just described, and the Uniontown coal, 50 feet still lower, are the principal beds that have been mined in Wayne Township. As these are the most important coal beds in the hills, any prospect or mine is almost certain to be in one of the two. The Meigs Creek coal, 100 feet below the Uniontown, is also valuable, but the bed lies low in the valley of Captina Creek and is beneath the creek in part of the township.

Above the Meigs Creek coal is the Benwood limestone, consisting of calcareous clay interbedded with argillaceous limestone in numerous layers 1 to 2 feet thick and varying considerably in appearance and durability. The Benwood is about 65 feet thick, being the thickest limestone member in the entire "Coal Measures" of eastern Ohio. The limestone is lacking in fossils of marine types, such as crinoids and brachiopods, but contains fish bones, small gastropods, and other minute fossil shells called *Spirorbis*, all representing forms believed to have lived in fresh or slightly brackish water. A thin-bedded shaly gray limestone about 25 feet above the Meigs Creek coal is especially prolific in these remains. The Benwood limestone in typical development may be seen at many places on South Fork of Captina Creek east of Somerton, in secs. 27 and 33, and thence eastward to the township line. One of the most peculiar appearing and characteristic beds is found about 15 feet above the base. It has an angular, checkered surface made up of cubes that have curved surfaces and sharp edges. In fact, the beds resemble flint clay in appearance but are shown by the acid test to contain considerable lime. These beds, which are 2 to 4 feet thick where they crop out along Captina Creek, give certain evidence as to the depth of the Meigs Creek coal where it lies below the stream bed. Over this blocky limestone are green clay and thin-bedded limestone grading up into the platy fossil-bearing limestone beds described above.

Shale associated with coal beds commonly contain beautifully preserved impressions of ferns and other plants that were buried in the coal swamp in Carboniferous time. A collecting place was found near the north edge of sec. 9, about 200 feet below the ridge road, in shale that underlies the Uniontown coal, which is mined for home use on the George Garrett farm.

STRUCTURE.

The geologic structure or "lay" of the rocks in this township is expressed on the map by means of structural contours that show the attitude or dip of the Pittsburgh coal throughout the township. As all strata near the surface are nearly parallel the map is almost

equally useful in showing the attitude of all the coal beds. The dip is southeastward at a rate ranging from 15 to 70 feet to the mile, with local variations in direction and degree of dip that produce terraces, "noses," and "embayments" such as those in the southwest corner of the township. The utility of the structural map in determining the depth and direction of dip of the Pittsburgh coal at any point is evident, as the contours are drawn on that bed.

MINERAL RESOURCES.

Coal is the principal mineral resource of Wayne Township, the entire township being underlain by beds that will be mined in a commercial way in the not distant future, when transportation facilities are provided by the building of a railroad along Captina Creek. Sandstone formations deep below the surface have been proved of considerable value as sources of oil and gas, and there is a possibility of extension of the productive pool. There are four principal pools in which oil and gas are produced—the Brushy Creek, Newcastle, Stumptown, and Cow Run pools. The most productive sand is the Big lime. Limestone in quantity sufficient for the construction of good roads is fairly well distributed throughout the township, and sandstone suitable for rough construction work is abundant.

COAL.

The stratigraphic positions of the principal coal beds that crop out and lie below the surface are shown in the general section for Wayne Township (pp. 111–112). These beds are, in ascending order, the Pittsburgh, Meigs Creek, Uniontown, Waynesburg, and Washington coals.

PITTSBURGH COAL.

The Pittsburgh coal lies 80 feet or more below the surface in Wayne Township. It is recorded in all oil wells whose records have been obtained, and its thickness is known from test holes drilled in secs. 10 and 23. A record of test hole No. 19, in sec. 10, is given below through the courtesy of Prof. F. A. Ray.

Condensed record of core-drill hole No. 19, sec. 10, Wayne Township.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Surface, place of Meigs Creek coal	8		8	
Interval, mostly sandy shale	26	6	34	6
Coal, Lower Meigs Creek		3	34	9
Interval, limestone, shale, clay, and sandy beds	33	2	67	11
Coal and black slate, Pomeroy	1	3	69	2
Interval, mostly shale and limestone	25	4	94	6
Pittsburgh coal: Coal		10	95	4
Pittsburgh coal: Clay	1		96	4
Pittsburgh coal: Coal	5	7	101	11
Clay	4	1	106	

The well test in sec. 23 (No. 16) was not so favorable, showing only 2 feet 5½ inches of coal, divided into two parts by a thin layer of shale. Above the coal is sandstone, as was found 1½ miles to the northwest, in Goshen Township, where the coal bed is likewise below the normal thickness. These two measurements constitute the only available evidence of an unfavorable nature concerning the Pittsburgh coal in Wayne Township. All the oil-well records serve to support the belief that practically the whole township is underlain by the coal in valuable thickness. There are, it is true, areas of 1 square mile or more where no drilling has been done, but from the generally reliable character of this great coal bed it seems safe to assume its persistence.

MEIGS CREEK COAL.

The outcrop of the Meigs Creek coal, as shown on Plate VI (p. 32) follows the valleys of Captina Creek and its branches, but the coal passes below the creek bed in sec. 10. On South Fork the coal is exposed for a distance of slightly more than 1 mile. At the east side of sec. 33 the coal if present lies about 10 feet below the creek bed, as is indicated by the positions of certain limestone key strata seen there.

The lower part of the Benwood limestone, which rests upon the Meigs Creek coal, has been replaced by a coarse sandstone lens in parts of sec. 21 and at other places in the township. It has been observed that where this sandstone assumes prominence the Meigs Creek coal is commonly thin. Below the Meigs Creek coal is sandy shale which likewise gives place to massive sandstone that locally extends above the position of the coal and unites with the sandy beds above. It is certain that the Meigs Creek coal is thin or lacking in places, especially in the south half of Wayne Township. Its usual position is 90 to 100 feet above the Pittsburgh coal. Well records in the oil field at Newcastle show coal about 70 feet above the Pittsburgh, which is designated the "Mapletown," and that bed is doubtless the Lower Meigs Creek, and the Meigs Creek coal is lacking. Well records in the Brushy Creek pool and neighboring territory likewise indicate that the Meigs Creek coal is generally thin and that the Lower Meigs Creek coal is the one commonly recorded.

The thickness of the Meigs Creek coal on its outcrop is illustrated by several sections and accompanying notes. In the SW. ¼ sec. 36, along North Fork of Captina Creek, the coal varies considerably in thickness and at one point is lacking. Downstream, in the north central portion of sec. 35 in an opening on the King farm (locality 70), a thickness of 4 feet 1½ inches of clear coal was measured. The coal lies between two thick sandstone beds, which are separated from it by a few feet of shale.

The variable character of the beds overlying the coal is apparent from the following sections measured on the road leading up the hill

half a mile east of the King mine (locality 71), where the coarse sandstone has disappeared and greenish shale and limestone of the Benwood member are found.

Section of beds overlying Meigs Creek coal in sec. 29, Wayne Township.

	Ft.	in.
Clay and shaly limestone.		
Limestone, creamy yellow, argillaceous	5	
Chert, dark colored		2
Limestone, shaly and chalky	2	
Shale, calcareous, greenish	17	
Coal, Meigs Creek, thickness not evident.		

At the junction of Long Run with North Fork of Captina Creek (locality 72) a thickness of slightly more than 2 feet was noticed. A mile up Long Run, in a coal mine on the Turner farm (locality 68), the coal is 3 feet 3 inches thick, but about a quarter of a mile farther upstream, near the forks of the road, where several prospect pits have been dug, a thickness of 16 inches was observed. Near the crossroads in sec. 17 the coal is less than 2 feet thick.

Exposures of the Meigs Creek coal in the vicinity of the junction of the two forks of Captina Creek are not good, because the coal lies at or near water level. From portions of the bed seen in the creek at several points it seems probable that the thickness is 2 to 3 feet.

UNIONTOWN COAL.

On the map (Pl. XII, in pocket) the outcrop of the Uniontown coal is represented where it is believed to be of workable thickness. The extent of the bed is further illustrated by the index map (Pl. VII, p. 32). The area where the coal can be considered as of value occupies the northeast quarter of the township. Elsewhere the coal is commonly so intimately intercalated with shale that it is worthless, and in other places the bed consists of bony shale. The bed at best can not be compared with the Meigs Creek or Pittsburgh, because it is invariably high in ash and contains one or more layers of shale.

The thickness and character of the coal in the valley of Long Run, in the northwest corner of the township, is represented by the following section, measured a short distance north of the township line:

Section of Uniontown coal on road in sec. 31, Goshen Township (locality 100).

	Ft.	in.
Coal and thin shale films		6
Shale		4
Coal		2½
Shale		2
Coal		7½
Shale		3
Coal		10½
Shale.		
Thickness of bed	2	11½

South and west of Long Run, in the valley of North Fork of Captina Creek, the Uniontown coal was nowhere observed in workable thickness, and toward the south the carbonaceous material marking its horizon becomes very thin. There is little or no Uniontown coal on South Fork and its tributaries, the coal bed mined in that drainage basin being the Waynesburg, which lies about 50 feet above the Uniontown. In the valley of Piney Creek, in the southeast corner of the township, there is only a thin layer of carbonaceous shale to mark the place of the Uniontown coal.

The only place on the south side of Captina Creek valley where the coal was found exposed in a prospect is on the George Garrett farm, near the north edge of sec. 9 (locality 109), where the coal bed has a thickness of 3 feet 3 inches and is overlain by 6 inches of carbonaceous shale.

About 2 miles northwest of the Garrett prospect a roadside exposure in the SW. ¼ sec. 17 (locality 108) shows a thickness of about 2 feet. North of this place the bed thickens and for a distance of several miles along Jakes Run its value has been proved by a number of openings. In an old prospect at the extreme southeast margin of sec. 24 (locality 107) the thickness is about 3 feet. Half a mile northwest of Hunter, at locality 106, a thickness of 3 feet 11 inches was measured in an opening recently made. No shale impurities were found in the coal.

East of Jakes Run, on Mikes Run, Berry Run, and other tributaries of Captina Creek, the thickness of the coal is known only from ravine and roadside exposures. It is believed to be somewhat less than that at Hunter but probably as much as 2 feet.

A measurement made in the D. H. Hatcher mine, Bend Fork in sec. 6, in the extreme northeast corner of the township (locality 105), gives the following result:

Section of coal bed in D. H. Hatcher mine, sec. 6, Wayne Township.

	Ft.	in.
Shale grading up into flaggy limestone.		
Coal	1	11
Bone		1
Coal		4
Shale		2
Coal		6
Shale.		
Thickness of bed	3	

A similar thickness was measured in another opening on the west side of the valley a few hundred feet north of the township line (locality 104). Downstream near the east township line the coal thins and is of doubtful value for a distance of about half a mile.

WAYNESBURG COAL.

Probably three-fourths of Wayne Township is underlain by the Waynesburg coal in thicknesses of 2 to 3 feet. The principal areas where it is known to be of little value are in the northeast and northwest corners, in secs. 5, 6, 12, 24, 29, 30, and 36.

The many openings made on Piney Creek and its tributary Long Run give an average thickness of about 2 feet for the coal. About 17 feet lower is a thinner coal bed resting on yellowish-brown limestone in a number of layers. In the SE. ¼ sec. 9 (locality 140), the following section was measured:

Section of Waynesburg coal in sec. 9, Wayne Township.

	Ft.	in.
Coal, bony		7½
Coal	1	3
Clay		3
Coal		4½
Shale.		

Near the forks of the creek half a mile farther east, at locality 141, a thickness of 2 feet 9 inches was measured. The bed where mined south of Piney Creek is in places free from shale bands but contains bony layers.

About 1 mile west of the mines on Long Run and half a mile northeast of Newcastle, in a ravine near the crossroads (locality 139), the Waynesburg coal is 6 to 18 inches thick and has an undulating roof of sandstone.

In the southwest quarter of the township, west of Newcastle and on Brushy and Cranenest creeks, there are numerous places where the coal has been prospected and temporarily mined in a small way. The thickness is generally 2 to 3 feet, and only one place was observed where the bed is as thin as 1 foot—in a roadside exposure at the south side of sec. 20 (locality 142). A section of the bed believed to be representative of this coal in the southwest quarter of the township was measured in the Howard Brown mine in sec. 26 (locality 143), where a sample of the coal was taken for analysis (No. 20234, p. 41). A section of the bed 2 feet 6½ inches thick is given on page 48.

A slightly greater thickness probably as much as 3 feet, was found in an opening at the north side of sec. 27 (locality 138), and also at a place near the east edge of sec. 33.

No prospect pits in the Waynesburg coal were found in secs. 24, 29, 30, 35, and 36, and roadside exposures indicate that the bed is not present in minable thickness. Northward beyond the township line, however, there is an area of thicker coal. The bed also thickens toward the east. In an opening on the McEndree farm, in the NE. ¼, sec. 22 (locality 137), 3 feet of clear coal was measured. A mile north of this place, on the west side of Jakes Run, the coal is 2 feet 10 inches

thick, and at the east edge of sec. 16 (locality 136), a little more than 1 mile southeast of that locality, the thickness is about 3 feet.

Near the center of sec. 18, on the hill road southwest of Hunter, the coal has been mined, but no openings are accessible. A natural exposure in that vicinity (locality 130) showed a thickness of about 2 feet.

A coal, probably the Waynesburg, has been mined to a slight extent on Mikes Run on the Price farm, in sec. 12 (locality 132). The bed is in two parts separated by about 1½ feet of shale; the lower bench is about 2 feet thick, and the upper bench is thinner and shaly.

A measurement on the John White farm, in the north-central part of sec. 4 (locality 134), shows 2 feet 6 inches of hard, tough coal overlain by 4 inches of bony coal and underlain by sandy shale. Information obtained east of Wayne Township indicates that the bed is increasingly valuable in that direction.

In a prospect on the Wallace farm, north of Captina Creek, in sec. 10 (locality 135), the coal is in a single clear bed 3 feet 2 inches thick, with a grading up into sandstone.

Near the southwest edge of sec. 10 (locality 136) is another opening in which the coal closely resembles the bed as found at the Wallace prospect.

WASHINGTON COAL.

The Washington coal lies 105 to 120 feet above the Waynesburg coal and 365 to 385 feet above the Pittsburgh. It is probably present throughout Wayne Township in thicknesses ranging from 1 to 3 feet for the upper and thicker bench, there being commonly two benches separated by 6 inches to 5 feet of clay. The coal has been stripped at dozens of places for home use, but has rarely been extracted from underground workings. Although high in ash, an analysis showing 21 per cent, the coal compares favorably with the Waynesburg and Uniontown of this region, being only a little lower in heating value. Few exposures that permit accurate measurement are available, but there are many places on road sides and in ravines where approximate results can be obtained, some of which are given.

Section of Washington coal on road east of Hunter, Wayne Township (locality 77).

	Ft.	in.
Shale.		
Coal	2	6
Shale, carbonaceous	5	
Coal		10

Section of Washington coal on Davis farm on the west side of sec. 9, Wayne Township (locality 80).

	Ft.	in.
Clay shale, with carbonaceous streaks.		
Coal, with clay streaks	2	4
Clay		3
Coal, impure	1	4
Clay.		

On the E. Moore farm, near the center of sec. 2, the coal is 2 feet 4 inches thick. On the T. C. Perkins farm, in sec. 6 (locality 78), the upper bench is about 2 feet 7 inches thick. In the northeast corner of sec. 17 (locality 79), on the Russell farm, the section in descending order is coal 2 feet 9 inches, clay shale 5 feet, coal 2 feet. On the ridge road at the southwest corner of sec. 27 (locality 86) the thickness is about 1 foot 3 inches. The bed is apparently at its best from Hunter and Newcastle eastward in the east half of the township and thinnest in the southwestern part.

LIMESTONE.

The principal limestone beds of Wayne Township are in the Benwood limestone member, overlying the Meigs Creek coal. The layers form "pavements" at many places on the valley floors of Captina Creek and its tributaries and are exposed in the steep valley sides, thus furnishing a large quantity of easily accessible road material for all parts of the township. Nevertheless not a mile of limestone pike has been built, and the roads are almost impassable except in the dry summer period. A slight attempt has been made at improving them, and the main traveled routes are graded into a rounded surface to prevent wash and facilitate drainage, but only the sandy ridge roads continue good after a few days of wet weather.

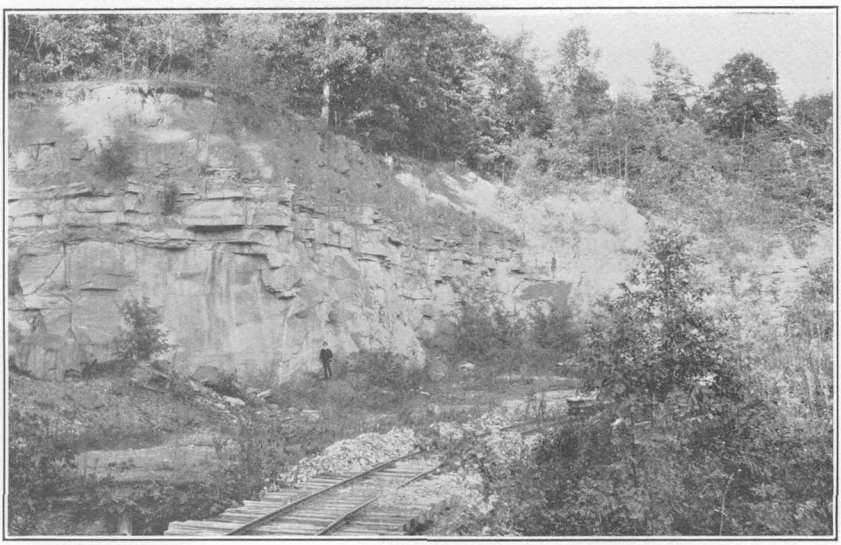
Probably the most durable and therefore the most valuable limestone beds of the Benwood member occur near the top, about 25 feet below the Uniontown coal. These beds include one layer that is especially persistent. It is about 2 feet thick, gray in color, smooth textured, and of laminated appearance on the weathered surface. The typical appearance of the lower beds of the Benwood limestone is illustrated by Plate X, *B* (p. 54). They consist of many layers interbedded with calcareous clay, some of which are sufficiently durable for road metal, whereas others are argillaceous and decompose readily on weathering.

In the southeastern part of the township, where the sandstone over the Uniontown coal is thin and less massive than in other localities, there is a limestone in the upper portion of the Uniontown-Waynesburg interval. This limestone is prominently exposed in the beds of Piney Creek and tributaries, where its brownish-yellow resistant layers form "cobble pavements." The stratigraphic position of this limestone is illustrated by a measurement made on the hill road at the east side of sec. 3 (locality 131).

Section of Waynesburg coal and associated strata in sec. 3, Wayne Township.

	Feet.
Shale, sandy.	
Coal, Waynesburg	2
Shale	16
Coal	½
Limestone, in brownish-yellow layers	10±

A. SANDSTONE OVERLYING MEIGS CREEK COAL AT MOUTH OF BRUSHY FORK OF CAPTINA CREEK.



B. QUARRY IN SANDSTONE NEAR WOODSFIELD.

Another valuable limestone occurs 40 feet above the Washington coal throughout the township. It is most prominent near the east border, where its thickness is 3 to 5 feet. The rock little weathered in ravine exposures is sufficiently durable to furnish excellent material for road metal. Along the south edge of the township this bed is thinner and occurs in nodules rather than layers. Still farther south the bed disappears entirely. The hills in the west half of the township contain several limestone beds 50 to 100 feet above the one just described. These, together with reddish clay beds, form the summits of ridges southeast of Hunter and east of Newcastle.

SANDSTONE.

Sandstone of various kinds is plentiful in Wayne Township. There are coarse beds 25 to 40 feet thick with no bedding planes, sandstone in irregular lenticular beds, and even-bedded flagstones that can be quarried in slabs.

Rock of the massive, coarse type is particularly abundant east of Newcastle, along Piney Creek and its branches. The geologic position of this sandstone is below the Washington coal and above the Waynesburg coal. The rock is not firmly cemented but is sufficiently resistant to crushing stresses to be useful for foundations. Sandstone of similar character but not so thick is found below and also above the Meigs Creek coal at a few localities on Captina Creek and its branches. The Meigs Creek coal at the mouth of Jakes Run, in sec. 17, is underlain by coarse sandstone more than 18 feet thick. Toward the north and west this bed loses its massive character and becomes flaggy. Sandstone replaces the lower portion of the Benwood limestone on Brushy Creek in secs. 21, 26, and 27. It is irregularly bedded and grades into shale along its outcrop. The appearance of this sandstone near the mouth of Brushy Creek is shown in Plate XI, *A*.

WASHINGTON AND SMITH TOWNSHIPS.

Washington and Smith townships adjoin Wayne and Goshen townships on the east, and a narrow strip along their west edges is included in the Woodsfield quadrangle. Excellent exposures of the rocks are found in the deep valleys of Captina Creek and its tributaries.

COAL.

The minable coal beds of this area include the Pittsburgh, Meigs Creek, Uniontown, Waynesburg, and Washington. These coals, with the exception of the Pittsburgh, which is 100 feet or more below the surface, are mined by the farmers at numerous places along their outcrops.

PITTSBURGH COAL.

The Pittsburgh coal has been tested by core drilling at a number of places in both townships. Records of tests obtained lead to the belief that the whole area is underlain by a bed of coal 5 feet or more thick.

MEIGS CREEK COAL.

The Meigs Creek coal lies about 100 feet above the Pittsburgh. At the west side of Washington Township it is about 15 feet below Captina Creek. About 3 miles farther east, beyond the limits of the area represented on the map, in the big bend of the creek 1 mile north of Alledonia, a station on the Ohio River & Western Railroad, the coal rises above drainage level and has been opened by Shipman Bros. The coal is also at the surface for a short distance along Bend Fork to the north.

Section of Meigs Creek coal bed in Shipman Bros.' mine, north of Alledonia.

	Ft.	in.
Roof, clay and limestone.		
Coal	2	1
Coal, bony cannel		2½
Coal		1½
Clay		½
Coal	1	6
Floor, clay shale.		
Thickness of bed	3	11½

A sample of the coal in Shipman Bros. mine was taken for analysis (No. 20237, p. 40).

The thickness of the Meigs Creek coal, in a diamond-drill hole at Alledonia, was found to be 2 feet 8 inches, and that of the Lower Meigs Creek coal, about 18 feet lower, 1 foot 9 inches.

UNIONTOWN COAL.

The Uniontown coal, lying about 100 feet above the Meigs Creek coal, is mined at many places on Joy Fork and Bend Fork, in the southwest corner of Smith Township and in Goshen Township, to the west. It is also mined in secs. 30 and 36 of Washington Township, but is of variable thickness and has an undulating sandstone roof. Farther south, in the western part of the same township, in the valley of Captina Creek and also to the south up Crabapple Creek, the coal is merely a faint blossom in most places, and the Waynesburg coal bed, 50 feet higher, is the principal source of fuel for the farmers. On the map (Pl. XII, in pocket) are represented the outcrops of all coal beds where known to be of minable thickness. This map should be studied by the reader who wishes information concerning specific localities.

In places on Bend Fork and its tributary Joy Fork both the Uniontown and Waynesburg coals are mined. The Uniontown is as a rule divided into two benches by a band of clay several inches thick; the Waynesburg is usually in one bench 3 to 4 feet thick. The typical structure of the Uniontown coal is illustrated by a measurement made in the extreme northeast corner of Wayne Township, on the east bank of Bend Fork (locality 105, Pl. VII, p. 32). Half a mile downstream from locality 105, across the line in Washington Township, the coal is too thin to be of value, but it thickens still farther downstream and is mined near the mouths of Joy Fork and Millers Run.

WAYNESBURG COAL.

The Waynesburg coal is most valuable in the western part of Washington Township south of Captina Creek, on Crabapple and Piney creeks. The bed is also of more or less value to the north in parts of Smith Township. It is mined at several places on Joy Fork, where that stream follows the township line, and is generally 2½ to 3½ feet thick.

A representative measurement of the coal bed where mined on Crabapple Creek was measured in the Stoffel mine, on the Nathan Davis farm, on the east side of the valley halfway between Crabapple and Alledonia stations, about half a mile east of the area represented on the map.

Section of Waynesburg coal bed in Stoffel mine, near Alledonia.

	Ft.	In.
Roof, shale.		
Coal, bony		4
Coal	2	5½
Floor, clay shale.		

The analysis of a sample of coal from the Stoffel mine is given on page 41 (No. 20236).

WASHINGTON COAL.

The Washington is the highest coal bed in the stratigraphic column of this area. It lies about 100 feet above the Waynesburg coal. The bed is of little value, partly because of its impurity and partly for the reason that there is generally a foot or so of clay shale near the middle, which is a hindrance in mining. In the same general region are the lower coal beds, which are thicker and more easily accessible, and therefore little attempt has been made to mine the Washington coal. The bed shows much greater uniformity throughout large areas than most other coals of this region. Its thickness is illustrated by a single section measured in an opening on the S. A. Moore farm, in sec. 33, Washington Township (locality 81).

Section of Washington coal on S. A. Moore farm, sec. 33, Washington Township.

	Ft.	In.
Roof, shale.		
Coal, bony		3
Coal, bony in lower part	2	1
Clay		8
Coal		11
Floor, shale.		
Thickness of bed	3	11

The analysis of a sample taken in the Moore mine is given on page 41 (No. 20238). The ash content is 21.0 per cent, more than twice that of an average sample of Pittsburgh coal.

MONROE COUNTY.

SENECA TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Seneca Township includes a part of the original square township designated by the early land survey T. 7 N., R. 7 W. The two west columns of sections have been added to Marion Township, Noble County, and a few square miles in the southeastern part to Summit Township. The Ohio River & Western Railroad crosses the southern part, following South Fork of Wills Creek and thence going up a tributary to the village of Summerfield in Noble County. Calais (pronounced kay'liss), the only village in Seneca Township, is situated near the north edge in the broad flood plain of Seneca Fork. That stream partakes of the characteristics of all branches of Wills Creek and other tributary streams of the Muskingum River system in that it is a sluggish muddy stream of low gradient. In fact, the gradient is so slight that disastrous floods are common, and nearly every year Calais village is flooded and for this reason the population has decreased more than half during recent years. The number of people in 1920 was 49, as compared with 114 in 1900. The census of 1920 shows the population of the entire township to be 933.

The hills bordering the broad valleys of this township rise in moderately steep slopes that have for the most part been cleared of timber and planted to tobacco, which is one of the principal crops. Landslides are so prevalent, however, that in a few years after removal of the woods large hillside tracts begin to creep during rainy seasons, and the result is great scars and a hummocky surface of little use except for grazing. The relief, or local range in elevation, for the township is a little less than 500 feet, the lowest valley being 840 feet above sea level and the highest summits on the ridges 1,250 to 1,300 feet.

GEOLOGIC SECTION.

At first inspection the rocks of Seneca Township would seem to be a monotonous jumble of clay, shale, and limestone with a few beds of sandstone. It is true that coal beds are almost lacking and that the other strata composing the geologic section have a certain similarity. But on closer examination it is found that most of these beds have individual character and can be correlated with similar strata in more or less remote areas. This is true in particular of certain limestone beds which are not only persistent throughout the Summerfield quadrangle, but northeastward beyond Ohio River into West Virginia and Pennsylvania. The columnar sequence of strata exposed in Seneca Township is illustrated by the following section measured near Calais:

Geologic section, in descending order, of strata near Calais.

	Feet.
Shale and sandstone beds, unmeasured.	
Coal blossom, Waynesburg.	
Shale	7
Clay, greenish gray	5
Sandstone, shaly to thick bedded	54
Coal blossom, Uniontown.	
Clay shale with a number of limestone beds	88
Clay, olive-green	6
Clay shale and limestone	13
Coal blossom, Meigs Creek.	
Sandstone, shaly	28
Limestone, Fishpot, with black streak above; position of Lower Meigs Creek coal	3
Clay, shale	25
Shale, carbonaceous with dark shaly limestone below; position of Pomeroy coal	2
Shale, sandy	25
Clay, carbonaceous; position of Pittsburgh coal	1
Limestone, bluish with clay shale and nodular limestone below	20
Limestone, Lower Pittsburgh, in several thick beds	6
Clay and limestone nodules, grading down into shale and sandy beds.	

The scarcity of prominent sandstone members in Seneca Township is manifested in the type of topography, which differs from that of Malaga Township, to the east, in being much less rugged. The hills, it is true, are steep, but their terraced slopes have a covering of soil and turf through which project only a few of the limestone beds, which crop out in rows of bleached boulders that are conspicuous even from a distance.

MINERAL RESOURCES.

Oil and gas have been found in Seneca Township in small quantities only, coal is almost lacking, and other mineral products with the exception of limestone are scarce. Therefore this township must

count as its chief mineral resource the soil, which compares very favorably with that of the richest agricultural communities in eastern Ohio.

COAL.

The only coal bed of possible value is the Meigs Creek, and its extent in workable thickness (1½ to 2 feet) is limited to the southern part of the township. The coal is a mere blossom in the vicinity of Calais. To the south, where seen on a road in sec. 16 (locality 53), on the south side of the valley, the bed is 10 inches thick. At Ethel station, in the southwest corner of the township (locality 50), the bed is 2 feet thick where exposed on the road leading up the hill to the east. At the township line, in the southwest corner of sec. 13 (locality 51), it is 1 foot 2 inches thick.

The position of the Pittsburgh coal bed, which is so valuable to the east in parts of Belmont and Monroe counties, is marked in this township by an inconspicuous black shale about 100 feet below the Meigs Creek coal. About 20 feet lower is the prominent Lower Pittsburgh limestone, which can be traced continuously from Calais downstream to the mouth of Beaver Creek and up that valley beyond Batesville to Temperanceville, where the Pittsburgh coal is 4 to 5 feet thick.

LIMESTONE.

Seneca Township is abundantly supplied with beds of limestone accessible for use on the roads. Nevertheless not a mile of pike has been built, and the roads rank among the poorest in the region. Several of the limestone members are 4 to 5 feet thick, and their nodular outcrops are easily accessible in almost any ravine.

FRANKLIN TOWNSHIP.

About 7 square miles in the northern part of Franklin Township lies within the Summerfield quadrangle. Clear Fork of Little Muskingum River flows southeastward through the central portion, and along it are exposures of the Meigs Creek coal and associated strata. The valley descends at the rate of about 20 feet to the mile, in close agreement with the dip of the rocks. Therefore the coals maintain about the same position with reference to the valley floor across the township.

The Pittsburgh coal is missing in Franklin Township. Its position is about 100 feet below the Meigs Creek coal, or 50 to 60 feet below the valley of Clear Fork. So far as known the bed has never been recorded in oil-well drillings in this area.

The Meigs Creek coal is most valuable in the southwestern part of the township, in the Macksburg quadrangle, where it is 2 to 3 feet thick. It is less than 2 feet thick on Clear Fork in the northern part

of the township, and little or no attempt to mine it has been made by the farmers. The thickness at Swazey is 8 inches and at the north township line (locality 51), 1 foot 2 inches.

The strata higher than the Meigs Creek coal, although more than 200 feet thick, lack coal beds of any value. The Uniontown and Waynesburg beds are represented here by mere "markers" or impure shaly coal only a few inches thick.

SUMMIT TOWNSHIP.

LOCATION AND SURFACE FEATURES.

The political division designated Summit Township is an irregular-shaped area occupying parts of four townships of the original land survey. One square mile at the south side lies within the Matamoras quadrangle; the greater part is in the Woodsfield quadrangle; and a narrow strip along the west border lies in the Summerfield quadrangle. The Ohio River & Western Railroad extends eastward across the south-central portion, and on it is Lewisville, the only village in the township. The population of Lewisville in 1920 was 230, and that of the township 915.

The central part of the township consists of several divides which separate the waters of northwestward-flowing tributaries of Wills Creek, of the Muskingum River system, from eastward-flowing branches of Sunfish Creek and southward-flowing streams that empty into Little Muskingum River. The railroad follows the principal divide westward from Woodsfield to Lewisville and thence goes down South Fork of Wills Creek for several miles. A few hills near the railroad in the eastern part of the township rise more than 1,300 feet above sea level, but the general elevation of the upland ridges ranges from 1,200 to 1,250 feet. In the valley at the northwest corner of the township the elevation is about 900 feet. The surface of Summit Township is somewhat less rugged than that of the western part of Malaga Township, especially in the approaches to the valleys, owing to the less prominent exposures of certain sandstone beds that are conspicuous to the north.

STRATIGRAPHIC SECTION OF ROCKS AT THE SURFACE.

The thickness of the strata appearing at the surface in Summit Township is about 550 feet, including beds ranging in position from a few feet above the Pittsburgh coal horizon to more than 100 feet above the Washington coal bed, which crops out throughout the eastern part of the township. The succession of strata is illustrated by the following general section, which is compiled from measurements made at a number of places.

Generalized section, in descending order, of strata in Summit Township.

	Feet.
Washington formation:	
Shale, red clay, and thin-bedded sandstone	130
Coal, nonpersistent.	
Shale, clay, or sandstone	25
Coal, Washington	1–2
Clay, and shale	18
Shale, sandy, with beds of shaly sandstone	56
Carbonaceous shale, Waynesburg "A" coal horizon.	
Shale, reddish or gray, with local sandstone beds	53
Monongahela formation:	
Coal, thin, or only carbonaceous shale; position of Waynesburg coal.	
Shale	8
Clay, greenish gray	5
Shale, grading down into sandstone of variable character, coarse grained and massive at north edge of township	48
Coal or black shale, Uniontown, commonly in two parts with 10 feet of shale between, the lower part the more prominent.	
Clay shale, with nodular limestone in lower portion	9
Shale, sandy, or sandstone	25
Clay shale, with thin beds of clayey limestone	60
Clay, olive-green	4
Clay shale, or impure limestone	11
Coal, Meigs Creek, thin.	
Shale, sandy	27
Coal, Lower Meigs Creek	1–2½
Limestone in several layers; upper beds gray, lower ones yellowish	5
Shale, sandy	24
Limestone or limy clay	1
Shale, sandy	27
Shale, black, with dark limestone below	3
Shale, sandy or sandstone	23
Pittsburgh coal horizon; black shale underlain by limestone beds. No outcrop in the township. The coal is missing in the western part of the township but may be of minable thickness in the eastern part.	

Probably the most persistent beds of this section are the Washington coal and the greenish-gray clay below the position of the Waynesburg coal. The green clay a few feet above the Meigs Creek coal is also present in large areas and forms a conspicuous greenish band on the washed hillsides that can hardly be mistaken for any other stratum. Generally sandstone overlies the Uniontown coal, but it is far less massive and prominent than in ravines farther north. The sandstone lying below the Washington coal is shaly at the east edge of the township and of increasing prominence eastward beyond Woodsfield.

STRUCTURE.

The dip of the beds ranges from nearly east to south at a rate of 10 to 30 feet to the mile. There are no well-defined anticlines in Summit or neighboring townships, and the only variations from the regular southeastward dip are a few cross flexures that produce synclinal "embayments" or slight promontory-like "noses" such as that 1 mile west of Lewisville. The direction and degree of dip are represented on Plate XII (in pocket) by contours drawn on the base of the Pittsburgh coal.

MINERAL RESOURCES.

The mineral resources of Summit Township of greatest importance are oil and gas. Coal is present, but the quantity can be proved with certainty only when considerable testing has been done with the diamond drill. Sandstone and limestone occur in moderate amount, the former being found well up in the hills and the latter low in the valleys in the western part of the township.

The principal oil sands are the Big Injun, Keener, Big lime, and Maxton, all of which are productive in the pool at Lewisville and eastward. In fact, several of these sands may be productive in the same well.

COAL.

There are three coal beds of possible value in Summit Township—the Pittsburgh, Lower Meigs Creek, and Washington. (See general section, p. 16.) The Pittsburgh coal is below the surface, and its thickness is in doubt throughout most of the township. The other two are of only moderate value owing to their inferior quality and thinness and for other reasons that are given below.

PITTSBURGH COAL.

The Pittsburgh coal, one of the most valuable beds in Belmont and Monroe counties, is of known value as far west as Malaga and Miltonsburg, but thins abruptly a short distance farther west. In Summit and Center townships the western limit of valuable coal is in doubt. The only information at hand is derived from oil-well records, which are far from reliable. A coal at about the position of the Pittsburgh is recorded eastward from Lewisville and northeastward toward Miltonsburg, but not in the Cooper or Monroefield oil pools. The reasons for questioning the value of the Pittsburgh coal in parts of Center Township, as explained in the description of that township, are also applicable to Summit Township.

On the index map (Pl. V, p. 28) are represented the locations of some of the wells drilled for oil, the records of which mention a coal

bed that is possibly the Pittsburgh. The elevation of each well has been determined and also the elevation of a near-by outcrop of the Washington coal; therefore, at each well the interval between the Washington and Pittsburgh coal beds has been determined. The interval is about 380 feet at Lewisville and increases eastward to about 415 feet near Woodsfield. It is possible that the coal recorded at Lewisville is the Pomeroy, whose position is 25 to 35 feet above the Pittsburgh. In the logs of many of the wells, including practically all wells west of a line extending from Lewisville toward Miltonsburg (shown by the dotted line on the map), drillers have reported "no coal" or "coal marker." In summing up the evidence it is therefore believed unsafe to regard any portion of the Pittsburgh coal in Summit Township as of proved value. There may be a considerable area of valuable coal, but its presence can be demonstrated only by testing with the diamond drill.

MEIGS CREEK AND LOWER MEIGS CREEK COAL.

The Meigs Creek and Lower Meigs Creek coal beds crop out low in the valleys in the western part of the township. Neither is more than 2 feet thick at any place where seen. Their relative positions, as shown in the general section, are about 28 feet apart. The lower coal is invariably underlain by gray limestone, and the interval between it and the upper coal consists of sandstone or sandy shale. About 15 feet above the Meigs Creek coal is a bed of olive-green clay differing in appearance from any other in the region, and this of itself is an unerring guide in the identification of the subjacent coal. The greatest thickness of the Meigs Creek coal was seen on the valley road in the southwest corner of sec. 2 (locality 54, Pl. VI), where it is 1 foot 2 inches thick. The Lower Meigs Creek bed is slightly thicker, ranging from 1½ to 2 feet in sec. 2 and at other places.

WASHINGTON COAL.

The Washington coal bed is confined to the high hills from Lewisville northward and eastward. Its blossom may be seen on nearly every ridge road. At a few places the thickness is evident in natural exposures. Near Lewisville the bed is about 1 foot thick, and has yellow clay below and sandstone above. Near the railroad at the east side of the township the bed is 1½ feet thick and has been mined by stripping at a few places.

SANDSTONE AND LIMESTONE.

Sandstone in massive, bold exposures is far less plentiful in Summit Township than to the north in Malaga Township or to the east in Center Township. The most prominent beds probably occur above the Uniontown coal horizon, as in the western part of Malaga Town-

ship, but the beds are, as a rule, even-bedded, shaly layers and, except along the north edge of the township, are not well suited for easy quarrying and of little use for building. There is, however, a supply of sandstone more than adequate for local use in the construction of foundations.

The strata at the surface in the eastern two-thirds of the township include no limestone beds of value, and the same is true of the western portion with the exception of the deeper valleys, whose terraced slopes contain a number of prominent limestone layers interstratified with sandy shale. One of the best layers lies below the Lower Meigs Creek coal. It is 3 to 6 feet thick and sufficiently durable for road metal. The rock has also been burned for agricultural lime. A number of limestone layers are distributed through the section 20 to 70 feet above the Meigs Creek coal, but most of them are clayey and not very durable.

MALAGA TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Malaga Township is an irregular-shaped area covering parts of two townships of the early land survey, including the northwest third of T. 6 N., R. 5 W., and the north two-thirds of T. 6 N., R. 6 W.

Malaga, Miltonsburg, and a part of Jerusalem are the only villages. The population, which in 1920 was 1,106, consists largely of people of German descent whose fathers settled in the region 30 or 40 years ago. Shipping facilities are furnished by the Ohio River & Western Railroad, which crosses the adjoining township at a distance of about 2 miles beyond the south and east township limits. Woodsfield, the principal town on the railroad, is about 7 miles from Miltonsburg and 8 miles from Malaga.

There is no limestone pike within the township. A good road extends from Barnesville, about 17 miles north, to the county line half a mile north of Malaga village. Most of the ridge roads are good because of the generally sandy soil, but most of the valley roads are poor.

The surface of Malaga Township is drained chiefly by southeastward-flowing tributaries of Sunfish Creek, which head in the west-central portion and flow in valleys 100 to 200 feet deep. The western third is deeply channeled by westward-flowing tributaries of Willis Creek, a branch of Tuscarawas River. These streams, almost to their sources, are bordered by steep valley slopes 200 feet high. The bottoms of the valleys are about 900 feet in elevation at the west township line. The least elevation on the eastward-flowing streams is about 1,000 feet.

The surface of the upland is far from level, but there are fairly smooth areas in the southeastern part of the township at about 1,220

feet above sea level, rising northward to about 1,300 feet near Malaga. Whether these level stretches are controlled by resistant underlying rock or are solely the result of erosion is not certain. It is evident, however, that the terraced slopes so prevalent in this region are caused by strata of unequal hardness, the resistant sandstone and sandy shale beds forming steep slopes which flatten to a gentle angle on the outcrops of clay, shale, and coal beds.

GEOLOGIC SECTION.

The rocks that crop out in Malaga Township constitute a columnar section a little more than 400 feet thick. At the base, along Paynes and Seneca forks of Willis Creek, are limestones at the horizon of the Pittsburgh coal, which is too thin to be of value there but is of economic importance where it lies under cover in the eastern part of the township. The floors of valleys on the southeast border of the township consist of rocks overlying the Uniontown coal and more than 200 feet above the Pittsburgh bed. In the hills is the Washington coal with associated limestone beds. The strata that make up the hills vary greatly from place to place. Some coal and limestone beds are persistent throughout entire counties; others may appear and disappear within a distance of only a few miles.

The beds between the coals consist largely of shale and sandstone, which are especially variable, there being all gradations from shale through sandy shale to coarse massive sandstone.

The Washington coal appears in roadside outcrops on most of the ridge roads and is in fact the only coal bed of any value in the hills. The Waynesburg coal fails to appear in workable thickness, and the Uniontown coal is likewise thin except along the creek beds in the extreme southeast corner of the township. The Washington coal is therefore of especial value as a key to geologic exposures because it is so easily recognized.

Chert or flinty rock is far from abundant in the Woodsfield and Summerfield quadrangles, being found at only two places, one of which is in the high hills west of Miltonsburg. The cherty rock occurs in a number of thin beds about 120 feet above the Washington coal. It is only a few feet thick, but is so resistant to weathering that fragments of it are strewn over the surface of the hills. The rock is of a rusty brownish color, flecked with peculiar small white spots of angular outline which are cross sections of crystals.

The beds to a depth of 120 feet below the Washington coal consist of shale, reddish clay, or sandy strata, most of which are not strongly resistant to erosion and form gently receding slopes, slightly terraced. A little lower, however, is the prominent sandstone (correlated with the Gilboy sandstone of West Virginia reports) which overlies

the Uniontown coal bed and is largely accountable for the steep valley slopes in the western part of the township.

STRUCTURE.

The lay or geologic structure of the rocks is illustrated on Plate XII (in pocket) by contours drawn on the base of the Pittsburgh coal. Although that bed is not everywhere present where geologically due, its position is conspicuously marked by underlying limestone beds, and the structural contours are drawn from elevations taken on the limestone. There is a fairly uniform southeasterly dip throughout the township, with a few local irregularities such as the terrace-like flattening at Malaga and the shallow trough extending in a nearly north-south direction east of that village. In the western part of the township there is a flat anticline from which the rocks dip to the southwest, south, and east.

MINERAL RESOURCES.

The principal mineral products of Malaga Township are oil and gas, there being more than 120 wells that have produced one or the other of these products. The principal productive oil sands are the Keener and the Big lime. The Berea sand yields oil at a few places.

COAL.

The coals that crop out in Malaga Township are of little value, although the positions of at least six beds of value in other townships are marked by more or less carbonaceous material. These are, in ascending order, the Pittsburgh, Lower Meigs Creek, Meigs Creek, Uniontown, Waynesburg, and Washington.

PITTSBURGH COAL.

Outcropping portion.—The Pittsburgh coal bed, so far as known, is little more than a carbonaceous shale where exposed in the valleys of Seneca Fork, Paynes Fork, and North Fork, in the western part of the township and in Seneca Township to the west. The position of the bed is marked by black shale underlain by limestone and sandy shale. About 20 feet lower is the prominent Lower Pittsburgh limestone, which can be followed in outcrop northward to regions where the Pittsburgh coal is a valuable bed.

The coal lying beneath a heavy sandstone low in the valleys near the west edge of the township is the Lower Meigs Creek coal and not the Pittsburgh bed, although it has been so identified by some observers. This bed has been mined in a small way near the headwaters of Paynes Fork and Seneca Fork of Wills Creek.

Portion under cover.—Under cover the Pittsburgh coal probably exists in valuable thickness throughout the eastern two-thirds of the

township. This is indicated by several core-drill tests and by records of numerous oil wells. The oil-well records, it is true, are of little value as positive evidence of the thickness of a coal bed, but the fact that the coal is noticed by the driller is fair evidence that the bed is several feet thick. The approximate western limit of workable coal, as designated on the index map (Pl. V, p. 28) by a dashed line, extends in a direction slightly east of south from the middle of sec. 24 to the south township line in the western part of sec. 15. Northward the line extends along the west side of Boston to Temperanceville. The coal is reported in the oil wells of the Egger pool, in sec. 15, and also in the coal test on the Williams farm, at the west edge of sec. 18. No record of the coal test on the Miller farm, in the same section, was obtained. No Pittsburgh coal is reported in wells drilled in sec. 21 or westward in the Monroefield pool. The coal is likewise missing in the Cooper pool southeast of Monroefield

On the index map (Pl. V) are shown by dots the locations of some of the oil wells in the records of which mention is made of the Pittsburgh coal. The presence of the bed south of Miltonsburg in sec. 9 and a portion of sec. 15 seems established.

Records of the strata penetrated in diamond-drill coal test holes on several farms have been furnished by Mr. Edward Christman and are given in part below.

Partial record of core-drill hole No. 23, on Williams farm, sec. 18, Malaga Township.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Shale, carbonaceous, place of Uniontown coal	1 6	29 6
Interval mostly shale and limestone	106	135 6
Shale, carbonaceous, place of Meigs Creek coal	2	135 8
Interval, mostly shale	24 10	160 6
Coal, Lower Meigs Creek	2 3	162 9
Interval, shale, sandstone, and limestone	82 4	245 1
Coal, Pittsburgh	4 7	249 8
Limestone.		

Condensed record of core-drill hole No. 26, on Sloan farm, in the NE. ¼ sec. 17, Malaga Township.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Sandstone, limestone, and clay	119 9	119 9
Waynesburg coal bed:		
Slate and coal	5	.....
Slate, dark	5 1	.....
Slate and coal	3	.....
Shale, dark	1 6	.....
Coal	1 3	.....
Shale, dark	2 3	.....
Slate and coal	6	131
Limestone, shale, and sandstone	146	277
Coal marker, Meigs Creek	1 3	278 3
Limestone, shale, and sandstone	83 4	361 7
Coal, Pittsburgh	4 3	365 10
Limestone.		

LOWER MEIGS CREEK COAL.

The Lower Meigs Creek coal, as shown in the record of the core-drill hole on the Williams farm, lies 82 feet above the Pittsburgh bed. Its thickness, 2 feet 3 inches, as recorded there, is similar to that found to the west where seen in outcrop. The bed has locally a thickness of 3 feet, but 2 feet is nearer the average. It has been mined by stripping at a few places. In the valley northwest of Monroefield the coal contains many "soot" bands or "dirt" streaks. The bed is at its best on Paynes and Seneca forks, there being few places elsewhere in eastern Ohio where it is present in minable thickness.

This coal has been recorded in nearly all the oil wells in the Monroefield pool and has been labeled the Pittsburgh by the drillers. Its position, about 325 feet below the Washington coal, which crops out at Monroefield, alone is proof that the bed is too high to be the Pittsburgh, whose position is about 400 feet below the Washington coal as recorded in wells 2 miles east of Monroefield.

MEIGS CREEK COAL.

The Meigs Creek coal normally lies 25 to 35 feet above the Lower Meigs Creek coal. It is thin or lacking on the outcrop in Malaga Township and is likewise of little or no importance to the east under cover. A coal reported 75 to 85 feet above the Pittsburgh in most oil wells is probably the Lower Meigs Creek described above. The usual interval between the Pittsburgh and Meigs Creek coals in this township is 95 to 105 feet.

UNIONTOWN COAL.

The Uniontown coal is represented by black shale on the outcrop in the western part of the township. Over the shale is a thick bed of coarse sandstone. The outcrop in the eastern part of the township is limited to a distance of about 1 mile along the valley of Baker Fork and its tributary Grassy Creek in secs. 27 and 33. The bed is 2 to 3 feet thick and contains a number of shale layers. It has been mined for home use at a number of places. The following measurement made on the D. T. Clark farm (locality 111) is representative.

Section of Uniontown coal on D. T. Clark farm, sec. 27, Malaga Township.

	Ft.	in.
Shale, unmeasured.		
Coal		4
Shale		½
Coal, with earthy bands	1	
Clay, with coal streaks	1	8½
Coal		9½
Clay		5
Coal		10
Shale.		
Thickness of coal bed	5	1½

A few feet above the coal is sandstone ranging from shaly and irregularly bedded to coarse grained and massive. Coal is recorded at the Uniontown horizon in a number of oil wells in the eastern part of the township, but there is little hope that the bed is anywhere more valuable than in the mine on the Clark farm.

WAYNESBURG COAL.

The Waynesburg coal is of little value on its outcrop in Malaga Township. No place was found where the bed has been mined. It is possibly present in workable thickness along the north boundary and is known to be of some value in the adjoining township to the north in Belmont County. In the western part of the township the bed consists of a few inches of shaly coal lying in the midst of sandy shale, with a bed of green clay about 7 feet below. This clay, which is 5 to 8 feet thick, is persistent throughout large areas both where the coal is lacking and where it is of minable thickness.

The Waynesburg coal has been recorded in core-drill hole No. 26, on the Sloan farm, in the NE. ¼ sec. 17, and the measurement is as follows:

Section of Waynesburg coal in core-drill hole on Sloan farm, sec. 17, Malaga Township.

	Ft.	in.
Shale, unmeasured.		
Coal and shale		5
Shale	5	1
Coal and shale		3
Shale	1	6
Coal	1	3

WASHINGTON COAL.

Practically all coal seen in the roadside exposures in the hills near Monroefield, Miltonsburg, and Malaga is the Washington bed. This coal is the most persistent in the entire region but has been utilized very slightly, owing to its inferior quality and small thickness. At Monroefield (locality 92) the bed consists of two layers, the lower 1 foot, 2 inches thick and the upper 8 inches, with 5 inches of clay between. West of Malaga, at locality 90, the bed is about 2 feet thick, and southward beyond Miltonsburg it diminishes to about 1½ feet. The two layers with the middle clay band represent the usual form of the bed.

SANDSTONE AND LIMESTONE.

The principal sandstone beds of Malaga Township lie above the Uniontown coal. They vary considerably in appearance. On Baker Fork, in the southeast corner of the township, the sandstone ranges from a single thick homogeneous coarse-textured layer suitable for quarrying to thin-bedded irregular layers that can have no

use except for road metal. There is also considerable variation in character where the beds crop out in the western part of the township. North of Monroefield, about the headwaters of Paynes Fork, the rock is in massive layers 30 to 40 feet thick that form cliffs and overhanging shelves along the ravines. The appearance of the sandstone on the W. F. Peters farm, in sec. 22, is illustrated by Plate X, *A*. The Catholic Church near Miltonsburg was built of stone quarried on the Peters farm.

The roads of the township have not been piked with limestone, although there is a fair supply of rock that can be obtained without great difficulty. In the central and eastern parts, the only limestone bed of importance lies above the Washington coal. It is 3 to 5 feet thick in the vicinity of Miltonsburg, Malaga, and Jerusalem but of less prominence or lacking near Monorefield and other places in the southern part of the township. The limestone near Miltonsburg consists of several layers of dark-gray color and tough texture which lie 10 feet above the Washington coal.

In the valleys in the western part of the township are numerous limestone beds lying 170 to 400 feet stratigraphically lower than the limestone over the Washington coal. The principal beds are below the Lower Meigs Creek coal and are adequate in quality and quantity for piking roads throughout the township.

SUNSBURY TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Sunsbury Township is an irregular area made up of parts of T. 4 N., R. 4 W., and T. 5 N., R. 5 W. All but two columns of sections on the east side of the township lie within the Woodsfield quadrangle.

The population of Sunsbury Township in 1920 was 1,490. Of this number 555 were attributed to Beallsville, the principal village. The Ohio River & Western Railroad runs northward along the west side and eastward along the north side for 4 miles, thence northeastward across Belmont County to Bellaire, on Ohio River.

Nearly all the waters of Sunsbury township are carried by tributaries of Sunfish Creek which rise near the north edge of the township and flow a little east of south. The principal streams are Death Creek, Piney Fork, East Fork of Piney Fork, and Ackerson Run. The Sunfish Creek drainage basin is separated from that of Captina Creek by an east-west divide which is followed for several miles by the railroad. The upper waters of Piney Fork flow in broad valleys bordered by gentle slopes and low hills, but to the south near the township line there is an abrupt deepening and the valleys narrow to gorges bounded by steep wooded slopes and sandstone cliffs. This change from mild to rugged topography is due to the presence of a prominent sandstone bed 40 to 50 feet thick.

The least elevation is about 860 feet on Piney Fork. The neighboring hills rise to about 1,200 feet, and the general elevation of the upland on the principal divides is 1,250 to 1,300 feet. The greatest elevation is in the northeast corner of the township, where two hilltops rise above 1,400 feet.

GEOLOGIC SECTION.

The rocks that crop out in Sunsbury Township resemble those of Malaga Township in that they contain only one coal bed of any value—the Washington. The strata exposed have a thickness of nearly 500 feet, and the horizons of several coals below the Washington are included, but no coal of workable thickness is known. The township is underlain, however, by the Pittsburgh coal bed, which is several hundred feet below the surface throughout the township. The stratigraphic sequence of the outcropping strata is illustrated by the following generalized section:

Generalized section in descending order, of strata outcropping in Sunsbury Township.

	Feet.
Washington formation:	
Clay, shale, and sandy beds to hilltops	200±
Coal, bony or black shale, seen in northeastern part of township	2
Shale, red clay, and sandstone, variable	100–120
Limestone, present only in northeast quarter of township	3
Shale or shaly sandstone, locally limestone near base	40
Coal, Washington	1–3
Shale, sandy	20–30
Sandstone, exceedingly prominent along Piney Fork and branches; less massive to the west; correlated with Mannington sandstone of West Virginia reports	35–50
Coal or carbonaceous shale position of Waynesburg "A" coal; locally 1 foot thick.	
Shale, sandy, with thin-bedded sandstone and layer of dark limestone near base	60
Shale, carbonaceous, underlain by reddish-brown clay shale.	
Monongahela formation:	
Waynesburg coal	3
Shale, sandy, and sandstone	55
Coal, thin, Uniontown.	
Clay shale grading down into shaly sandstone	18
Limestone, Benwood member, in many layers intercalated with calcareous shale; upper portion exposed in valley of Piney Fork	60±
Covered to Pittsburgh coal	132

The strata overlying the Washington coal comprise a monotonous succession of sandstone, shale, and clay, commonly of red color and with little or no limestone except in the basal portion. To the north,

in Belmont County, there are a number of limestone beds in this part of the geologic column. The Washington coal is exposed at many places on the roads and has been stripped in the ravines. Being almost the only coal bed in the township it serves as an excellent key for determining geologic structure.

Few valleys in eastern Ohio are more picturesque and precipitous than that of Piney Fork, with its sandstone cliffs and wooded slopes. The rugged topography is largely caused by the sandstone lying below the Washington coal. In places this sandstone is at least 50 feet thick, but toward the west it thins and grades into shaly sandstone and shale. Oil drillers call this sandstone the "Mountain sand," and in many well logs it is reported to be 60 feet thick. At its base is a coal bed which is locally 1 foot thick. The limestone beds of the Benwood member are prominently exposed near the mouth of Piney Fork, in Adams Township, where they form a cliff along the valley.

STRUCTURE.

In mapping the geologic structure the elevation of the Washington coal was obtained at many points. The interval between this bed and the Pittsburgh coal in different parts of the township is known through core-drill and oil-well records, and it was only necessary to subtract that amount from the elevation of the Washington coal in order to determine the position of the Pittsburgh at each point. Contour lines were then drawn connecting points of equal elevation, and the result is a contour map of the Pittsburgh coal (Pl. XII, in pocket) which shows the attitude or lay of that bed. The direction of dip varies from east to south and locally southwest. The dip varies from almost nothing near Jerusalem, where there is a structural terrace, to more than 60 feet to the mile in the vicinity of Beallsville.

MINERAL RESOURCES.

Sunsbury Township has produced considerable oil and gas but far less than Malaga Township. The most valuable pools lie in the western and northern parts of the township. The principal productive sands are the Big Lime and Keener. In the vicinity of Beallsville oil is also produced from a shallow sand, probably the Buell Run, although called the Cow Run by drillers. The most recently discovered pool, known as the Schriver, is 3 miles southeast of Beallsville. The product here is largely gas derived from the Berea sand.

The township is poorly supplied with easily accessible coal beds and has only a small amount of limestone for road metal. Sandstone is present in inexhaustible quantity, but there is little demand for it except for foundations.

COAL.

PITTSBURGH COAL.

All of Sunsbury Township is probably underlain by the Pittsburgh coal bed in a thickness of about 5 feet. Its presence has been proved by several core-drill tests near Beallsville and one at the mouth of Piney Fork. It is also recorded in the logs of dozens of wells drilled for oil in various parts of the township. It is reported that in drilling one well near the county line northeast of Beallsville no Pittsburgh coal was found, but this report is not significant in view of the unreliability of the churn drill for testing coal.

The following record of a core-drill hole on the William Tracy farm, in sec. 12, was furnished by Mr. Joe I. Johnson, of Johnstown, Pa. It is of interest because both the Meigs Creek and Lower Meigs Creek coals are present.

Partial section of core-drill hole on Tracy farm (No. 28), sec. 12, Sunsbury Township.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Surface	6		6	
Sandstone	60		66	
Slate	2		68	
Coal, probably Waynesburg	2		70	
Interval, mostly slate and lime	208		278	
Coal, Meigs Creek	2	6	280	6
Interval, sand, sandy shale, and slate	18	6	299	
Coal, Lower Meigs Creek	3		302	
Interval	69		371	
Pittsburgh coal: Coal		10	378	3
Pittsburgh coal: Draw slate	1			
Pittsburgh coal: Coal	5	5		

The Pittsburgh coal has a similar thickness in the test hole on the Daniel Kimpton farm, in sec. 35, where the "roof" coal is 1 foot 3 inches and the lower bench 5 feet thick. The clay between is unusually thick, measuring 4 feet. A thickness of 5 feet of coal is reported in coal-test hole No. 30, drilled in sec. 36, about 2 miles east of Beallsville.

OTHER COAL BEDS.

The Lower Meigs Creek and Meigs Creek coal beds lie 70 and 95 feet, respectively, above the Pittsburgh coal. Both are recorded in the logs of wells drilled at several places in the township but are of only remote prospective value owing to their lack of persistence, thinness, and inferior quality. The two coals are recorded in the log of a diamond-drill test hole on the Tracy farm given above. In coal test No. 32, on the Fleaman farm, at the mouth of Piney Fork, in Adams Township, the Meigs Creek coal is in two benches, the upper 1 foot and the lower 2 feet 6 inches thick, with 1 foot 6 inches of clay between. Both the Meigs Creek and Lower Meigs Creek

coals are recorded in the log of coal test No. 31, on the Daniel Kimpton farm, in sec. 35, which is given below.

The Uniontown coal is probably missing or too thin to be of value throughout the township. It is mined to the south along Sunfish Creek in Adams Township, but to the north, up Piney Fork, it changes to a thin layer of carbonaceous shale. The Waynesburg coal is likewise thin on its outcrop in the southern part of the township. From information obtained in well records it is also seen to be of no importance in the northern part. Another coal 1 to 3 feet thick found about 200 feet above the Meigs Creek coal in the test holes on the Kimpton and Tracy farms is believed to be the Waynesburg "A" coal.

The Washington coal appears in outcrop in various parts of the township and has been stripped by the farmers at many places. Its thickness and position with reference to lower coal beds are illustrated by the following core-drill record:

Partial record of core-drill hole No. 31, on Daniel Kimpton farm, sec. 35, Sunsbury Township.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Coal, Washington	1	6	14	
Interval, mostly sandstone	83		97	
Coal, possibly Waynesburg "A"	1		98	
Interval, mostly shale and lime	213		311	
Coal, Meigs Creek	2	3	313	3
Interval, mostly sandstone	37		350	3
Coal, Lower Meigs Creek	2		352	3
Interval, lime and slate	57	9	410	
Pittsburgh coal: Coal	1	3	420	3
Pittsburgh coal: Clay	4			
Pittsburgh coal: Coal	5			

The Washington coal is probably thickest in the eastern part of the township, as indicated by roadside exposures. At the east side of sec. 16 (locality 93) it is 1 foot thick, in the NW. ¼ sec. 3 (locality 95) 1 foot, and in the SE. ¼ sec. 4 (locality 94) 1 foot 6 inches. In some places farther east the bed consists of two benches each 1 to 2 feet thick, with a bed of clay between.

SANDSTONE AND LIMESTONE.

Sandstone is present in great quantity in Sunsbury Township. There are varieties suited to foundations, building, the manufacture of grindstones, curbstones, and paving. The principal sandstone bed below the Washington coal varies greatly in texture and structure and is believed to be fitted for all the above-named uses at one place or another in the township. Some of the rock is sufficiently durable to be suitable for road metal and could be used in areas far from convenient sources of limestone.

Limestone in quantity sufficient to be an important source of road metal is not plentiful. The principal source is the Benwood member, exposed only in the valley of Piney Fork near the south edge of the township. Only a few of the uppermost beds are at the surface. Farther downstream, near the mouth of Piney Fork, the bed is 40 feet thick. The limestone is in many layers 1 to 2 feet thick interbedded with calcareous clay and shale.

The strata lying above the Benwood limestone are almost devoid of limestone. The one noteworthy layer, about 300 feet higher, lies a few feet above the Washington coal. This limestone is seen in ravines on the county line near Jerusalem and Beallsville and is present east and southeast of Beallsville on Ackerson Run, but disappears farther south. In its most prominent exposures the rock is in one or two layers having a combined thickness of about 3 feet.

CENTER TOWNSHIP.

GENERAL FEATURES.

Center Township, like other political divisions of Monroe County, has an irregular boundary and includes parts of several of the square townships of the early land survey. For this reason the east column of sections bear numbers that are duplicated on the west side of the township. In like manner there is a duplication of section numbers at the north and south sides. Woodsfield, a town of 2,394 inhabitants and the seat of Monroe County, lies near the center of the township on the Ohio River & Western Railroad. In 1920 the population of the township outside of Woodsfield was 1,451. The southern third of Center Township lies within the New Matamoras quadrangle, and the following geologic description does not apply to that part.

The divide between the waters of the eastward-flowing Sunfish Creek and southward-flowing tributaries of Little Muskingum River extends eastward through the south-central part of the township. It is followed by the railroad westward from Woodsfield. The general elevation of this divide is 1,200 feet, but a few hills rise as much as 1,300 feet above sea level. The valleys are cut to depths ranging from 250 to 400 feet below the upland, and most of them are bounded by steep wooded slopes. Sunfish Creek follows an extremely crooked course over a narrow valley floor. At the sweeping bends there are indications of rock terraces at various elevations, which suggest that the valley has at one time been less crooked than the modern intrenched gorge.

GEOLOGIC SECTION.

The stratigraphic succession of strata exposed is represented in part by the following section, which was measured on the Barnesville road at the north edge of Woodsfield.

Geologic section, in descending order, on Barnesville road from Woodsfield.

	Feet.
Washington formation:	
Clay, reddish brown	4
Shale, yellowish brown, sandy in lower portion	15
Sandstone, shaly	9
Shale and red clay	9
Poorly exposed interval	17
Clay, yellowish and red	8
Shale, sandy, grading downward into sandstone	21
Carbonaceous shale, thin.	
Clay	4
Sandy shale	5
Clay	4
Coal, Washington	1¼
Clay	3
Shale	6
Clay shale	5
Shale	8
Clay, red	3
Shale, argillaceous, sandy, irregularly bedded	32
Sandstone, coarse, with micaceous laminae. This sandstone, which is correlated with the Mannington sandstone of the West Virginia reports, thickens to more than 40 feet east of Woodsfield and forms the prominent cliffs along Sunfish Creek	7
Shale, dark	5
Coal, thin, Waynesburg "A."	
Shale, dark gray	12
Carbonaceous shale, thin.	
Clay, reddish brown, ferruginous	8
Shale, chocolate-brown	5
Limestone, dark gray	¼
Shale, sandy	9
Sandstone	13
Shale, sandy, bluish and brownish	8
Monongahela formation:	
Carbonaceous shale, thin; position of Waynesburg coal.	
Shale, dark	7
Clay, greenish, with nodular iron carbonate concretions	4
Shale, sandy, grading down into shaly sandstone	15
Sandstone	17
Shale, sandy	5
Coal, impure, shaly, Uniontown	1
Shale	2
Sandstone	5
Shale, reddish brown	3
Limestone, bluish, laminated, exposed in creek bed at site of old mill; uppermost beds of Benwood limestone member.	

In the deep valley of Sunfish Creek northeast of Woodsfield limestone beds below those recorded at the base of the above section are at the surface, and their combined thickness at the east edge of the township is more than 40 feet. Beneath the limestone on the banks of the creek in that locality and eastward for a number of miles in Adams Township is cross-bedded sandstone which overlies the Meigs Creek coal.

The sandstone above the Waynesburg "A" coal in massive form is seen at the quarry on Standingstone Creek east of Woodsfield and thence eastward along Sunfish Creek for miles. It is not so conspicuous west of Woodsfield, where it consists of a single layer only 7 feet thick with shale above and below, as shown in the section at the north side of the town. This is only 1½ miles northwest of the quarry, where the principal bed is 28 feet thick and is overlain by 20 feet of thin-bedded sandstone. Farther west and northwest there is shale or shaly sandstone or locally red clay at this horizon. Beds of red clay with nodules of hematite iron ore are not uncommon above the Washington coal.

STRUCTURE.

The strata throughout most of Center Township do not lie flat but dip at the rate of as much as 40 feet to the mile in a southeasterly direction, with local variations. At the east edge of Woodsfield there is a shallow synclinal depression bordered on the southeast by a low arch, east of which the normal southeasterly dip is resumed. Northeast of Woodsfield there is an area of more than 1 square mile where the rocks lie nearly flat. The geologic structure is represented on the map (Pl. XII, in pocket) by contours drawn on the base of the Pittsburgh coal. The position of this bed with reference to the Washington coal and other outcroping strata is known through well records and direct measurements made elsewhere.

Although the strata at and near the surface lie almost parallel to one another, there is a varying interval between any one of these and the several deep sandstones that yield oil and gas. For this reason a special structural map has been prepared for the Berea oil sand.[14]

MINERAL RESOURCES.

Oil and gas, coal, sandstone, and limestone are the principal mineral resources of Center Township. The oil and gas pools, which rank among the most important in Monroe County, derive their products chiefly from the Berea, Keener, and Big lime sands.

[14] U. S. Geol. Survey Bull. 621, Pl. 25, 1916.

COAL.

PITTSBURGH COAL.

Information concerning the thickness and extent of the Pittsburgh coal in Center Township is derived entirely from records of wells drilled for oil and gas. Two core-drill test holes (Nos. 27 and 34) have been drilled in the eastern part of the township, but the records were not obtained. The coal is recorded in the logs of nearly all the hundreds of wells drilled in the northern half of the township, but there are no reliable data as to its thickness. The bed is an excellent key stratum and for this reason is recorded in drilling. The coal at its best, as shown by a number of core-drill tests, averages 4½ to 5½ feet in thickness north and east of Center Township, and it is not improbably of the same thickness in the northeast half of Center Township. The bed is of value in the vicinity of Miltonsburg and Malaga but it thins abruptly a short distance to the west. Farther south, in Center and Summit townships, the extent of the valuable coal is not so conclusively determined. There is difficulty in obtaining reliable information, especially from oil men, owing to a suspicion that such information is to be used in the enforcement of troublesome legislation concerning the method of casing and the plugging of oil wells. Possibly certain other persons wish to promote the sale of coal lands, even though of doubtful value, and therefore willfully misrepresent facts. The value of the Pittsburgh coal in much of Center Township is undetermined, and the operator is advised to carry on careful exploration with the diamond drill before purchasing land.

MEIGS CREEK AND LOWER MEIGS CREEK COALS.

Two coal beds lying 75 and 95 feet, respectively, above the Pittsburgh coal are recorded in oil-well drilling at various places. The name Mapletown is commonly applied by the drillers to one or the other of these coals. The one most commonly noted is probably the Lower Meigs Creek bed, which appears in outcrop to the northwest, in valleys near Monroefield. Neither of these coals is of much prospective value in Center Township.

UNIONTOWN COAL.

The Uniontown coal, lying 170 to 180 feet above the Pittsburgh, is of slight value as a source of fuel in Center Township. It crops out about 120 feet above the valley floor of Sunfish Creek at the east edge of the township but descends westward to a point 1½ miles northwest of Woodsfield, where it lies in the bed of the creek. To the north, up Baker Fork, the outcrop extends into Malaga Township.

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The coal at best is characterized by the presence of several shale layers which interfere with its easy mining, and furthermore the bed is subject to considerable change in thickness from place to place. It is too thin to be of value on Standingstone Run and probably on the railroad north of Coats station. The bed is locally split into two parts north of Woodsfield, the lower, a shaly coal 2 to 3 feet thick, being separated from the upper, less valuable bed by 10 feet or more of sandstone containing irregular veinlets of coal.

The thickness and character of the Uniontown coal in different localities is illustrated by the following measurements. The locality numbers are represented on the maps (Pls. VII and XII).

Sections of Uniontown coal in Center Township.

Hillside road on south side of Sunfish Creek, a quarter of a mile east of township line (locality 115)

	Inches.
Shale.	
Coal	8
Shale	3
Coal	6

Ravine exposure near Woodsfield reservoir site, 2 miles north of Woodsfield (locality 110).

	Ft.	in.
Shale.		
Coal		7
Shale, sandy, with carbonaceous layers	10	
Coal, impure shaly with iron concretions	1	2
Shale and limestone		8
Coal, bony.		
Shale	1	
Sandstone.		

Along Baker Fork, in D. T. Clark prospect, just across north township line (locality 111).

	Ft.	in.
Shale.		
Coal		4
Shale		½
Coal, with shaly bands	1	
Clay with several coal streaks	1	8½
Coal		9½
Clay		5
Coal		10
Shale.		
Thickness of coal bed	5	1½

WASHINGTON COAL.

The Washington coal, 170 to 180 feet above the Uniontown, is the only other outcropping coal that has any value in Center Township. Its thickness is rarely more than 2 feet, but the bed is persistent in large areas with a thickness of about 1½ feet. At the railroad crossing a quarter of a mile east of Woodsfield (locality 97, Pl. IX, p. 34) the bed is 1 foot 5 inches thick, with clay above and below. The thickness at the northeast corner of sec. 17 (locality 98), 2½ miles east of Woodsfield, is 1 foot 2 inches. The coal is probably thickest west of Woodsfield and in former years has been extensively stripped and also taken from underground by drift-mining. A thinner coal is commonly found 15 to 25 feet higher.

SANDSTONE.

Sandstone has probably been quarried more extensively in Center Township than in any other part of Monroe County. The principal quarry, on the railroad 1 mile east of Woodsfield, was operated for many years but is now abandoned. (See Pl. XI, *B*.) The quarry face shows a thickness of 28 feet of massive moderately coarse textured rock, with no regular horizontal partings. There are many irregular lines of weakness along which the rock breaks readily. These are produced by flaky plates of dark mica which on weathering change the light bluish-gray color of the rock to a rusty gray-brown. These micaceous bandings do not favor the quarrying of rectangular blocks. Above the quarry is 10 to 20 feet of thin-bedded sandstone that has been stripped as the work of quarrying progressed. The rock is poorly suited for use in building, being insufficiently cemented to withstand weathering. This friable character is manifested by a peculiar pitted surface on the weathered rock. The rock is apparently best suited for use as railroad ballast, rough rubble, and foundations. There is an unlimited quantity along the valley slopes of Sunfish Creek and its tributaries east of Woodsfield. The rock loses its massive character west of Woodsfield.

LIMESTONE.

Center Township is poorly supplied with limestone, and the only beds worthy of consideration as a source of material for road metal lie below the Uniontown coal along Sunfish Creek, in the eastern half of the township. The uppermost layers form pavements in the creek bed on the Barnesville road 1½ miles north of Woodsfield. Eastward downstream lower and lower layers rise above the bottom of the valley. The combined thickness of these and the interbedded shale and clay is about 30 feet. Some of the layers are argillaceous and not sufficiently durable for use as road metal, but the quantity of good material available is considerable.

ADAMS TOWNSHIP.

LOCATION AND SURFACE FEATURES.

Less than half of Adams Township lies within the Woodsfield quadrangle, the remainder being in the New Matamoras, New Martinsville, and Clarington quadrangles, which adjoin the Woodsfield quadrangle on the south, southeast, and east respectively. The township is made up of parts of four square townships of the original land survey. The population for 1920, as given by the Census Bureau, was 683. The only village within the area is Cameron, at the east edge, in the valley of Sunfish Creek. There is no railroad within the

township but sooner or later a line will reach this area for the exploitation of the Pittsburgh coal. Presumably the route followed will be the valley of Sunfish Creek. The Ohio River & Western Railroad is a short distance west of the township, but with its present route can never be of importance as a carrier of coal because of the many steep grades.

The surface of Adams Township is channeled into rugged relief by Sunfish Creek and its tributaries, which flow in valleys bordered by precipitous rocky slopes 400 feet high. The valley floor is about 700 feet above sea level at the east edge of the township and about 800 feet at the west edge. A few hills are more than 1,300 feet in elevation, but in general the ridges range from 1,200 to 1,250 feet. The gradient of Sunfish Creek, like that of most tributaries of the Ohio in this region, is considerable, and in much of its course the stream flows on bedrock. The steep slopes are largely caused by a prominent bed of sandstone.

GEOLOGIC SECTION.

The strata that crop out in the portion of Adams Township within the Woodsfield quadrangle range from about the horizon of the Meigs Creek coal upward to beds about 100 feet above the Washington coal. The Pittsburgh coal is 100 feet or more below the surface in the valley of Sunfish Creek. Its position at the mouth of Piney Creek, together with that of other strata penetrated in a core-drill hole, is shown by the following record furnished by Mr. D. A. Elvin.

Record of core-drill hole No. 32, on John W. Fleahman farm, sec. 31, Adams Township.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Surface	10		10	
Shale	3		13	
Sandstone	15		28	
Shale	5		33	
Coal, Meigs Creek:				
Coal	1		34	
Shale, gray	1	6	35	6
Coal	2	6	38	
Fireclay	1		39	
Limestone	7		46	
Sandstone	2		48	
Shale, sandy	1		49	
Shale	5		54	
Limestone	2		56	
Shale	1		57	
Sandstone	9		66	
Shale, green	4		70	
Shale, dark	2		72	
Shale, red	3		75	
Shale, green	13		88	
Limestone	1		89	
Shale, limy	11		100	
Sandstone	30		130	
Slate	2	7	132	7
Coal, Pittsburgh	4	4	136	11
Fire clay		6	137	5

The elevation of the Pittsburgh coal in this hole is 638 feet above sea level. The elevation of the Washington coal, as calculated from determinations at outcrops on three sides, is 1,070 feet, giving 432 feet as the interval between the Pittsburgh and Washington coals, which is about 30 feet greater than that at the Belmont County line 5 miles farther north.

The general character of the strata that crop out in Adams Township is illustrated by the following section, compiled from measurements made at several places in the township. The lowest beds are the same as those at the top of core-drill hole No. 32, given above.

Generalized section, in descending order, of strata outcropping in Adams Township.

	Feet.
Washington formation:	
Sandstone, shale, and red clay, with one or more layers of nodular hematite	200
Shale, and shaly sandstone, with beds of clay Coal thin. Clay, brittle, greenish gray, grading down into shale	26
Coal, Washington	1–2
Clay and shale	15
Sandstone; forms prominent cliffs along Sunfish Valley; correlated with Mannington sandstone of West Virginia reports.	58
Coal, Waynesburg "A," thin.	
Shale, sandy, with sandstone layers	23
Limestone, dark gray	½
Shale, sandy	29
Monongahela formation:	
Shale, black; position of Waynesburg coal	½
Shale, sandy, grading down into sandstone	52
Coal, Uniontown, mined on Sunfish Creek	2–3
Shale, grading down into sandstone	35
Limestone, Benwood member, in many layers interbedded with calcareous clay and shale	60
Shale and sandstone, exposed low in valley of Sunfish Creek.	25

STRUCTURE.

The dip in the western half of Adams Township is in general east to southeast at a rate ranging from 15 to 40 feet to the mile. On the whole the eastward dip of the strata is similar to the grade of Sunfish Creek, and the same strata are exposed in the valley across the township. The method of preparation of the structural map (Pl. XII, in pocket) is described on page 23.

MINERAL RESOURCES.

The principal mineral resource of Adams Township is coal, there being two valuable beds—the Pittsburgh, which lies 100 feet or more below the surface and is of great value, and the Uniontown, which

crops out along the valleys, thus affording a convenient source of fuel for the farmers. Oil and gas have not been discovered in large quantities, but the township has not yet been thoroughly tested. A few wells derive gas from the Berea sand in the Schriver pool in the northern part, and small quantities of oil have been found in the Keener sand in sec. 5.

COAL.

PITTSBURGH COAL.

It is probable that all of Adams Township is underlain by the Pittsburgh coal bed in minable thickness. As found in several core-drill records its thickness ranges from 4 to 5 feet, and the bed is recorded in the drilling of oil wells. In the test hole on the John W. Fleahman farm (No. 32), at the mouth of Piney Fork, in sec. 31, the coal is 4 feet 4 inches thick. The complete record is given on page 148. A coal test hole was drilled in the SW. ¼ sec. 36, but no record was obtained.

MEIGS CREEK COAL.

Little is known concerning the Meigs Creek coal aside from information furnished in the record of core-drill hole No. 32, at the mouth of Piney Fork (see p. 148), in which the coal bed has the following parts, from top to bottom: Coal, 1 foot; shale, 1 foot 6 inches; coal, 2 feet 6 inches. The bed is recorded in the logs of a few oil wells, but its thickness is not evident.

UNIONTOWN COAL.

The Uniontown coal bed has been opened at a number of places on Sunfish Creek. It is as a rule divided into several parts by layers of shale and is high in ash, as shown by the analysis of a sample taken in the Charles Mobley mine (locality 113, Pl. VII), in sec. 31 (analysis 20259, p. 40). The measurement made in the Mobley mine is given on page 47.

Sections of Uniontown coal in Adams Township.

Roadside exposure in sec. 6 (locality 115).

	Ft.	in.
Coal		8
Shale		3
Coal		6
	1	5

Prospect on Willis farm, sec. 30 (locality 114).

Shale.	Ft.	in.
Coal	2	
Coal, bony		5
Shale.		
	2	5

Prospect on Pasco farm, sec. 30 (locality 116).

Shale.	Ft.	in.
Coal	1	10½
Coal, bony		6
Clay shale		7
Coal		10
Shale.		
Thickness of bed	3	9½

In addition to being divided into a number of layers by shale bands, the Uniontown coal varies considerably in thickness and is probably reduced to a thin carbonaceous layer in places—for example, up Piney Fork beyond the forks in sec. 2.

WASHINGTON COAL.

The Washington coal lies about 185 feet above the Uniontown coal bed. About halfway between the two is the position of the Waynesburg coal, but there is no coal at that horizon throughout the portion of Adams Township within the Woodsfield quadrangle. The Washington coal ranges from about 10 inches to 2 feet in thickness, and its "blossom" is seen at many places in the township. Here and there the coal has been stripped by the farmers, but so far as known it has not been mined from underground workings. The greatest thickness observed is in the northern part of the township, in secs. 26 and 32, where the bed is about 2 feet thick. Another coal bed, 16 to 24 feet higher, is locally several inches thick and may be mistaken for the Washington.

SANDSTONE AND LIMESTONE.

Sandstone suitable for a variety of uses is abundant in Adams Township. The principal bed is that above the Waynesburg "A," as shown in the general section on page 16. It is a coarse massive bed 40 to 60 feet thick and produces the precipitous slopes of many of the valleys and the "rock houses" so prevalent in ravines tributary to Sunfish Creek. The rock is sufficiently durable for use in building and for curbstone, foundations, and other purposes, being similar to the same bed where quarried on Standingstone Run near Woodsfield.

Little attempt has been made to improve the roads in Adams Township, although there is a fair supply of limestone that can be obtained with little trouble in the valley of Sunfish Creek. The beds lie below the Uniontown coal and are 40 to 80 feet above the valley floor. Excellent exposures may be seen at the mouth of Piney Fork and also in almost any hillside ravine. The argillaceous limestone beds, each 1 to 2 feet thick, are interbedded with calcareous shale.

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