DEPARTMENT OF THE INTERIOR

HAROLD L. ICKES, SECRETARY

UNITED STATES GEOLOGICAL SURVEY

W. C. MENDENHALL, DIRECTOR

GEOLOGIC ATLAS

OF THE

UNITED STATES

SOMERSET-WINDBER FOLIO

PENNSYLVANIA

BY

G. B. RICHARDSON

WASHINGTON, D. C.

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1934

GEOLOGIC ATLAS OF THE UNITED STATES.

UNITS OF SURVEY AND OF PUBLICATION.

The Geological Survey is making a topographic and a geologic atlas of the United States. The topographic atlas will consist of maps called *atlas sheets*, and the geologic atlas will consist of parts called *folios*. Each folio includes topographic and geologic maps of a certain four-sided area, called a *quadrangle*, or of more than one such area, and a text describing its topographic and geologic features. A quadrangle is limited by parallels and meridians, not by political boundary lines, such as those of States, counties, and townships. Each quadrangle is named from a town or a natural feature within it, and at the sides and corners of each map are printed the names of adjacent quadrangles.

SCALES OF THE MAPS.

On a map drawn to the scale of 1 inch to the mile a linear mile on the ground would be represented by a linear inch on the map, and each square mile of the ground would be represented by a square inch of the map. The scale may be expressed also by a fraction, of which the numerator represents a unit of linear measure on the map and the denominator the corresponding number of like units on the ground. Thus, as there are 63,360 inches in a mile, the scale 1 inch to the mile is expressed by the fraction $\frac{1}{63,360}$, or the ratio 1:63,360.

The three scales most commonly used on the standard maps of the Geological Survey are 1:31,680, 1:62,500, and 1:125,000, 1 inch on the map corresponding approximately to one-half mile, 1 mile, and 2 miles on the ground. On the scale of 1:31,680 a square inch of map surface represents about one-fourth of a square mile of earth surface; on the scale of 1:62,500, about 1 square mile; and on the scale of 1:125,000, about 4 square miles. In general a standard map on the scale of 1:125,000 represents one-fourth of a "square degree"—that is, one-fourth of an area measuring 1 degree of latitude by 1 degree of longitude; one on the scale of 1:62,500 represents one-sixteenth of a "square degree"; and one on the scale of 1:31,680 represents one-sixty-fourth of a "square degree." The areas of the corresponding quadrangles are about 1,000, 250, and 60 square miles, though they differ with the latitude, a "square degree" in the latitude of Boston, for example, being only 3,525 square miles and one in the latitude of Galveston being 4,150 square miles.

FEATURES SHOWN ON THE TOPOGRAPHIC MAPS.

The features represented on the topographic maps comprise three general classes—(1) inequalities of surface, such as plains, plateaus, valleys, hills, and mountains, which collectively make up the *relief* of the area; (2) bodies of water, such as streams, lakes, swamps, tidal flats, and the sea, which collectively make up the *drainage*; (3) such works of man as roads, railroads, buildings, villages, and cities, which collectively are known as *culture*.

Relief.—All altitudes are measured from mean sea level. The heights of many points have been accurately determined, and those of some are given on the map in figures. It is desirable, however, to show the altitude of all parts of the area mapped, the form of the surface, and the grade of all slopes. This is done by contour lines, printed in brown, each representing a certain height above sea level. A contour on the ground passes through points that have the same altitude. One who follows a contour will go neither uphill nor downhill but on a level. The manner in which contour lines express altitude, form, and slope is shown in figure 1.

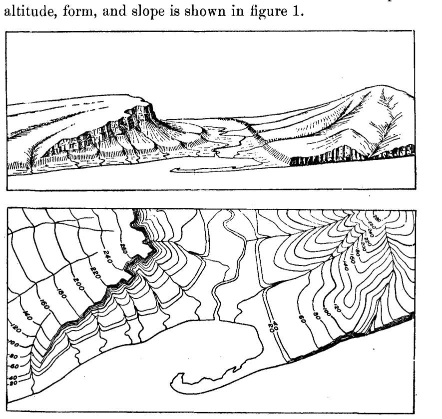

FIGURE 1.—Ideal view and corresponding contour map.

The view represents a river valley between two hills. In the foreground is the sea, with a bay that is partly inclosed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle upward slope; that on the left merges into a steep slope that passes upward to a cliff, or scarp, which contrasts with the gradual slope back from its crest. In the map each of these features is indicated, directly beneath its position in the view, by contour lines. This map does not include the distant part of the view.

As contours are continuous horizontal lines they wind smoothly about smooth surfaces, recede into ravines, and project around spurs or prominences. The relations of contour curves and angles to the form of the land can be seen from the map and sketch. The contour lines show not only the shape of the hills and valleys but their altitude, as well as the steepness or grade of all slopes.

The vertical distance represented by the space between two successive contour lines—the contour interval—is the same, whether the contours lie along a cliff or on a gentle slope; but to reach a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep slopes.

The contour interval is generally uniform throughout a single map. The relief of a flat or gently undulating country can be adequately represented only by the use of a small contour interval; that of a steep or mountainous country can generally be adequately represented on the same scale by the use of a larger interval. The smallest interval commonly used on the atlas sheets of the Geological Survey is 5 feet, which is used for regions like the Mississippi Delta and the Dismal Swamp. An interval of 1 foot has been used on some large-scale maps of very flat areas. On maps of more rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used, and on maps of great mountain masses like those in Colorado the interval may be 250 feet.

In figure 1 the contour interval is 20 feet, and the contour lines therefore represent contours at 20, 40, 60, and 80 feet, and so on, above mean sea level. Along the contour at 200 feet lie all points that are 200 feet above the sea—that is, this contour would be the shore line if the sea were to rise 200 feet; along the contour at 100 feet are all points that are 100 feet above the sea; and so on. In the space between any two contours are all points whose altitudes are above the lower and below the higher contour. Thus the contour at 40 feet falls just below the edge of the terrace, and that at 60 feet lies above the terrace; therefore all points on the terrace are shown to be more than 40 but less than 60 feet above the sea. In this illustration all the contour lines are numbered, but on most of the Geological Survey's maps only certain contour lines—say every fifth one, which is made slightly heavier—are numbered, for the heights shown by the others may be learned by counting up or down from these. More exact altitudes for many points are given in bulletins published by the Geological Survey.

Drainage.—Watercourses are indicated by blue lines. The line for a perennial stream is unbroken; that for an intermittent stream is dotted; and that for a stream which sinks and reappears is broken. Lakes and other bodies of water and the several types of marshy areas are also shown in blue.

Culture.—Symbols for the cultural features and for public-land land lines and other boundary lines, as well as all the lettering and the map projection, are printed in black.

FEATURES SHOWN ON THE GEOLOGIC MAPS.

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

KINDS OF ROCKS.

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

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as *igneous*. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages to or nearly to the surface. Rocks formed by the consolidation of molten material, or *magma*, within these channels—that is, below the surface—are called *intrusive*. An intrusive mass that occupies a nearly vertical fissure which has approximately parallel walls is called a *dike;* one that fills a large and irregular conduit is termed a *stock*. Molten material that traverses stratified rocks may be intruded along bedding planes, forming masses called *sills* or *sheets* if they are relatively thin and *laccoliths* if they are large lenticular bodies. Molten material that is inclosed by rock cools slowly, and its component minerals crystallize when they solidify, so that intrusive rocks are generally crystalline. Molten material that is poured out through channels that reach the surface is called *lava*, and lava may build up volcanic mountains. Igneous rocks that have solidified at the surface are called *extrusive* or *effusive*. Lavas generally cool more rapidly than intrusive rocks and contain, especially in their outer parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows are also usually made porous by the expansion of the gases in the magma. Explosions due to these gases may accompany volcanic eruptions, causing the ejection of dust, ash, lapilli, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone disintegration, of volcanic material deposited in lakes and seas, or of material deposited in such bodies of water by chemical precipitation or by organic action are termed *sedimentary*.

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

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

Most sedimentary rocks are made up of layers or beds that can be easily separated. These layers are called *strata*, and rocks deposited in such layers are said to be *stratified*.

The surface of the earth is not immovable; over wide regions it very slowly rises or sinks with reference to the sea, and shore lines are thus changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land surface is in fact composed of rocks that were originally deposited as sediments in the sea.

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

Metamorphic rocks.—In the course of time and by various processes rocks may become greatly changed in composition and texture. If the new characteristics are more pronounced than the old the rocks are called *metamorphic*. In the process of metamorphism the chemical constituents of a rock may enter into new combinations and certain substances may be lost or new ones added. A complete gradation from the primary to the metamorphic form may exist within a single rock mass. Such changes transform sandstone into quartzite and limestone into marble and modify other rocks in various ways.

From time to time during geologic ages rocks that have been deeply buried and have been subjected to enormous pressure, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structural features may have been lost entirely and new ones substituted. A system of parallel planes along which the rock can be split most readily may have been developed. This acquired quality gives rise to *cleavage*, and the cleavage planes may cross the original bedding planes at any angle. Rocks characterized by cleavage are called *slates*. Crystals of mica or other minerals may have grown in a rock in parallel arrangement, causing lamination or foliation and producing what is known as *schistosity*. Rocks that show schistosity are called *schists*.

As a rule, the older rocks are most altered and the younger are least altered, but to this rule there are many exceptions, especially in regions of igneous activity and complex structure.

GEOLOGIC FORMATIONS.

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

[Continued on inside back cover.]

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

AGE OF THE FORMATIONS.

Geologic time.—The largest divisions of geologic time are called *eras*, the next smaller are called *periods*, and the still smaller divisions are called *epochs*. Subdivisions of the Pleistocene epoch are called *stages*. The age of a rock is expressed by the name of the time division in which it was formed.

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

As sedimentary deposits accumulate successively the younger rest on the older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or their relations to adjacent beds have been changed by faulting, so that it may be difficult to determine their relative ages from their present positions at the surface.

Many stratified rocks contain *fossils*, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were washed into them or were buried in surficial deposits on the land. Such rocks are said to be fossiliferous. A study of these fossils has shown that the forms of life at each period of the earth's history were to a great extent different from the forms at other periods. Only the simpler kinds of marine plants and animals lived when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived forms that did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. If two sedimentary formations are geographically so far apart that it is impossible to determine their relative positions the characteristic fossils found in them may determine which was deposited first. Fossils are also of value in determining the age of formations in the regions of intense disturbance mentioned above. The fossils found in the strata of different areas, provinces, and continents afford the most effective means of combining local histories into a general earth history.

It is in many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or lies upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not that of their metamorphism.

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

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations that are known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. The colors in which the patterns of parallel lines are printed indicate age, a particular color being assigned to each system.

Each symbol consists of two or more letters. The symbol for a formation whose age is known includes the system symbol, which is a capital letter or monogram; the symbols for other formations are composed of small letters.

The names of the geologic time divisions, arranged in order from youngest to oldest, and the color and symbol assigned to each system are given in the subjoined table.

Geologic time divisions and symbols and colors assigned to the rock systems.

Era.	Period or system.	Epoch or series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent Pleistocene	Q	Brownish yellow.
	Tertiary	Pliocene Miocene Oligocene Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ћ	Peacock-blue.
Paleozoic	Carboniferous	Permian Pennsylvanian Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		Є	Brick-red.
Proterozoic	Algonkian		A	Brownish red.
	Archean		Æ	Gray-brown.

DEVELOPMENT AND SIGNIFICANCE OF SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. Most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains that border many streams were built up by the streams; waves cut sea cliffs, and waves and currents build up sand spits and bars. Surface forms thus constitute part of the record of the history of the earth.

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

All parts of the land surface are subject to the action of air, water, and ice, which slowly wears them down, producing material that is carried by streams toward the sea. As this wearing down depends on the flow of water to the sea it can not be carried below sea level, which is therefore called the *base-level* of erosion. Lakes or large rivers may determine base-levels for certain regions. A large tract that is long undisturbed by uplift or subsidence is worn down nearly to base-level, and the fairly even surface thus produced is called a *peneplain*. If the tract is afterward uplifted it becomes a record of its former close relation to base-level.

THE GEOLOGIC MAPS AND SHEETS IN THE FOLIO.

Areal-geology map.—The map showing the surface areas occupied by the several formations is called an *areal-geology map*. On the margin is an explanation, which is the key to the map. To ascertain the meaning of any color or pattern and its letter symbol the reader should look for that color, pattern, and symbol in the explanation, where he will find the name and description of the formation. If he desires to find any particular formation he should examine the explanation and find its name, color, and pattern and then trace out the areas on the map corresponding in color and pattern. The explanation shows also parts of the geologic history. The names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and metamorphic rocks of unknown origin—and those within each group are placed in the order of age, the youngest at the top.

Economic-geology map.—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the geologic formations is termed the *economic-geology map*. Most of the formations indicated on the areal-geology map are shown on the economic-geology map by patterns in fainter colors, but the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of each mine or quarry and is accompanied by the name of the principal mineral product mined or quarried. If there are important mining industries or artesian basins in the area the folio includes special maps showing these additional economic features.

Structure-section sheet.—The relations of different beds to one another may be seen in cliffs, canyons, shafts, and other natural and artificial cuttings. Any cutting that exhibits these relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of the beds or masses of rock in the earth is called *structure*, and a section showing this arrangement is called a *structure section*.

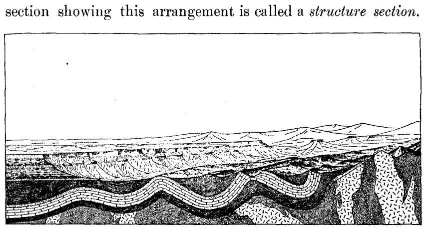

FIGURE 2.—Sketch showing a vertical section below the surface at the front and a view beyond.

The geologist is not limited, however, to natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks, after tracing out the relations of the beds on the surface he can infer their relative positions beneath the surface and can draw sections representing the probable structure to a considerable depth. Such a section is illustrated in figure 2.

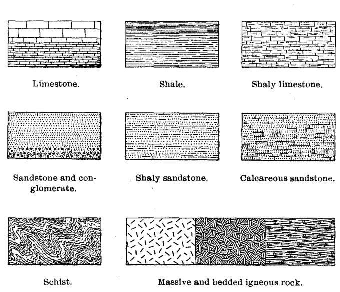

FIGURE 3.—Symbols used in sections to represent different kinds of rock.

The figure represents a landscape that is cut off sharply in the foreground on a vertical plane so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate patterns of lines, dots, and dashes. These patterns admit of much variation, but those shown in figure 3 are used to represent the commoner kinds of rock.

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

Where the edges of the beds appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed, and by means of these observations their positions underground are inferred. The direction of the intersection of the surface of a dipping bed with a horizontal plane is called its *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called its *dip*.

In many regions the beds are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the materials that formed the sandstone, shale, and limestone were deposited beneath the sea in nearly flat layers the fact that the beds are now bent and folded shows that forces have from time to time caused the earth's crust to wrinkle along certain zones. In places the beds are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in figure 4.

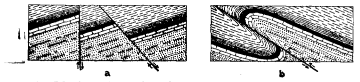

FIGURE 4.—Ideal sections of broken and bent strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. The schists are much contorted, and the form or arrangement of their masses underground can not be inferred. Hence that part of the section shows only what is probable, not what is known by observation.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of beds of sandstone and shale, which lie in a horizontal position. These beds were laid down under water but are now high above the sea, forming a plateau, and their change of altitude shows that this part of the earth's surface has been uplifted. The beds of this set are *conformable*—that is, they are parallel and show no break in sedimentation.

The next lower set of formations consists of beds that are folded into arches and troughs. The beds were once continuous, but the crests of the arches have been removed by erosion. These beds, like those of the upper set, are conformable.

The horizontal beds of the plateau rest upon the upturned, eroded edges of the beds of the middle set, as shown at the left of the section. The beds of the upper set are evidently younger than those of the middle set, which must have been folded and eroded between the time of their deposition and that of the deposition of the upper beds. The upper beds are *unconformable* to the middle beds, and the surface of contact is an *unconformity*.

The lowest set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were folded or plicated by pressure and intruded by masses of molten rock. The overlying beds of the middle set have not been traversed by these intrusive rocks nor have they been affected by the pressure of the intrusion. It is evident that considerable time elapsed between the formation of the schists and the beginning of the deposition of the beds of the middle set, and during this time the schists were metamorphosed, disturbed by the intrusion of igneous masses, and deeply eroded. The contact between the middle and lowest sets is another unconformity; it marks a period of erosion between two periods of deposition.

The section and landscape in figure 2 are ideal, but they illustrate actual relations. The sections on the structure-section sheet are related to the maps in much the same way that the section in the figure is related to the landscape. The profile of the surface in each structure section corresponds to the actual slopes of the ground along the section line, and the depth to any mineral-producing or water-bearing bed shown may be measured by using the scale given on the map.

Columnar section.—Many folios include a *columnar section*, which contains brief descriptions of the sedimentary formations in the quadrangle. It shows the character of the rocks as well as the thickness of the formations and the order of their accumulation, the oldest at the bottom, the youngest at the top. It also indicates intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition.

THE TEXT OF THE FOLIO.

The text of the folio states briefly the relation of the area mapped to the general region in which it is situated; points out the salient natural features of the geography of the area and indicates their significance and their history; considers the cities, towns, roads, railroads, and other human features; describes the geology and the geologic history; and shows the character and the location of the valuable mineral deposits.

GEORGE OTIS SMITH,
Director.

January, 1924.

DESCRIPTION OF THE SOMERSET AND WINDBER QUADRANGLES

By G. B. Richardson

INTRODUCTION

POSITION AND AREA

The Somerset and Windber quadrangles, in western Pennsylvania, are bounded by parallels 40° and 40° 15′ and meridians 78° 45′ and 79° 15′. They include an area of about 457 square miles, which is situated chiefly in Somerset County but embraces also parts of Westmoreland, Cambria, and Bedford Counties. (See fig. 1.) The quadrangles lie between the

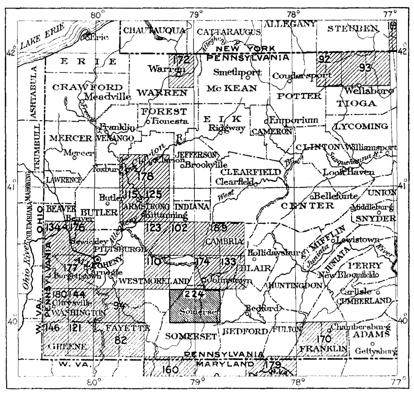

FIGURE 1.—Index map of western Pennsylvania and portions of adjacent States.

The location of the Somerset and Windber quadrangles is shown by darker ruling (No. 224). Published folios describing other quadrangles are indicated by lighter ruling and are listed on the back cover of this folio.

main line of the Pennsylvania Railroad on the north and that of the Baltimore & Ohio Railroad on the south and are crossed by the Rockwood-Johnstown branch of the Baltimore & Ohio. Formerly the towns of Somerset and Ligonier were connected by the Pittsburgh, Westmoreland & Somerset Railroad, but that road, although shown on the map, has been abandoned. Somerset, Windber, Ligonier, and Boswell are the chief towns. The area is situated in the bituminous coal fields, and its coal resources are being actively developed.

GENERAL GEOGRAPHIC AND GEOLOGIC RELATIONS

Appalachian Highlands.—The area included in these quadrangles forms part of the Appalachian Highlands, which extend from the Coastal Plain to the Interior Plains and from Alabama to Canada. (See fig. 2.) In Pennsylvania the Appa-

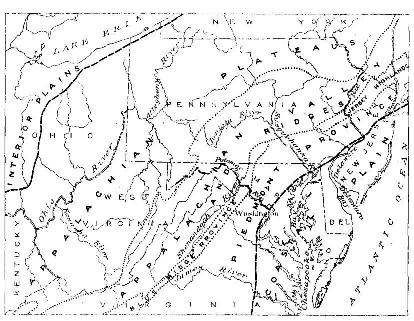

FIGURE 2.—Map of the central part of the Appalachian Highlands, showing its physiographic divisions.

lachian Highlands are divided into two almost equal parts by the escarpment known as the Allegheny Front. East of this escarpment lies a belt of northeastward-trending ridges and valleys—the Appalachian Valley and Ridge province—which is underlain by sharply folded early Paleozoic strata. This province is bounded on the east by the Blue Ridge province, east of which lies a dissected upland, the Piedmont province, which forms the easternmost division of the Appalachian Highlands and is underlain largely by pre-Cambrian metamorphosed rocks. West of the Allegheny Front is the Appalachian Plateaus province, a broad highland belt that is underlain by gently folded Carboniferous and older strata. The Somerset and Windber quadrangles are situated mainly in this province, near its eastern border, but a small part of the area is in the Appalachian Valley and Ridge province.

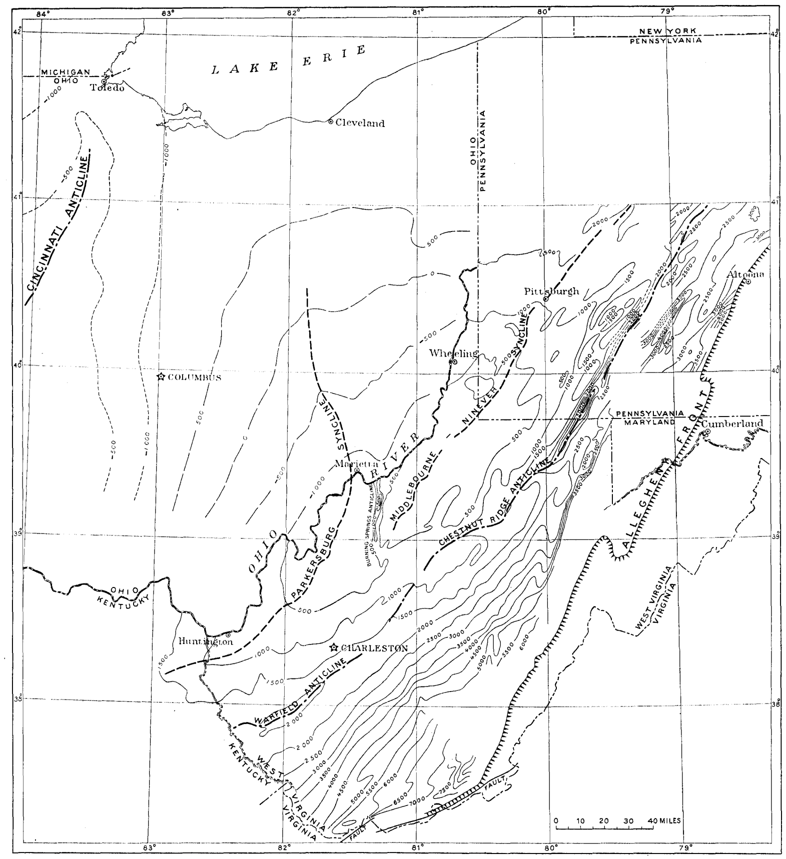

FIGURE 3.—Map of the Pittsburgh-Huntington Basin showing the geologic structure by contours drawn on the Pittsburgh coal in Pennsylvania and West Virginia, on the top of the Berea sand in eastern Ohio, and on the top of the Trenton limestone in central Ohio.

The eastern edge of the Appalachian Plateaus and the Allegheny Front is shown by hachured line. Contour interval 500 feet; datum, sea level.

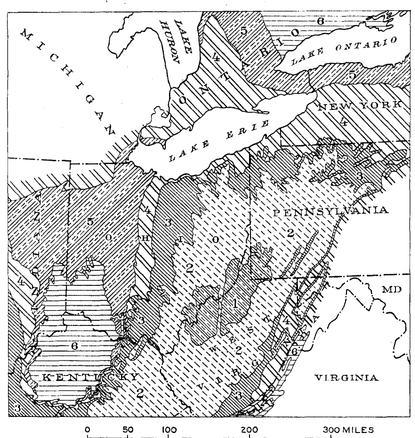

FIGURE 4.—Geologic sketch map of the northern part of the Appalachian Plateaus and adjacent region.

1, Permian; 2, Pennsylvanian; 3, Mississippian; 4, Devonian; 5, Silurian; 6, Ordovician.

Appalachian Plateaus.—The Appalachian Plateaus form a dissected upland that consists of rolling hills and valleys surmounted in its eastern portion by several high ridges.

The rocks that form the central part of the Appalachian Plateaus lie in a spoon-shaped structural trough—the Pittsburgh-Huntington Basin. On the northwest the strata rise on the flanks of the Cincinnati anticline, and on the southeast they rise to the crest of the Allegheny Front. This synclinorium is modified by subordinate folds. (See fig. 3.)

The rocks that crop out on the Appalachian Plateaus are chiefly of Carboniferous age. Devonian, Silurian, and older beds are exposed along the margins of the basin and underlie it to a depth of many thousand feet. (See fig. 4.)

TOPOGRAPHY

RELIEF

The Somerset and Windber quadrangles are traversed by two of the most prominent highland belts of the Appalachian Plateaus—the Allegheny Front, locally known as Allegheny Mountain, and Laurel Hill. These belts consist of flattish-topped forested ridges which rise to altitudes between 2,700 and 2,950 feet above sea level and are the dominant topographic features of the area. The rest of the region is an undulating hilly country, which in places is deeply trenched by streams. The lowest part of the area, the valley of Loyalhanna Creek, in the northwest corner of the Somerset quadrangle, has an altitude slightly above 1,100 feet, so that the extreme range in altitude is about 1,800 feet.

The Allegheny Front, where it crosses the southeast corner of the Windber quadrangle, forms a double highland belt, 2 miles in width, consisting of two parallel ridges separated by the steep, narrow valley occupied by Breastwork Run. The mountain trends northeastward and rises above the lowland at its eastern base in a steep escarpment. The base of this escarpment is formed by relatively soft strata, above which massive sandstones form a wall 500 feet or more in height. Between the foot and the crest of the escarpment there is a difference in altitude of 1,000 feet within a horizontal distance of 1 mile. The relatively flat zone on top of Allegheny Mountain is caused by the outcrop of soft shale. Where Breastwork Run has cut through these rocks into underlying hard sandstone it flows in a gorge. The western and higher ridge of Allegheny Mountain rises above the shale area and forms a second southeastward-facing escarpment composed of massive sandstone. The western flank of the ridge is a slightly dissected dip slope. Except for the area of shale on top of the ridge, on which a few farms are located, this part of Allegheny Mountain is a forested wilderness strewn with blocks of massive sandstone.

Laurel Hill occupies a belt about 6 miles wide that extends in a northeasterly direction across the Somerset quadrangle. The crest forms an even sky line, and as the ridge stands about 1,000 feet above the adjacent lowland it is a prominent landmark. In most places it is covered by a good stand of timber and also by a heavy growth of underbrush. A large part of the surface is strewn with blocks of massive sandstone, and except for a few cleared spots the ridge is an uninhabited wilderness that contrasts strongly with the adjacent thickly settled area. The flanks of Laurel Hill are deeply trenched by streams that occupy steep-sided narrow valleys which are cut for the most part in sandstone that crops out in cliffs. The streams have cut deeper on the west side of the ridge, where in places, as in the upper valley of Furnace Run, the gorge is 1,000 feet deep. The top of the ridge is a broad, rather flat area that rises to altitudes between 2,700 and 2,900 feet above sea level.

The undulating hilly country that constitutes the remaining part of the area is underlain chiefly by shale and thin-bedded sandstone, to the varying hardness of which the surface forms are adjusted. The hills are formed by the more resistant rocks, and the valleys are underlain by softer beds. Parts of the stream courses, as for instance considerable stretches along Stony Creek, in the Windber quadrangle, lie in narrow, steep-walled valleys trenched in cliff-making sandstone. Other parts of the valleys, underlain by less resistant rocks, form relatively broad lowlands. One of these lowland areas, part of the valley of Quemahoning Creek, in the Windber quadrangle, has been dammed at its lower end, above Hollsopple, in order to impound in Quemahoning Reservoir a large body of water which is used by manufacturing plants in Johnstown. In the area between the Allegheny Front and Laurel Hill a number of hilltops rise to altitudes between 2,200 and 2,400 feet, and these hilltops, when viewed from a distance, form an even sky line.

The northwest corner of the Somerset quadrangle, west of Laurel Hill, forms part of Ligonier Valley, which is not a valley in the sense of being occupied by a master longitudinal stream but in this area is crossed transversely by Loyalhanna Creek. It forms a distinct lowland belt in comparison with the bordering highland belts, Chestnut Ridge on the west and Laurel Hill on the east. Ligonier Valley is underlain chiefly by comparatively soft rocks.

DRAINAGE

The area considered in this folio lies almost entirely on the Appalachian Plateaus, but the Allegheny Front crosses the Windber quadrangle, the southeast corner of which is included in the Appalachian Valley and Ridge province. The drainage therefore flows chiefly to the Gulf of Mexico, but a small part is more directly tributary to the Atlantic. The Gulf drainage flows through upper tributaries of Allegheny and Monongahela Rivers, and the Atlantic drainage flows through headwaters of the Juniata.

Most of the area drains into Allegheny River. The major stream is Stony Creek, which with its branches drains the larger part of the tract between Allegheny Mountain and Laurel Hill. Stony Creek rises near the town of Berlin, south of the Windber quadrangle, and flows northward to join Conemaugh River, one of the principal tributaries of the Allegheny, at Johnstown. Paint and Shade Creeks, the main eastern branches of Stony Creek, drain the western flanks of Allegheny Mountain, and South Fork of Bens Creek, Quemahoning Creek, Beaverdam Creek, and Wells Creek are the main western branches. The area west of Laurel Hill is drained by Loyalhanna Creek, a tributary of the Conemaugh. The tributaries of Monongahela River, Laurel Hill Creek and Coxes Creek, flow in general southwestward to Castleman River and drain the southern part of the Somerset quadrangle. The small area southeast of Allegheny Mountain drains to the Raystown branch of Juniata River.

DESCRIPTIVE GEOLOGY

STRATIGRAPHY

AGE OF THE ROCKS

The rocks which crop out in the Somerset and Windber quadrangles belong to the Chemung and Catskill formations, of Devonian age, and the Pocono, Loyalhanna, Mauch Chunk, Pottsville, Allegheny, Conemaugh, and Monongahela formations, of Carboniferous age. (See columnar-section sheet.)

The youngest formation, the Monongahela, occurs only in small remnants north of Boswell, in the Somerset quadrangle, which have been left by erosion in the center of the Johnstown syncline. The greater part of the surface of both quadrangles is formed by the Conemaugh and Allegheny formations, which are best developed in the synclines and which have been removed by erosion from the crests of the major anticlines. The Pottsville formation crops out on all the anticlinal folds and also in some of the deeper valleys, and the Mauch Chunk, Loyalhanna, and Pocono formations are exposed chiefly on Laurel Hill and Allegheny Mountain. The Catskill and Chemung formations crop out only at the base of the Allegheny Front.

DEVONIAN SYSTEM

UPPER DEVONIAN SERIES

The upper part of the Upper Devonian series is represented by variable strata which are known as the Chemung and Catskill formations. These are the oldest rocks that crop out in the Somerset and Windber quadrangles.

CHEMUNG FORMATION

The Chemung formation, as developed in this region, includes fossiliferous greenish-gray shale and sandstone that lie between the Portage and Catskill formations. In Pennsylvania, just east of the Allegheny Front, the Chemung formation is about 2,400 feet thick.

Distribution and character.—This formation crops out in an area of less than 1 square mile in the extreme southeast corner of the Windber quadrangle and lies far beneath the surface in the remaining part of the quadrangle and throughout the Somerset quadrangle. Only the upper 2,000 feet is exposed, and the rocks, which dip 15°–25° NW., form the crest and southeastern slopes of a low range of hills. The light-gray soil into which these rocks weather forms a striking contrast to the bright-red soils derived from the overlying Catskill formation.

On the whole the Catskill and Chemung are readily distinguished by their colors, yet the boundary between the two formations in places is difficult to draw because of the presence of some reddish beds in the upper part of the Chemung. In the Windber quadrangle the boundary shown on the map was drawn either at the top of the highest fossiliferous stratum or at the lowermost persistent bright-red stratum.

In this area the rocks of the Chemung formation consist of alternating beds of fine-grained greenish-gray arkosic sandstone and sandy shale. The prevailing tone of the formation is grayish, but the general somber tone of the Chemung is varied in its extreme upper part by the presence of dull reddish-brown or chocolate-colored beds.

The Chemung, in contrast to the Catskill, contains many fossils, and the presence of a fossiliferous zone at or near the top of the formation serves for its delimitation. The following fossils, identified by Charles Butts, were collected from this zone at a place three-quarters of a mile north of the southeast corner of the Windber quadrangle.

Spirifer disjunctus.	Leptodesma elongatum.
Camarotoechia n. sp. or large variety of C. contracta.	Grammysia elliptica.
	Ptychopteria cf. P. lata.
Camarotoechia cf. C. contracta var. robusta Butts.	Fragments of small pelecypods.
	Orthoceras sp.

CATSKILL FORMATION

Definition and classification.—The name Catskill formation is given in this region to the bright-red sandstone and shale that lie above the Chemung formation. The Catskill is here classed as Devonian, following long-established usage. However, there are differences of opinion among geologists concerning the delimitation of the Devonian and Carboniferous systems in the Appalachian region, and the present classification is subject to revision.

Distribution and character.—The Catskill formation crops out in the Windber quadrangle in a zone slightly more than a mile wide at the base of Allegheny Mountain and lies far beneath the surface in the rest of the area here considered. As it is generally softer than the underlying Chemung and markedly softer than the overlying Pocono the Catskill outcrop forms a rolling lowland area, which is characterized by brilliant red soil that results from the disintegration of the rocks.

In this area the Catskill formation is between 1,800 and 2,000 feet thick. It is composed of bright-red sandy shale and clay shale, thin-bedded fine-grained red sandstone, and subordinate gray sandstone and shale. The sandstones are composed of subangular bits of quartz and interstitial clay. In the red varieties the pigment forms a film about the quartz grains and also forms part of the interstitial material. Fossils have not been found in the Catskill formation in this region.

CARBONIFEROUS SYSTEM

The greater part of the exposed rocks of the Somerset and Windber quadrangles are included in the Mississippian and Pennsylvanian series of the Carboniferous system. The Mississippian rocks include the Pocono formation, Loyalhanna limestone, and Mauch Chunk shale, and the Pennsylvanian rocks include the Pottsville, Allegheny, Conemaugh, and Monongahela formations. The Permian series is not represented.

MISSISSIPPIAN SERIES

POCONO FORMATION

Definition.—The Pocono formation consists of gray sandstone and subordinate sandy shale. It has a thickness of 2,000 feet on Susquehanna River and thins out to the north, south, and west. Along the Allegheny Front it is about 1,000 feet thick. The Pocono formation seems to lie conformably on the Catskill.

Distribution.—The Pocono formation crops out in both the Windber and Somerset quadrangles. It is exposed in a belt that ranges from a quarter of a mile to a mile in width in the southeast corner of the Windber quadrangle, where it forms the Allegheny escarpment. The hard sandstones in the upper part of the Pocono which form this escarpment also form the summit of the eastern ridge of Allegheny Mountain and extend some distance down the western slope, where the ridges are deeply trenched by Breastwork Run, which flows parallel to the strike of the rocks. The Pocono formation is conspicuously exposed along the Pittsburgh and Philadelphia road (the Lincoln Highway), where small sandstone quarries have been opened for road metal. Throughout the rest of the Windber quadrangle the Pocono formation is covered by younger rocks.

In the Somerset quadrangle, where the Laurel Hill anticline brings the formation to the surface again, the Pocono forms the crest and upper flanks of Laurel Hill for several miles north of the Pittsburgh and Philadelphia road and crops out south of the road in several deep valleys. Over the greater part of Laurel Hill a thick growth of vegetation conceals the rocks, but here and there along the summit and in some of the valley walls sandstone is conspicuously exposed.

Character and age.—In western Pennsylvania the upper part of the Pocono formation is separated locally into two members, the Burgoon sandstone and the Patton shale, but the lower part, which is more shaly than the upper part, has been given no special designation.

A thin bed of red shale near the middle of the formation possibly marks the thinning out in this direction of the Patton shale member. This bed crops out along the Pittsburgh and Philadelphia pike, where about 5 feet of brownish-red sandy shale is exposed. In the western part of the State the red Patton shale locally serves as a stratigraphic guide in the interpretation of well records.

Both above and below this red shale the Pocono formation consists of alternating beds of gray sandstone and sandy shale. Although the lower part of the formation contains relatively more sandy shale and the upper part more massive sandstone yet massive beds of sandstone occur in the lower part and considerable thin-bedded sandstone and shale in the upper part. The sandstone, which is fine to medium grained and in places is cross-bedded, is composed of rounded to subangular grains of quartz and subordinate kaolin and sericite; flakes of muscovite also occur and in places are conspicuously developed. On the summit of Laurel Hill small rounded pebbles of quartz mark a conglomeratic phase of the Pocono.

Fossils were not found in the Pocono formation in these quadrangles. In the Hollidaysburg-Huntingdon folio, now in press, Butts states that the lower part of the Pocono is somewhat fossiliferous, yielding both invertebrate and plant fossils, including undescribed calcareous algae. The Pocono formation is believed to be in part equivalent to the Cuyahoga formation of Ohio.

LOYALHANNA LIMESTONE

Definition, age, and correlation.—The Loyalhanna limestone, named from the conspicuous outcrops along Loyalhanna Creek, where it cuts through Chestnut Ridge a few miles northwest of the Somerset quadrangle, lies between the Pocono formation and the Mauch Chunk shale. When first described this limestone was included with the Mauch Chunk, and later it was included in the Pocono. Although fossils have not been found in the Loyalhanna limestone, Butts[1] correlates it with the Ste. Genevieve limestone of the Mississippi Valley, which is referred to the Chester group.

Character and distribution.—The Loyalhanna limestone, which averages about 40 feet in thickness, is a massive fine-

[1] Butts, Charles, The Loyalhanna limestone: Am. Jour. Sci., 5th ser., vol. 8, pp. 249–257, 1924.

grained blue-gray siliceous limestone that might with equal propriety be called a calcareous sandstone. It is composed of irregular-sized rounded grains of quartz with subordinate mica and decomposed feldspars embedded in a calcareous matrix. Some specimens show small segregations of pyrite. The following partial analysis by W. C. Wheeler shows the composition of a sample collected near the west end of the Laurel Hill tunnel of the projected but abandoned South Pennsylvania Railroad:

Partial analysis of Loyalhanna limestone

Insoluble	47.60
$Fe_2O_3+Al_2O_3$	2.58
MgO	.42
CaO	27.08
Loss on ignition	22.41
	100.09

The siliceous character of the rock is well exhibited by weathered surfaces. The lime has been superficially removed by solution, and the bedding planes, which are not apparent on fresh surfaces, are plainly marked by grains of quartz. Cross-bedding, characteristic of the limestone, is thus made very evident.

The Loyalhanna limestone was not separately mapped in the field, but its approximate position between the Pocono formation and the Mauch Chunk shale on Allegheny Mountain and Laurel Hill is shown on the geologic maps. This limestone has been used for paving blocks and for road metal, and several quarries have been opened in it, as shown on the economic-geology maps.

MAUCH CHUNK SHALE

Definition.—The Mauch Chunk shale consists chiefly of red sandy shale and clay shale and subordinately of sandstone and limestone. It has a maximum thickness of 3,000 feet in the southern anthracite field of Pennsylvania and becomes thinner toward the north, west, and south. In western Pennsylvania the Mauch Chunk ranges from a feather edge to about 250 feet in thickness. Where the formation is absent the Pottsville rests directly on the Pocono formation. Along the Allegheny Front in the Windber quadrangle the Mauch Chunk is about 200 feet thick, and in places on Laurel Hill in the Somerset quadrangle it is only 100 feet thick. The Mauch Chunk lies structurally conformably on the Loyalhanna limestone.

Distribution and character.—This formation crops out in both quadrangles. It is exposed in the valley of Stony Creek in the vicinity of Border, a station on the Baltimore & Ohio Railroad, at the north end of the Windber quadrangle. A more extensive area is occupied by the Mauch Chunk in the southeastern part of the quadrangle, where these soft rocks locally form a belt of relatively low land on Allegheny Mountain between its double crests, the eastern one of which is formed by the Pocono and the western by the Pottsville. Some farming is done on this belt of soft rocks on top of the mountains, and the cleared area that exposes the Mauch Chunk red beds forms a striking contrast to the wilderness occupied by sandstone on both sides. In the Somerset quadrangle the Mauch Chunk formation crops out only on Laurel Hill, where it is exposed locally on the summit but more commonly in an irregular zone on both flanks.

Exposures of the Mauch Chunk in this region are poor. The formation is composed of prevailing brownish-red, locally green and drab sandy shale and clay shale accompanied by subordinate thin cross-bedded fine-grained grayish-green and buff micaceous sandstone and thin lenses of gray and reddish limestone. The prevailing red color of the formation is characteristic, and because it forms the only zone of red rocks, with the exception of the thin bed of red shale in the Pocono, between the Catskill formation and the red beds of the Conemaugh, the Mauch Chunk is a valuable key formation in the study of well records.

Fossils.—The fossils named below, determined by G. H. Girty, were obtained from limestone in the Mauch Chunk on the north branch of Middle Fork of Mill Creek, in the Somerset quadrangle. Girty states that this is a Chester fauna related to that of the Maxville limestone of Ohio.

Fenestella? sp.	Composita trinuclea?
Productus ovatus.	Aviculipecten sp.
Diaphragmus elegans.	Leda sp.
Girtyella indianensis.	Leptodesma? sp.
Spirifer keokuk var.	Euomphalus aff. E. similis.

PENNSYLVANIAN SERIES

POTTSVILLE FORMATION

Definition.—The Pottsville formation is typically developed at Pottsville, in eastern Pennsylvania. In the western part of the State only the upper part of the formation is present, and this part, which is rarely more than 250 feet thick, has been separated into the Homewood sandstone at the top, an intermediate member—the Mercer shale—and the Connoquenessing sandstone, which in many places in western Pennsylvania forms the base of the upper Pottsville, although in other places lower members—the Sharon shale, the Sharon coal, and the Sharon conglomerate—are present. The stratigraphy is variable, and these subdivisions are not everywhere recognizable. The Pottsville lies unconformably on strata of the underlying Mississippian series, the unconformity being marked by thinning and local disappearance of the underlying Mauch Chunk shale and by the varying thickness of the Pottsville.

Western Pennsylvania and the adjacent areas apparently were above sea level and received no sediments during early Pottsville time, when a great thickness of rocks which constitutes the lower part of the formation was laid down in the eastern part of the Appalachian trough. The Pottsville at the type section is 1,200 feet or more thick and in the southern Appalachians more than 7,500 feet thick.

Distribution.—The Pottsville formation underlies the greater part of the Somerset and Windber quadrangles and crops out in a number of separate areas that are characterized by the presence of ledges or blocks of massive sandstone and that usually form a forested wilderness.

In the Windber quadrangle the most extensive outcrop is on the summit and western slope of Allegheny Mountain, where it occupies a belt between a quarter of a mile and 2 miles in width. The formation is also exposed in the valley of Stony Creek between Shanksville and Mostoller and between Foustwell and the northern border of the quadrangle, in the valley of Paint Creek below Scalp Level, along Quemahoning Creek near the west border of the quadrangle, and in the valley of Shade Creek, in the upper parts of both branches of which the outcrop of the Pottsville is continuous with another outcrop of the formation along the western slope of Allegheny Mountain. In the Somerset quadrangle the Pottsville formation crops out in an irregular zone on both flanks of Laurel Hill, and in places south of the Pittsburgh and Philadelphia road it caps the summit. The formation is also exposed in the valley of Quemahoning Creek below Boswell.

Composition.—The Pottsville, although it occupies a considerable area, as a whole is poorly exposed in the Somerset and Windber quadrangles because the outcrop is usually littered with débris. In places, however, as along Stony Creek between Foustwell and Paint Creek, exposures are fair, and a few diamond-drill holes have penetrated the formation, some passing entirely through it, so that its local thickness and general composition are known. A measurement of the formation in the cliffs on the west side of Stony Creek at the north end of the Windber quadrangle shows a thickness of about 200 feet, and a combination of the records of two diamond-drill holes southwest of Windber shows a thickness of 207 feet. The threefold division of the Pottsville into the Homewood sandstone, Mercer shale, and Connoquenessing sandstone members is recognizable in this area, but the Mercer member is thin and poorly exposed, and the sandstone members are more or less shaly. The following record of a diamond-drill hole shows the details of composition of the formation in the vicinity of Foustwell. Other sections of the Pottsville in these quadrangles are shown in the plotted records of diamond-drill holes on the back of the columnar-section sheet.

Section of Pottsville formation near Foustwell

[Diamond-drill record]

	Ft.	In.
Homewood sandstone member: Sandstone, gray	33	9
Mercer shale member:		
Shale, dark	2	9
Coal and shale	1	
Coal	1	9
Shale, black		4
Clay	7	7
Shale, dark	9	1¼
Coal		5¼
Shale, dark	1	5½
Shale		10
Connoquenessing sandstone member:		
Sandstone, gray	39	1
Shale, dark		11
Sandstone, gray	8	10
Shale and sandstone	2	11
Sandstone, gray	12	9
Shale and sandstone	3	2
Sandstone, gray	57	3
Mauch Chunk shale: Shale, green and red.		

Beds of shale in the Mercer member crop out in the bluff immediately above the road at the bend about midway between Foustwell and Seanor, where the following section of a part of the formation is exposed:

Section of part of Pottsville formation near Seanor

	Feet
Homewood sandstone member: Sandstone, indurated, fine grained, white, quartzose	25
Mercer shale member:	
Shale, carbonaceous, and impure coal	5
Shale, drab, sandy and clayey, and thin-bedded fine-grained micaceous sandstone, fossiliferous	5
Concealed	15
Connoquenessing sandstone member: Sandstone, massive, in bed of Shade Creek.	

The following fossils, obtained from the bed indicated in the section, were identified by David White:

Sphenopteris cf. S. mixta.	Neuropteris sp.
Oligocarpia n. sp.	Asterophyllites fasciculatus.
Neuropteris cf. N. rarinervis.	Calamites suckowii.
Neuropteris tenuifolia.	Sphenophyllum cuneifolium.

White reports that this collection is distinctly upper Pottsville in age, several of the forms being representative of species from the Mercer member of Pennsylvania or the Kanawha formation of West Virginia. The fossil fern *Neuropteris tenuifolia* was also found in a bed of shale that crops out by the Baltimore & Ohio Railroad track 200 feet southwest of the water tank about midway between Foustwell and Border stations.

Records of diamond-drill holes in the Windber quadrangle indicate that the Mercer member averages about 25 feet in thickness and consists of shale, thin beds of coal, and clay, the clay from 2 feet to 8 feet 6 inches in thickness.

The Homewood and Connoquenessing sandstones are lithologically much alike and can be differentiated only by means of the intervening shale member. Drill records indicate that the Homewood sandstone member averages about 50 feet in thickness, and the Connoquenessing in the one drill record in which it is completely shown is 124 feet thick. The sandstones are commonly massive, but in places the massive layers are intercalated with thin to medium bedded layers. They are composed of characteristically fine-grained hard white to gray quartzose material. Only locally is the prevailing fine grain varied by coarse lenses composed of well-rounded pebbles of white quartz that range from a small fraction of an inch to half an inch in diameter. In places there are flakes of muscovite and a small amount of interstitial material, composed of kaolin, sericite, and calcite, decomposition products of disseminated feldspars. Records of diamond-drill holes show that both the Homewood and Connoquenessing sandstones are interbedded with layers of shale.

Delimitation.—The lower limit of the Pottsville in these quadrangles is marked by the change from white sandstone at its base to the red shale of the underlying Mauch Chunk. In places, however, there may be uncertainty regarding the boundary because of the presence of red beds in the Pottsville that contain reworked material derived from the erosion of the Mauch Chunk. The upper limit of the Pottsville is not so distinct except where it is marked by an abrupt change from the Homewood sandstone to the overlying Brookville coal at the base of the Allegheny. In many places, however, the stratigraphy is varied, and the upper boundary of the formation is difficult to determine.

ALLEGHENY FORMATION

Definition.—The Allegheny formation includes the beds that lie between the base of the Brookville coal or of its under clay and the top of the Upper Freeport coal. These limits of the formation are arbitrary, and in places where the limiting members are absent or poorly defined precise delimitations of the formation, in the absence of paleobotanic evidence, are impossible. The Allegheny lies conformably on the Pottsville.

In western Pennsylvania the Allegheny formation averages about 300 feet in thickness. In the Somerset and Windber quadrangles diamond-drill records supplemented by surface exposures indicate a thickness of the Allegheny between 280 and 300 feet.

Distribution.—The Allegheny formation underlies the greater part of both quadrangles but is absent from the crests of Laurel Hill and Allegheny Mountain and a few other areas, from which it has been removed by erosion. It underlies the Berlin, Wilmore, Somerset, Johnstown, and Ligonier Basins and crops out in extensive areas along their flanks. The position of the outcrop of the Allegheny and of its most valuable coal beds is shown on the geologic maps of the Somerset and Windber quadrangles. It should be understood, however, that because of the variability and noncontinuity of the coal beds (see drill records on back of columnar-section sheet) and because of the general obscurity of the outcrops of the beds where they are not exposed by prospecting, the lines on the map that show the outcrop of the coal beds, aside from those based on actual exposures, represent only approximations.

Character.—The Allegheny formation consists of a variable sequence of beds of sandstone, shale, limestone, clay, and coal, and the great value of the coal gives the region its chief source of mineral wealth. The general composition of the formation and the variability of the beds are shown by the following section and by the diamond-drill records given on the back of the columnar-section sheet. These records in general were supervised by engineers of the coal companies, and although they can not be relied on as accurate characterizations of all stratigraphic details, they show the general composition and sequence of the strata, especially the intervals between the more prominent members and the thickness and position of the coal beds.

Section of part of Allegheny formation in Johnstown Basin, Somerset quadrangle

[Diamond-drill record]

	Ft.	in.
Coal and shale (Upper Freeport (E) bed)	6	
Clay (Upper Freeport) and shale	5	
Limestone (Upper Freeport) and shale	5	
Clay (Bolivar)	7	
Shale	19	

	Ft.	in.
Coal and shale (Lower Freeport (D) bed)	2	11
Clay (Lower Freeport)		8
Limestone (Lower Freeport)		2
Shale	24	6
Sandstone (Freeport)	8	10
Shale	11	8
Coal (Upper Kittanning (C') bed)	3	3
Clay (Upper Kittanning)		4
Limestone (Johnstown)	5	7
Shale and thin-bedded sandstone	44	8
Coal (Middle Kittanning (C) bed)	2	3
Clay (Middle Kittanning)	6	
Shale and thin-bedded sandstone	17	2
Sandstone	13	7
Shale and thin-bedded sandstone	18	7
Coal (Lower Kittanning (B) bed)	2	2
Clay (Lower Kittanning)	2	6
Shale and thin-bedded sandstone	12	
Sandstone (Kittanning)	50	6
Shale and thin sandstone	11	4
Clay	7	7
Shale and sandstone		6
Base of Allegheny not determined.		
	283	4

Sections showing the lower part of the Allegheny formation and the upper part of the Pottsville formation are given below.

The Allegheny formation has been subdivided into a number of members, and the same names have long been used in far separated areas. Detailed work, however, has shown that in many instances members to which the same names have been applied are not identical beds. Nevertheless, in spite of marked lenticularity of the beds, there is a pronounced uniformity in sequence, and some of the beds are known to be persistent throughout large areas, so that if the employment of these names is duly qualified they serve a useful purpose. In this folio the use of the well-known names for subdivisions of the Allegheny formation does not imply continuity with beds at the type localities from which the names were derived but rather only the approximate stratigraphic position of the member in the formation. The following are the principal members and other divisions of the Allegheny formation in the Somerset and Windber quadrangles, beginning at the top:

Upper Freeport (E) coal.
Upper Freeport limestone member.
Bolivar clay.
Lower Freeport (D) coal.
Lower Freeport limestone member.
Freeport sandstone member.
Upper Kittanning (C') coal.
Johnstown limestone member.
Middle Kittanning (C) coal.
Lower Kittanning (B) coal.
Lower Kittanning clay.
Kittanning sandstone member.
Clarion (A')—Brookville (A) coal zone.

Brookville (A) and Clarion (A') coals and associated beds.—Approximately the lower 20 to 50 feet of the Allegheny formation consists of a zone of shale, sandstone, clay, and two or more beds of coal. The lowest coal is the Brookville or A bed, and the highest in this zone is the Clarion or A' bed. In general, neither of these coals in the area considered in this folio is of much economic value, and they are characteristically streaked with a number of shale partings.

Coal prospects on beds in this zone have been opened at a few places in the Somerset and Windber quadrangles. At the Hitechew country bank, 2½ miles southeast of Cairnbrook, a bed that is thought to be the Brookville has been mined for a number of years. Coal at approximately this horizon has been prospected and locally mined at a number of localities, as in the valley of Paint Creek below Scalp Level, in the valley of Shade Creek east of Hillsboro, in the valley of Stony Creek below Shanksville, in the valley of Quemahoning Creek below Boswell, and on Laurel Hill. The Clarion coal is not so persistent nor so well developed in this region as the Brookville. A thin coal bed, however, at approximately the horizon of the Clarion coal is present in a number of places and it almost immediately overlies a thick bed of clay.

Clay at this horizon is reported in the records of most of the drill holes in the Windber and Somerset quadrangles that have gone through the Allegheny formation; the records show the bed to be between 40 and 65 feet below the Lower Kittanning coal. When the area was surveyed this bed of clay was quarried at only one locality—in the southeastern part of the borough of Windber. At this quarry the following section is exposed:

Section of part of Allegheny formation at Windber

	Ft.	in.
Interval below Lower Kittanning coal (estimated)	50	
Shale, gray	10	
Coal (Clarion (A') bed)	1	10
Clay, hard, gray; base not well exposed	9	

A fine specimen of a fossil fern, which was identified by David White as *Alethopteris serlii*, was found embedded in the clay at the base of this section.

The stratigraphic position of this bed of clay and its relation to the bed of clay in the Mercer member of the Pottsville formation is shown by the following partial record of a diamond-drill hole southwest of Windber. (See also records on back of columnar-section sheet.) Results of tests of this clay are given on page 13.

Section of lower part of Allegheny formation and upper part of Pottsville formation

	Ft.	in.
Allegheny formation:		
Coal (Lower Kittanning (B) bed).		
Shale and clay	5	5
Shale	10	5
Coal	1	11
Clay	2	
Shale, sandy	5	1
Sandstone (Kittanning)	13	
Shale	14	3
Coal and shale (Clarion (A') bed)	2	6
Clay (Clarion)	4	11
Shale	9	
Coal	1	1
Shale	22	
Coal and shale (Brookville (A) bed)	12	2
Pottsville formation:		
Sandstone (Homewood)	30	
Coal (Mercer)	1	2
Clay	3	11
Shale	4	9
Sandstone (Connoquenessing)	24+	

A bed of sandstone corresponding in position to the Clarion sandstone member, between the Clarion and Brookville coals, locally is well developed. In places, in the eastern part of the Windber quadrangle for instance, the Clarion coal is absent and the Clarion sandstone merges with the overlying Kittanning sandstone.

Kittanning sandstone member.—The Kittanning sandstone, which lies between the Lower Kittanning coal and the Clarion-Brookville coal zone, is uncommonly well developed in this region. It crops out conspicuously in Stony Creek and in a number of its branches, along the lower flanks of Allegheny Mountain and on Laurel Hill, and it is quarried at Boswell and Rowena. Diamond-drill records (see back of columnar-section sheet) show that the Kittanning sandstone ranges in thickness from 10 to 80 feet. In sections where it merges with the Clarion sandstone the greater part of the Allegheny formation below the Lower Kittanning coal is sandy.

The Kittanning sandstone, as here developed, is a massive whitish to gray, commonly medium to fine grained, prevailingly quartzose sandstone. In places, however, it is conglomeratic and bears rounded pebbles of white quartz that range from one-eighth to one-fourth of an inch in diameter. Although the sandstone is prevailingly quartzose it contains appreciable amounts of decomposed feldspar, which at the Rowena quarry is removed from the crushed rock by washing.

Lower Kittanning clay.—The Lower Kittanning coal is commonly underlain by a valuable bed of soft clay, which, although it is mined in a number of places elsewhere, had not been mined in these quadrangles when they were surveyed. This clay is reported in most of the drill holes and ranges in thickness from 2 to 5 feet.

Lower Kittanning (B) coal.—The Lower Kittanning coal, also known in this region as the Miller or B bed, is one of the most persistent and valuable coal beds in this region. It is extensively mined in the Windber quadrangle, where it is unusually well developed, but in the Somerset quadrangle it is mined at only a few places and is not so valuable as some of the higher Allegheny coals. The Lower Kittanning coal lies 75 to 115 feet below the Johnstown limestone. It can be identified by its stratigraphic position and its underlying soft clay, and it also has characteristic physical properties. It has a brilliant luster, is one of the softest coals of the area, and readily breaks down into small prismatic fragments. Details of this coal bed are given in figure 8, and analyses of the coal on page 14; its outcrop is shown on the economic-geology maps.

Middle Kittanning (C) coal.—A coal bed of little value, the Middle Kittanning, rarely more than a foot in thickness and generally only a few inches, is present in most places about midway between the Upper and Lower Kittanning coals. This bed is locally known as the "Dirty C." In places two thin beds of coal are present in the Middle Kittanning zone.

Johnstown limestone member.—One of the most useful key beds, in determining structure in the Somerset and Windber quadrangles, is the Johnstown limestone. This bed is persistent over wide areas in both quadrangles.

The Johnstown limestone member occurs about one-third down from the top of the Allegheny formation. Drill records show that it ranges from 90 to 120 feet below the Upper Freeport coal; a common distance is about 100 feet. The Johnstown limestone ranges in thickness from 5 to 10 feet, and throughout considerable areas it is 8 to 9 feet thick. It is a fine-grained blue-gray magnesian limestone. An analysis of a sample from the Adams coal mine, near Wells Creek, is given on page 13. This limestone is burned for lime at a number of localities. Its outcrop is practically coincident with that of the Upper Kittanning coal, which is shown on the economic-geology maps.

Upper Kittanning (C') coal.—The Johnstown limestone is almost immediately overlain by a bed of coal known as the Upper Kittanning, from which it is usually separated by only a few inches of shale. Clay is not characteristically present below this coal bed. The Upper Kittanning is one of the most valuable coal beds in this region and is extensively mined, particularly in the Johnstown and Somerset Basins. In contrast with the Lower Kittanning and Lower Freeport coals the Upper Kittanning is a relatively hard coal, which can be mined and shipped in blocks. Details of this coal bed are given in figure 9, and its outcrop is shown on the economic-geology maps.

The bed of coal that almost immediately overlies the Johnstown limestone and occurs approximately one-third down from the top of the Allegheny formation, following local usage, is in this folio tentatively referred to the Upper Kittanning. Between it and the Upper Freeport coal two beds of limestone are locally present, which presumably correspond, respectively, to the Lower and Upper Freeport limestones. The Johnstown limestone seems to be a lens that does not extend as far west as the Allegheny Valley, but it remains to be determined whether or not the coal bed here referred to the Upper Kittanning is equivalent to the Upper Kittanning coal in the type section.

Freeport sandstone member.—A variable bed of sandstone occurs above the Upper Kittanning coal. In places, particularly in the Somerset Basin, this sandstone immediately overlies the coal and on account of its hardness locally causes trouble where it has to be cut through in mining. As recorded in drill holes this sandstone ranges from a feather edge to 35 feet in thickness. It is poorly developed in the southern part of the Johnstown Basin and in the Berlin Basin.

Lower Freeport limestone member.—The Lower Freeport limestone occurs about midway between the Johnstown limestone and the Upper Freeport coal. It is of variable occurrence and in these quadrangles as a rule is poorly developed. In many places it is absent, and where present it is generally only a few inches thick.

Lower Freeport (D) coal.—Like the Lower Freeport limestone, which it almost immediately overlies, the Lower Freeport coal is of variable thickness in this region. In the Somerset quadrangle it seems to be of little worth, but it increases in thickness in the Windber quadrangle, where it is locally mined. It occurs from 35 to 60 feet above the Johnstown limestone. In contrast with the overlying Upper Freeport coal and the underlying Upper Kittanning coal the Lower Freeport is softer and in physical properties somewhat resembles the Lower Kittanning bed. Measurements of this coal are given in figure 10.

Bolivar clay.—A valuable bed of hard clay that has long been mined at Bolivar, Westmoreland County, Pa., is of local occurrence between the Upper and Lower Freeport coals. This bed has been found at several localities in the Somerset quadrangle, although it has not yet been worked there, but apparently it is poorly developed in the Windber quadrangle. Drill holes in the northern part of the Johnstown Basin show 4 or 5 feet of clay at the Bolivar horizon, from 10 to 15 feet beneath the Upper Freeport coal.

Upper Freeport limestone member.—The Upper Freeport limestone, which lies between the Bolivar clay and the Upper Freeport coal, in general is poorly represented in this region. At several localities on the divide between Stony and Shade Creeks, in the vicinity of Forward, openings have been made on a bed of limestone below a bed of coal that is probably the Upper Freeport.

Upper Freeport coal.—The Upper Freeport coal is one of the most persistent and valuable coal beds in western Pennsylvania. In these quadrangles coal at the Upper Freeport horizon is usually present but its thickness is variable, and in places the bed is of little value. Its best development is in the Ligonier, Johnstown, and Somerset Basins, where it is mined, but it is comparatively thin or in places absent in the Wilmore and Berlin Basins.

Fossil plants.—The following fossil plants from the Allegheny formation were identified by David White:

From hillside 1 mile northeast of Laughlintown, about 50 feet below Upper Freeport coal:
- Pecopteris, probably P. pennaeformis and P. oreopteridia.
- Calamarian stem, probably Calamites ramosus.
- Neuropteris ovata.
- Annularia stellata.
- Annularia sphenophylloides.

From roof of Upper Kittanning (C') coal, Reading mine No. 3, Stoystown:
- Pecopteris miltoni.
- Neuropteris ovata.
- Neuropteris scheuchzeri.
- Neuropteris capitata.
- Callipteridium mansfieldi.
- Lepidodendron dichotomum?
- Stigmaria verrucosa.

From Clarion clay 60 feet below Lower Kittanning coal, 1 mile southeast of Windber:
- Alethopteris serlii.

CONEMAUGH FORMATION

Definition.—The Conemaugh formation includes the beds that lie between the Upper Freeport coal, at the top of the underlying Allegheny formation, and the Pittsburgh coal, at the base of the overlying Monongahela formation. It lies conformably on the Allegheny.

Distribution and thickness.—The Conemaugh formation occupies considerable portions of the Somerset and Windber quadrangles and forms the surface of the central parts of the Berlin, Wilmore, Somerset, Johnstown, and Ligonier Basins. Almost everywhere in these basins erosion has removed the upper members of the formation, and its entire thickness is present only in a small area in the Johnstown Basin northwest of Boswell. Records of diamond-drill holes show that this outlying remnant of the Conemaugh formation has a thickness of 850 to 870 feet. The formation thins to the west and near the Pennsylvania-Ohio State line is approximately 500 feet thick. In Ohio it decreases to about 350 feet.

Character.—The Conemaugh formation consists of a variable sequence of sandstone, shale, clay, and thin beds of limestone and coal. It is characterized by the occurrence of red beds, the first above the Mauch Chunk shale, and by the presence in its lower half of several calcareous beds that contain marine fossils. The general composition of the formation is indicated by the following section of rocks measured in two diamond-drill holes in the Johnstown Basin in the Somerset quadrangle.

Section of Conemaugh formation in the Johnstown Basin northwest of Boswell, as shown by two diamond-drill records

Record No. 1

	Ft.	in.
Pittsburgh coal (base of Monongahela formation).		
Interval	21	
Shale, light	16	
Shale, dark	4	
Coal (Upper Little Pittsburgh)	1	6
Shale, dark	1	6
Coal, bony		10
Limestone (Upper Pittsburgh)	5	2
Lime shale	20	
Shale, bony		9
Shale, mixed, lime	19	
Clay shale	10	2
Coal, bony		4
Shale, light	15	
Coal (Franklin?)	1	
Clay	2	10
Shale, sandy	12	
Shale, light	23	
Sandstone	11	
Shale, dark, sandy	13	
"Limestone"	6	
Shale, light, sandy	17	
Shale, dark	1	
Coal (Little Clarksburg?)	1	6
"Limestone" (Clarksburg?)	5	6
Shale and lime	13	
Shale, gray	10	
"Limestone"	7	
Clay and shale	8	
Shale, red variegated	4	
Shale, sandy (horizon of Morgantown sandstone)	36	
Clay	4	
Shale, dark, sandy (horizon of Morgantown sandstone)	24	
Shale	2	
Coal (Wellersburg?)		3
Shale, black	2	
Shale, dark, sandy	17	
Clay	5	9
Shale, light	14	
Shale, sandy	8	
Shale, dark	26	
Shale	5	
Coal (Barton?)	1	
Clay	9	
Shale, sandy	24	
Shale, black	30	
Shale, black, fossiliferous (horizon of Ames limestone)	15	6
Coal (Harlem)	1	6
	476	

Record No. 2

	Ft.	in.
Shale, black fossiliferous (horizon of Ames limestone).		
Coal (Harlem).		
Clay and shale	6	
Shale, light, and lime spots (Ewing? limestone)	25	
Shale, light, sandy	10	6
"Pittsburgh Reds":		
Shale, red and light	3	8
"Limestone"	3	4
Shale, light	6	
Shale, variegated	4	6
Shale, light	7	
Shale, red and light	1	
Clay	4	
Shale, red and light	3	
Clay	4	
Shale, light, sandy	31	
Clay and shale	8	
Clay and black shale	4	8
Shale, black, fossiliferous (horizon of Cambridge? limestone)	17	4
Coal (Lower Bakerstown? or Thomas?)		7
Clay	5	5
Clay and shale	6	
Shale, light	17	2
Shale, red and light	6	5
Clay and shale	3	11
Clay	3	8
Clay, red	4	
Shale, light, sandy	27	10
Clay and shale	14	6
Shale, black	18	
Coal		2
Clay and shale	18	4
Shale, black and fossiliferous (horizon of Brush Creek limestone)	22	
Coal, bony		10
Coal (Brush Creek)	1	2
Clay and shale	8	3
Shale, variegated	7	
Clay	5	
Shale, gray, sandy	17	9
Shale, variegated	5	2
Shale, light, with lime	4	10
Shale, light	8	
Sandrock and shale (Mahoning)	31	6
Shale, black		6
Upper Freeport coal (top of Allegheny formation).		
	377	

Total thickness of Conemaugh formation shown in Records Nos. 1 and 2

	Feet
Record No. 1	476
Record No. 2	377
	853

The Conemaugh, like the Allegheny formation, has been subdivided into a number of members, the names of which have long been in use. However, the identity of members of the Conemaugh formation that have been given the same names in far separated areas can not be established in all localities, and as used in this folio the names for subdivisions of this formation imply only approximate stratigraphic position. The beds of fossiliferous limestone and shale afford the most valuable key horizons in correlation. The following are some of the members and minor divisions of the Conemaugh formation in the Somerset and Windber quadrangles:

Upper Pittsburgh limestone member.
Connellsville sandstone member.
Clarksburg limestone member.
Morgantown sandstone member.
Ames limestone member.
Harlem coal.
Ewing (?) limestone member.
"Pittsburgh Reds" and other horizons of red shale.
Saltsburg sandstone member.
Bakerstown coal.
Cambridge (?) limestone member.
Buffalo sandstone member.
Brush Creek limestone member.
Brush Creek coal.
Mahoning sandstone member.

Mahoning sandstone member.—The lower 100 feet of the Conemaugh formation is characteristically sandy. In some places the Upper Freeport coal is immediately overlain by sandstone, which locally attains a thickness of 60 feet; in other places the base of the Conemaugh formation is composed of sandy and clay shale. No widespread division of the Mahoning into upper and lower sandstones separated by shale, as is characteristic of some areas, has been recognized here, yet a few sections contain a bed of coal several inches thick, the so-called Mahoning coal, between 40 and 60 feet above the base of the Conemaugh formation. A thin band of red shale, rarely more than 5 feet thick, which is exposed in a number of localities and is reported in several drill records between 45 and 75 feet above the Upper Freeport coal, is of widespread occurrence. The upper part of the Mahoning is commonly composed of sandy and clay shale.

As developed in this area the Mahoning sandstone is prevailingly fine grained and is composed of rounded or irregular grains of quartz, subordinate kaolin and sericite and small flakes of muscovite. The cement is calcareous. The color is usually gray or buff, but in places the sandstone is considerably stained with iron. It is commonly thin bedded, though in places the layers are as much as 3 feet thick.

Some of the best exposures of the Mahoning sandstone occur in the Johnstown Basin along the route of the projected but not completed South Pennsylvania Railroad south of the place where the Pittsburgh, Westmoreland & Somerset Railroad leaves the old grade about 3 miles west of Edie, where there are ledges as much as 15 feet thick, and near by, in the old grade, the Upper Freeport coal is exposed immediately beneath the sandstone. The Mahoning sandstone also is well exposed in the Somerset Basin, on the hillside above the Stauffer No. 1 mine (47), northeast of Listie; in the Berlin Basin, along the road above the George Grove country bank, half a mile south of Reels Corners; and in the Ligonier Basin, above the old Dr. Burnett country bank 2 miles southeast of Ligonier, and above the Müller country bank 2 miles northeast of Laughlintown. On the other hand, sandstone in the Mahoning member of the Conemaugh formation is poorly developed in the southern part of the Windber quadrangle and also locally south of the town of Somerset. The Upper Freeport coal is well exposed along the road where it crosses the southern border of the Somerset quadrangle, 800 feet west of the Baltimore & Ohio Railroad, but there the overlying Mahoning is represented by sandy shale.

Brush Creek coal.—A bed of coal that corresponds to the Brush Creek bed is shown in most of the records of diamond-drill holes between 90 and 120 feet above the Upper Freeport coal. It has been found in all the basins and is particularly well developed in the Johnstown Basin. The thickness of the coal differs from place to place, but in most places it is less than 2 feet, and the bed has been but little prospected. In the valley of Laurel Hill Creek, in the southwestern part of the Somerset quadrangle, a bed of coal that may be equivalent to the Brush Creek coal has been mined at a few country banks.

Brush Creek limestone member.—Black shale that lies almost immediately above the coal referred to the Brush Creek bed crops out in a number of places in both quadrangles. A few records of diamond-drill holes in the Johnstown Basin show the presence of fossils at this horizon.

Buffalo sandstone member.—Above the Brush Creek horizon lies a zone of arenaceous rocks that corresponds to the Buffalo sandstone, the base of which is approximately 150 feet above the Upper Freeport coal. In places at this horizon a bed of sandstone from 10 to 40 feet in thickness is present, whereas in other places only shale occurs. The Buffalo sandstone forms the cliff along the Somerset road three-quarters of a mile south of Sipesville; it occurs also in the ridge east of Laurel Hill Creek in the southwest corner of the Somerset quadrangle, in the hillside north of the South Fork of Bens Creek, and in the hillside a quarter of a mile southwest of the old Burnett coal mine, 2 miles southeast of Ligonier, where the stone is quarried. The Buffalo sandstone as here developed is fine grained, gray to buff, and composed of quartz and decomposed feldspars.

Cambridge (?) limestone member.—A bed of fossiliferous calcareous black shale, which commonly contains nodules and thin bands of limestone, occurs about 250 feet above the Upper Freeport coal. This fossiliferous shale lies in the approximate stratigraphic position of the Cambridge limestone, but in the absence of careful tracing of beds across western Pennsylvania and eastern Ohio and checking of both paleontologic and stratigraphic evidence, precise correlation of closely related fossiliferous beds in the Conemaugh formation can not be made.

Fossils, identified by G. H. Girty, were collected from this black shale at the following locality:

From shaly limestone in a ravine $1\frac{1}{2}$ miles northeast of Laughlintown and $2\frac{1}{4}$ miles southeast of Ligonier:
Lophophyllum profundum.
Lingula carbonaria.
Phanerotrema grayvillense?

Bakerstown coal.—One or more thin beds of coal are shown in diamond-drill records, mostly in the Johnstown Basin but also in the Somerset and Berlin Basins, between 230 and 260 feet above the Upper Freeport coal between the Buffalo and Saltsburg sandstones in the zone in which the Bakerstown coal occurs. These coals are thin and lenticular and it is questionable whether any one of them is continuous with the Bakerstown coal at the type locality in Allegheny County. Coal in this zone has been prospected near the top of the hill at the eastern border of the Somerset quadrangle immediately south of Beaverdam Creek. The so-called "Lower Bakerstown (?)" or "Thomas (?)" bed, represented by a few inches of coal in drill records, occurs beneath the Cambridge (?) limestone.

Saltsburg sandstone member.—The Saltsburg sandstone is only locally well developed, and in most places in the area under consideration the rock at its horizon is shale. The chief occurrences of the sandstone are in the southwestern and northeastern parts of the Somerset quadrangle. Near the southwestern corner of the quadrangle blocks of buff quartz-feldspar sandstone, which litter the surface of the ridge east of Laurel Hill Creek, are in the approximate position of the Saltsburg, and in the highland area north of the South Fork of Bens Creek, in the northeastern part of the quadrangle, massive brownish arkosic sandstone forms ledges along the middle slopes between 300 and 350 feet above the Upper Freeport coal.

"Pittsburgh Reds" and other zones of red shale.—The Conemaugh formation contains several zones of red shale. One zone has been mentioned in the description of the Mahoning sandstone member as occurring between 45 and 75 feet above the Upper Freeport coal.

Another persistent zone of red shale occurs between the Brush Creek and Cambridge (?) limestones, 160 to 180 feet above the Upper Freeport coal. Several diamond-drill records show the presence of red shale in this zone between 3 and 20 feet thick. Red shale at this horizon crops out in a number of places and is conspicuous along the road 3 miles southwest of Jennertown and at several places along the road between 2 and $2\frac{1}{2}$ miles south and southwest of Ralphton.

The zone of red beds known as the "Pittsburgh Reds" occurs between the Cambridge (?) and Ames limestones. In the drill holes that have been put down through these rocks they were encountered between 325 and 375 feet above the Upper Freeport coal. A conspicuous outcrop of the "Pittsburgh Reds" occurs in the cut on the Pittsburgh, Westmoreland & Somerset Railroad half a mile northwest of Allenvale, where at least 15 feet of sandy red shale is exposed. Other conspicuous outcrops of red shale in this zone occur along the Forbes road $2\frac{3}{4}$ miles east of Ligonier and at a number of places in that vicinity. The highest horizon of red beds observed in this area is about 250 feet below that of the Pittsburgh coal, where 4 or 5 feet of red shale has been seen in a few outcrops and in drill cores.

Ewing (?) limestone member.—A bed of limestone crops out in the vicinity of Lavansville, in the Johnstown Basin, and formerly was quarried for use in making lime on almost every farm where it occurs. It is a massive fine-grained blue-gray limestone, a partial analysis of a sample of which is given on page 13. It ranges from 4 feet to 6 feet 6 inches in thickness and is commonly 5 feet. It is overlain by a bed of coal averaging 12 inches in thickness, which may be the Harlem coal, and locally is underlain by red shale. In places 2 or 3 feet of drab shale intervenes between the coal and the limestone.

Minute coiled shells, identified by G. H. Girty as *Spirorbis anthracosia?*, are the only fossils found in this limestone. Very little drilling has been done in the area of outcrop, and the precise stratigraphic position of this bed has not been determined. It is tentatively correlated with the Ewing limestone.

Ames limestone member.—One of the most persistent members of the Conemaugh is the Ames or "Crinoidal" limestone, which occurs about midway in the formation. In the area here considered it is represented by a fossiliferous calcareous dark-gray or greenish to black shale, carrying thin limestone layers and concretions, which occurs between 380 and 400 feet above the Upper Freeport coal.

The Ames limestone has been removed by erosion from a large part of the Berlin and Somerset Basins in these quadrangles. In the Johnstown Basin the Ames outcrop was found at a few localities southeast of Laurel Hill, and records of diamond-drill holes in the northern part of the basin show the presence of a fossiliferous black shale, which presumably is the representative of the Ames limestone and which lies immediately above a thin bed of coal (the Harlem?). The Ames limestone is well exposed in the cut of the Pittsburgh, Westmoreland & Somerset Railroad half a mile northwest of Allenvale, where the following section was measured:

Section in railroad cut half a mile northwest of Allenvale

	Feet
Sandstone, arkosic, thin to medium-bedded	10+
Shale, buff to dark, sandy	15
Shale, dark gray to black, calcareous, with limestone layers and concretions, highly fossiliferous (horizon of Ames limestone)	5
Coal (Harlem)	1
Shale, drab and black, clay	15
Shale, red and green ("Pittsburgh Reds").	

The fossils listed below, identified by G. H. Girty, were obtained from the calcareous shale at this place:

Derbya crassa?	Deltopecten occidentalis?
Chonetes aff. C. flemingi.	Acanthopecten carboniferus.
Productus pertenuis.	Parallelodon tenuistriatus.
Ambocoelia planiconvexa (very abundant).	Patellostium montfortianum.
Edmondia sp.	Euphemus carbonarius.
Nucula parva.	Phanerotrema grayvillense.
Leda meekana.	Orestes nodosus?
Allorisma geinitzi.	Schizostoma catilloides.
	Pseudorthoceras knoxense.

In Ligonier Basin the Ames limestone is locally conspicuous, and its outcrop is shown on the map. Outcrops were observed along the road 2½ miles east of Ligonier, both east and west of a small ravine half a mile west of Lebanon Church at altitudes of 1,550 and 1,600 feet respectively; along the Pittsburgh and Philadelphia road 1 mile southeast of Ligonier, at an altitude of 1,260 feet; and 2 miles south of Ligonier, on the northeast side of a high hill at an altitude of 1,400 feet. At all these outcrops the Ames is characterized by a greenish shaly fossiliferous limestone 1 to 3 feet thick.

Morgantown sandstone member.—The Morgantown sandstone is well exposed in the Ligonier Basin and crops out conspicuously in the vicinity of the town of Ligonier. Ledges of this sandstone are prominent at the base of the hill on the south side of Loyalhanna Creek opposite Ligonier, where a quarry has been opened. This sandstone is prominently developed in the hills on both sides of the Pittsburgh and Philadelphia road south and east of Ligonier, where it can be followed as a zone of sandstone and sandy shale across the northwest corner of the Somerset quadrangle.

In this area the Morgantown sandstone occupies a zone of about 60 feet, the base of which lies approximately 300 feet below the Pittsburgh coal. In this interval several lenses of massive sandstone are separated by sandy shale. Massive sandstone 50 feet thick in places passes along the strike into thin beds of sandstone and shale. In other places there is no massive bed of sandstone, but the entire Morgantown interval is represented by thin beds of sandstone and shale. In the vicinity of Ligonier the Morgantown is a fine-grained gray to greenish-gray sandstone composed of quartz and decomposed feldspar and subordinate muscovite.

Clarksburg limestone member.—Limestone in the approximate position of the Clarksburg crops out locally in the Johnstown and Ligonier Basins and has been encountered in diamond-drill holes. Records of drill holes northwest of Boswell show beds of limestone 200 and 300 feet above the Ames limestone.

In the Johnstown Basin just north of the Pittsburgh and Philadelphia road, near Jennertown, in a quarry on a bed of limestone, the following section was measured:

Section at quarry half a mile west of Jennertown

	Ft.	in.
Shale, buff, sandy	12	
Calcareous shale	1	2
Limestone conglomerate	1	
Limestone, massive, fine grained, blue-gray	4	

A bed of limestone crops out along the road at the forks half a mile north of Glessner, in the northeastern part of the Somerset quadrangle, where a small quarry was once opened. The rock is a fine-grained blue-gray limestone, of which not more than 4 feet is exposed. It contains the coiled shell *Spirorbis.* A diamond-drill hole in the vicinity of this limestone shows that it is 640 feet above the Upper Freeport coal. A bed of limestone at approximately the same horizon has been opened in three places on the plateau north of the South Fork of Bens Creek, in the northeast corner of the quadrangle.

In the Ligonier Basin two quarries have been opened on a bed of limestone referred to the Clarksburg—one on the J. A. Miller farm, 1¾ miles northeast of Ligonier, 1 mile south of the north border of the quadrangle, at an altitude of about 1,570 feet, and another on the Singer farm, at the north border of the quadrangle, 2 miles northeast of Ligonier, at an altitude of 1,450 feet. The bed consists of a fine-grained blue-gray limestone about 4 feet thick.

Connellsville sandstone member.—The Connellsville sandstone is poorly developed in this region and forms few conspicuous outcrops. Its most notable occurrence is near the center of the Johnstown syncline, on the plateau north of the South Fork of Bens Creek, in the northeast corner of the Somerset quadrangle. There the Connellsville is represented by a zone of buff sandstone less than 20 feet thick. In the Ligonier Basin the Connellsville is less conspicuous, and the beds at its horizon consist of sandy shale.

Upper Pittsburgh limestone member.—A bed of limestone in the approximate position of the Upper Pittsburgh occurs in the Ligonier and Johnstown Basins, between 40 and 50 feet below the Pittsburgh coal.

In the Johnstown Basin the Upper Pittsburgh limestone has been quarried at several places a few miles northwest of Boswell, as shown on the map, and above it occur the outlying remnants of the Monongahela formation.

The Upper Pittsburgh limestone is a massive fine-grained blue-gray rock about 5 feet thick.

In the Ligonier Basin within the limits of the Somerset quadrangle this limestone is known to crop out in only one locality. It caps the hill half a mile southwest of Ligonier at the border of the quadrangle, where it is quarried by H. M. Karns.

In a few places, as at the Karns quarry, this limestone is overlain by a bed of coal, in most places only a few inches thick. The greatest thickness recorded is 1 foot 6 inches in a drill hole northwest of Boswell. It is the bed known as the Upper Little Pittsburgh coal. The interval between this bed and the top of the Conemaugh, about 40 feet, is occupied by shale.

MONONGAHELA FORMATION

Definition.—The Monongahela formation extends from the base of the Pittsburgh coal to the top of the Waynesburg coal. The formation is named from Monongahela River, along which these rocks are well developed.

Distribution and thickness.—The Monongahela formation is represented by small outlying areas in the center of the Johnstown syncline northwest of Boswell, in the Somerset quadrangle. The presence of the Monongahela in these areas is shown by the records of diamond-drill holes, two of which were started a few feet below the Pittsburgh coal and continued down to the Johnstown limestone, in the Allegheny formation. The Monongahela formation also occurs in Ligonier Valley in several disconnected areas that lie outside the Somerset quadrangle, and the Pittsburgh coal crops out on a hill three-quarters of a mile west of Ligonier. Other outlying areas of this formation occur in the Berlin Basin south of the area mapped in this folio.

The Monongahela formation ranges from less than 200 to somewhat more than 400 feet in thickness. In Fayette and Westmoreland Counties I. C. White reports a thickness of 367 feet, but in the Somerset quadrangle erosion has carried away all but the lower 80 feet or less of the formation.

Pittsburgh coal.—The Pittsburgh coal, which lies at the base of the Monongahela formation, is the most persistent and valuable coal bed in western Pennsylvania, where it underlies an area of more than 2,000 square miles, and averages possibly 7 feet in thickness.

In the Somerset quadrangle the small outlying area of Pittsburgh coal in Jenner Township is in large part exhausted. The coal has been mined there for many years at country banks in which the complete section of the bed is not exposed. The following measurements were made at the mines indicated:

Sections of Pittsburgh coal at mines in Jenner Township

	Ft.	in.
J. G. Berkey mine:		
Coal	4	10
Reuben Horner mine:		
Sandstone.		
Coal	1	6
Shale		1
Coal	2	2
Sandstone	2	
Coal	2	
Fred Trexel mine:		
Clay shale	8	
Coal	6	
Base not exposed.		

Overlying beds.—The poor exposures do not reveal the detailed composition of the beds that overlie the Pittsburgh coal in this region. Local sections show sandy shale and clay shale and thin beds of sandstone up to about 50 feet above the coal in the northernmost of the areas of the Monongahela formation. In the southern area the Pittsburgh coal is overlain by another bed of coal which may possibly correspond to the Redstone bed. The interval, however, is somewhat short, and more probably it is the equivalent of the Pittsburgh Rider. Here the two coals are separated by about 35 feet of shale. The upper bed of coal underlies only a few acres near the top of a hill, under scarcely any cover, so that it is of no commercial value.

STRUCTURE

The rocks of the Somerset and Windber quadrangles, in accordance with their situation near the margin of the Appalachian Plateaus, on the eastern flanks of the Pittsburgh-Huntington Basin, are folded into a series of pronounced anticlines and synclines. The relation of the structure in these quadrangles to the geologic structure in southwestern Pennsylvania is shown in figure 5. The illustration emphasizes the northeastward trend; the general decrease in the steepness of the folding from east to west; the persistence for many miles of the main axes of folding; the development of secondary folds; the local curvature of the axes; and the occurrence of knobs and depressions along the axes.

The structure is indicated on the maps by means of contour lines—that is, lines that connect points at which the bed selected for a reference stratum lies at equal altitude with respect to sea level. The contour lines show the strike and dip of the beds, the positions of anticlinal and synclinal axes, and some details of folding.

In the Somerset quadrangle the contours are based on the top of the Johnstown limestone and in the Windber quadrangle on the bottom of the Lower Kittanning coal. In the synclinal areas, about the margins of which these reference strata crop out and beneath which they have been encountered in mining operations and in drilling,[2] the data are much more complete than on Allegheny Mountain and Laurel Hill, from which the reference strata have been eroded and where the chief dependence in drawing contours has been placed on outcrops of the Loyalhanna limestone and the Mauch Chunk shale. In the Ligonier syncline, where little is known of the Johnstown limestone, and where no records of diamond-drill holes are available the structure contours are less reliable than those in the other basins, where there are more data. In the Ligonier Valley the outcrops of the Lower Kittanning and Upper Freeport coals and the Ames limestone are the main key beds.

The two chief arches of the quadrangles are the Savage Mountain and Laurel Hill anticlines, which are regional folds that persist for a number of miles beyond the limits of the area. The Johnstown and Ligonier synclines, which lie respectively east and west of the Laurel Hill anticline, are strongly developed basins, but the folds that lie between the Johnstown syncline and the Savage Mountain anticline—the Boswell dome, Somerset syncline, Wilmore syncline, Negro Mountain anticline, and Berlin syncline—here are relatively less strong, and they all terminate either at their northern or southern ends within the small area embraced by these quadrangles—in fact, the Boswell dome and Somerset syncline are entirely confined to this area.

Savage Mountain anticline.—The most pronounced fold that affects the rocks in the quadrangles is an anticline, the western limb of which forms the Allegheny Front in the Windber quadrangle and for some distance beyond. Detailed geologic work has not been done in a large area occupied by this fold, which is named the Savage Mountain anticline by the Second Geological Survey of Pennsylvania.

Because of the steep dips structure contours have not been drawn east of Allegheny Mountain. Near the southeast corner of the Windber quadrangle Chemung sandstone dips 20°–25° NW. The dip decreases northwestward and on Allegheny Mountain is between 5° and 10°. The Lower Kittanning coal crops out on the flanks of the mountains at an altitude of 2,700 feet and descends to an altitude below 1,700 feet at the base of the arch.

Berlin syncline.—The Berlin syncline is named from the town of Berlin, 7 miles southwest of Shanksville. Near the southern border of Pennsylvania this fold is also known as the Salisbury syncline, and in the Accident-Grantsville folio a fold that presumably is the same one is called the Castleman syncline.[3] The Berlin syncline lies between the Savage Mountain and Negro Mountain anticlines and is a typical canoe-shaped basin, in which the rocks rise along the axis in both directions from the center of the trough, which is a few miles north of the Pennsylvania-Maryland State boundary.

In the Windber quadrangle the north end of the Berlin syncline terminates on the western limb of the Savage Mountain anticline in the vicinity of Dark Shade Creek, near Reitz.

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[2] The Geological Survey is under obligations, for permission to use mine maps and drill records, to the coal-mining companies that operate in the two quadrangles, especially to the Consolidation Coal Co.; Berwind-White Coal Mining Co.; Reading Iron Co., Somerset Coal Department; Loyal Hanna Coal & Coke Co.; Hillman Coal & Coke Co.; Quemahoning Coal Co.; Reitz Coal Co.; Stauffer-Quemahoning Coal Co.; Knickerbocker Coal Co. S. E. Dickey & Co. and C. Collins, mining engineers, and F. W. Cunningham, State coal-mine inspector, also extended many courtesies.

[3] U. S. Geol. Survey Geol. Atlas, Accident-Grantsville folio (No. 160), p. 9, 1908.

From Reitz the axis of the syncline extends southwestward through Cairnbrook, west of Central City, and east of Buckstown and crosses the southern border of the quadrangle 1¼ miles southeast of Shanksville. Along the plunging axis the Lower Kittanning coal descends from an altitude of 2,250 feet to less than 1,700 feet above sea level within a distance of about 10 miles, and along both limbs of the syncline the rise of the rocks is greater. The steepest dips are along the southeastern limb, near the south margin of the quadrangle, where the reference coal bed rises from an altitude of 1,200 feet along the axis of the fold to 2,300 feet at the outcrop, 1½ miles distant. On the northwest limb the same rise occurs in 2½ miles.

Negro Mountain anticline.—The Negro Mountain anticline is named from Negro Mountain, a prominent topographic feature near the Pennsylvania-Maryland line. This anticline is well developed along Castleman River between Rockwood and Garrett, where the Mauch Chunk shale is brought to the surface. Northward, however, the fold decreases in intensity and disappears in the Windber quadrangle in the vicinity of Shade Creek between Reitz and Hillsboro. In this area the fold is not conspicuous topographically, although it roughly corresponds to a highland zone that marks the northern extension of Negro Mountain. The axis enters the Windber quadrangle near its southwest corner and extends northeastward approximately parallel to the trend of the adjacent folds.

syncline at the north in the vicinity of Hollsopple and at the southwest near Lavansville. This fold formerly was thought to be continuous with the Wilmore syncline, but the two are clearly separated, as shown on the structure map.

The Somerset syncline is a curved fold that trends northeast in its southern part and almost due north in its northern part. It is about 17 miles long and between 7 and 8 miles wide. On the eastern limb of the syncline the dips are fairly regular and carry the Johnstown limestone from an altitude of almost 2,400 feet down to an altitude between 1,600 and 1,700 feet. On the western limb, owing to the shape of the adjacent Boswell dome, the rise of the strata is irregular and the maximum altitude attained by the Johnstown limestone is about 2,100 feet. The Somerset syncline at its southwestern extremity merges into the Johnstown syncline by the fading away of the southward-pitching south end of the Boswell dome. So, too, it merges at its north end into the Johnstown syncline in an embayment of that syncline around the north end of the northward-pitching Boswell dome.

Boswell dome.—The Boswell dome is named from the town of Boswell, in the Somerset quadrangle. This dome was formerly thought to be continuous with the Viaduct anticline, now called the Ebensburg anticline. That fold, however, terminates at the south edge of the Johnstown quadrangle and is distinctly separated from the Boswell dome.

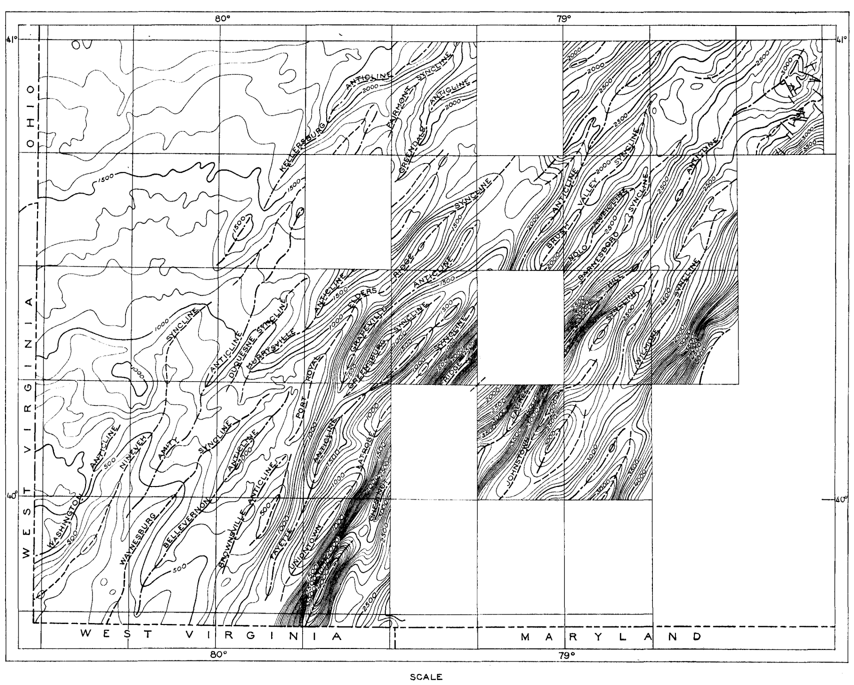


FIGURE 5.—Map of part of southwestern Pennsylvania showing the structure by contours drawn on the Pittsburgh coal. Contour interval 100 feet; datum, sea level.

The Negro Mountain anticline throughout the greater part of its extent in this area is a flat-topped regular fold between 7 and 8 miles wide from base to base. The horizon of the Lower Kittanning coal lies at an altitude slightly more than 2,300 feet above sea level along the crest and descends to less than 1,700 feet in the Berlin Basin on the east and to less than 1,500 feet in the Somerset Basin on the west. At the northern extremity of the anticline, where this fold merges with the western limb of the Savage Mountain anticline, the dips are somewhat undulating.

Wilmore syncline.—The Wilmore syncline is named from the town of Wilmore, on the Pennsylvania Railroad west of Portage. It is a canoe-shaped basin about 32 miles long, which terminates at the north in the Patton quadrangle and at the south in the Windber quadrangle in the vicinity of the town of Windber. The deepest part of the trough, where the Lower Kittanning coal lies at an altitude of 800 feet, is at the border of the Ebensburg and Johnstown quadrangles, 9 miles northeast of Windber. From this place the rocks rise steeply along the axis until in the Windber quadrangle the Lower Kittanning coal attains an altitude of more than 1,700 feet. In the vicinity of Windber the 1,700-foot structure contour swings around the axis of the Wilmore syncline at its south end, and the 1,750-foot contour extends across the western limb of the Mount Savage anticline.

Somerset syncline.—The Somerset syncline, named from the town of Somerset, merges at both ends into the Johnstown

The Boswell dome is an elongated quaquaversal fold, which lies between the Somerset and Johnstown anticlines. It trends northeastward and is about 13 miles long and 6 miles wide. The crest of the dome lies about 2 miles south of Boswell, and from it the rocks slope away in all directions. The Johnstown limestone attains an altitude somewhat above 2,100 feet at the crest and descends to an altitude between 1,600 and 1,700 feet in the Somerset Basin and to less than 900 feet in the trough of the Johnstown Basin.

Johnstown syncline.—The Johnstown syncline, named from the city of Johnstown, in Cambria County, is a structural trough that extends for a number of miles immediately east of Laurel Hill. Its axis crosses the northwestern part of the Windber quadrangle, where its course is almost due east, and thence it trends southward across the central part of the Somerset quadrangle, which it leaves near the southwest corner. In the Windber quadrangle an extraordinary local development of the fold occurs in the area where the Ebensburg anticline, Wilmore syncline, Negro Mountain anticline, and Berlin syncline fade away. In a belt 3 to 5 miles wide between Windber and Hillsboro the beds rise continuously along the southeastern limb of the Johnstown syncline, which in that area is also the northwestern limb of the Savage Mountain anticline, so that the Lower Kittanning coal, which along the axis of the syncline has an altitude of about 1,100 feet, attains an estimated altitude of more than 2,600 feet at the eastern border of the quadrangle within a distance of about 12 miles. South of this belt, in the vicinity of Davidsville and Hollsopple, around the north end of the Boswell dome, the Johnstown syncline merges into the Somerset syncline as already mentioned.

In the Somerset quadrangle the Johnstown syncline is divided into two quite different parts. In the northern half of the quadrangle this syncline is a deep and narrow trough that forms a distinct canoe-shaped basin. The center of this trough lies 5 miles almost directly north of the crest of the Boswell anticline, and in that distance the Johnstown limestone rises from an altitude of less than 900 feet to more than 2,100 feet. On the northwestern limb the dip is even steeper, and there the Johnstown limestone rises to an estimated altitude of more than 3,200 feet. Along the axis of the syncline the Johnstown limestone rises to the northeast from less than 900 to about 1,200 feet and on the southwest to almost 1,600 feet. In the southern part of the Somerset quadrangle, owing to the fading away of the Boswell dome and to its coalescence with the Somerset syncline, the Johnstown Basin broadens out on the east and occupies approximately the entire width of the quadrangle. In the broad central area of this part of the Johnstown syncline the Johnstown limestone lies between 1,600 and 1,700 feet above sea level.

Laurel Hill anticline.—The Laurel Hill anticline, one of the major folds of the plateau region, extends for a number of miles beyond the area here considered. Almost throughout its extent its location is marked by a conspicuous zone of highlands, and the axis of the fold corresponds approximately with the crest of Laurel Hill.

In the Somerset quadrangle the anticlinal axis for the most part lies somewhat west of the actual divide. In the northern part of the quadrangle the axis in general trends N. 30° E., but between the heads of Furnace Run and Indian Creek the axis curves and trends more westward. The position of this change in trend marks a low zone toward which the axis plunges, for the strata rise along the axis from this zone toward the northeast and southwest. The northeastward rise does not continue far, however, and for several miles along the axis the beds lie practically flat.

The Laurel Hill anticline as developed in the Somerset quadrangle is a broad, flat-topped unsymmetrical fold, the southeastern limb of which is shorter and steeper than the northwestern limb. For a distance of 1½ miles across the strike on the crest of the fold the rocks lie almost level. On the southeastern flank the beds descend 2,200 feet in a distance of 2½ miles, and on the northwestern flank an equal descent is accomplished in 4 miles.

These dips bring to the surface beds that deeply underlie the greater part of the quadrangle. The Pocono formation occupies a considerable part of the crest of Laurel Hill and is exposed in the valleys for some distance down each flank. Near the western border of the quadrangle, close to the plunging axis, the Pocono formation passes beneath the surface, the Mauch Chunk and Pottsville formations successively form parts of the summit, and locally outliers of the Allegheny formation cap the ridge. Throughout the greater part of Laurel Hill, however, the coal measures have been removed by erosion.

Ligonier syncline.—The Ligonier syncline, named from the town of Ligonier, lies northwest of the Laurel Hill anticline, and only its southeastern limb is included in the Somerset quadrangle. It lies between Chestnut Ridge and Laurel Hill, and the distance from crest to crest across the strike is 11 miles, the axis of the basin at Ligonier being 7 miles from the crest of the Laurel Hill anticline and 4 miles from that of the Chestnut Ridge anticline. The steep dips along the upper flanks of Laurel Hill extend to the vicinity of Laughlintown, beyond which the strata flatten so that their inclination is barely perceptible in the vicinity of Ligonier. The greater part of the surface of the basin within the Somerset quadrangle is occupied by the Conemaugh formation, and at Ligonier the sandstones of the Pocono formation, which form the crest of Laurel Hill, lie about 1,200 feet below the surface, or practically at sea level.

GEOLOGIC HISTORY

PALEOZOIC ERA

GENERAL OUTLINE

The area included in the Somerset and Windber quadrangles formed part of the Appalachian geosyncline, a long and relatively narrow trough that extended with varying outlines during different epochs of Paleozoic time across the eastern part of the continent from the Gulf of Mexico to the Gulf of St. Lawrence. The epicontinental sea that occupied this trough was bordered on the east by a land mass, Appalachia, which lay mostly east of the present Blue Ridge in the region of the Piedmont Plateau, the Coastal Plain, and the Continental Shelf.

Into this sea vast quantities of sand and clay derived from the disintegration of the rocks of the bordering land were transported by rivers and distributed by currents or deposited in deltas. In places calcareous deposits were formed of calcium carbonate that was withdrawn from solution in sea water by the secretion of plants and animals or possibly at times by direct chemical precipitation. Conditions of deposition varied, so that while sand was being laid down in one area, mud was accumulating in another and calcareous ooze elsewhere. Finally a great mass of sediment, having a maximum thickness of about 40,000 feet, was deposited in the trough, which throughout the greater part of Paleozoic time was a downwarping area. In general, subsidence kept pace with the deposition of the sediments, but depression was interrupted a number of times by uplifts. These uplifts and downwarps and the corresponding retreat and advance of the sea caused hiatuses and overlaps, but the most pronounced stratigraphic variation is the great increase in the thickness of the strata from west to east, toward the source of the sediments. Between central Ohio and the region east of the Allegheny Front in central Pennsylvania, for instance, the thickness of rocks of Upper Devonian age increases from less than 800 feet to more than 8,000 feet.

UPPER DEVONIAN EPOCH

CHEMUNG AND CATSKILL TIME

During Chemung and Catskill time varied conditions of deposition prevailed in the Appalachian trough. Extending southwestward from the Catskill Mountain area, in New York, across Pennsylvania, Maryland, and West Virginia, a great mass of red beds consisting chiefly of shale and fine-grained sandstone, marked by the presence of ripple marks and mud cracks, was laid down in large part in a series of deltas along the mouths of rivers in an area more or less cut off from the sea. Deposition of red beds began in the Catskill Mountain area in pre-Chemung time and continued in parts of the basin through the Devonian period and possibly into the Mississippian epoch. In other parts of the basin the fossiliferous greenish-gray sandstone and shale of the Chemung formation were laid down coincident with red-bed deposition elsewhere. In the Allegheny Front region, including the Somerset and Windber quadrangles, marine conditions under which the fossiliferous beds of the Chemung formation were deposited were succeeded by nonmarine conditions under which red beds of the Catskill facies accumulated.

The red color of the Catskill formation is due to the presence of interstitial red pigment, ferric oxide, derived from the decomposition of iron-bearing minerals in the rocks that supplied the sediments. In the change the iron passed through various stages of oxidation and hydration, with corresponding shades of yellow and brown, until it finally became dehydrated to the red ferric oxide. The red beds possibly were derived from residual red soil. As originally deposited, however, the sediments may not have been entirely red, but presumably the present color of the formation was developed in part during and after deposition.

CARBONIFEROUS PERIOD

MISSISSIPPIAN EPOCH

POCONO AND LOYALHANNA TIME

Although the Catskill formation is apparently overlain conformably by the Pocono changed conditions of sedimentation are indicated by the fact that red beds are abruptly succeeded by gray sediments. The inclosed area in which the Catskill beds were laid down gave way in Pocono time to an area of more open water, and uplift of at least part of the adjacent land area is indicated by local beds of coarse sandstone and conglomerate in the Pocono formation. Vast quantities of sand and relatively less clay were spread widely over the Appalachian Gulf during Pocono time. An interval between the deposition of the Pocono and that of the overlying Loyalhanna limestone is indicated by the absence of the Keokuk, Warsaw, Spergen, and St. Louis faunas in this general region.

MAUCH CHUNK TIME

After the deposition of the Loyalhanna limestone conditions somewhat similar to those of Catskill time prevailed in this region, and Mauch Chunk time is characterized by the deposition of red beds. The presence of mud cracks and ripple marks and the general absence of fossils in the Mauch Chunk red beds indicate that the deposits were laid down in a shallow, more or less inclosed area of the sea, in which the accumulating sediments were at times exposed to subaerial conditions. The presence of thin limestone beds in the Mauch Chunk shale, which contain marine fossils and which represent the northward fading away of the Greenbrier limestone, a formation that attains considerable thickness in Virginia, is evidence that the area in which the Mauch Chunk was deposited had local connections with the sea.

In Pennsylvania the present varying thickness of the Mauch Chunk shale, although no doubt in part due to differences in quantity of the original deposits, is in part due to pre-Pottsville erosion. The Mauch Chunk is more than 2,000 feet thick in the northeastern part of the State, only about 200 feet thick along the Allegheny Front, about 50 feet thick below Blairsville, to judge from well records, and is absent in parts of Armstrong County and farther west.

The uplift that initiated this erosion marks the end of Mississippian time and the beginning of Pennsylvanian time. In western Pennsylvania and adjacent regions this erosion interval lasted throughout the greater part of Pottsville time, for while several thousand feet of deposits of that age were being laid down in the southeastern portion of the Appalachian trough the region of the Allegheny Front was a land area. This area was not submerged so as to receive deposits until the later part of Pottsville time.

PENNSYLVANIAN AND PERMIAN EPOCHS

POTTSVILLE TIME

After the deposition of the Mauch Chunk shale there was regional uplift, and a portion of the Appalachian Gulf became a land area that was subjected to subaerial erosion. A large part of the Mauch Chunk was thus removed, and in places in western Pennsylvania the entire formation and part of the underlying Pocono was washed away.

At the end of this period of emergence and erosion apparently the extreme western part of Pennsylvania and adjacent parts of Ohio were submerged sooner than the Allegheny Front region, for in the western region the earliest deposits of Pottsville age are the Sharon conglomerate member and the overlying Sharon coal and Sharon shale member, which are not represented in the Allegheny Front region.

In the Allegheny Front region, including the Somerset and Windber quadrangles, the earliest deposits of Pottsville age, marking the transgression of the sea upon this region, constitute the Connoquenessing sandstone member, which in the extreme western part of the State overlies the Sharon shale member. The almost pure quartzose sand, practically free from admixture with feldspar and other minerals, in contrast to the arkosic sandstones of earlier and later formations in this region, indicates that the deposits were sorted and well washed before sedimentation, and the presence of quartz pebbles scattered throughout the Connoquenessing sandstone implies local relatively strong currents.

After the deposition of more than 100 feet of these sands, conditions changed to those favorable to the accumulation of mud and beds of peat off the shore of a low-lying land area and in coastal swamps, where a luxuriant vegetation thrived and peat bogs formed. Thus the Mercer shale member was deposited, the area of deposition was further submerged, and possibly the adjacent shore was uplifted. Conditions like those in Connoquenessing time then returned, and a well-washed quartzose sand, the Homewood sandstone member, was deposited.

ALLEGHENY TIME

During Allegheny time alternating beds of clay, sand, calcareous mud, and peat were laid down. The most characteristic and notable deposit was peat, from which were formed the beds of coal that are now extensively mined. General slow subsidence of the Appalachian trough continued during Allegheny time, varied by local uplifts and periods of relative repose, when peat deposits were formed in vast coastal swamps.

The widespread distribution of coal in the Allegheny formation and the general correspondence in the sequence of deposits over many thousand square miles indicate uniformly varying conditions over an immense area. The climate throughout the greater part of Pennsylvanian time is indicated by the character of the plant remains to have been humid, warm, and equable and generally favorable to the growth of a luxuriant vegetation, so that where the appropriate adjustment of land surface and water level favored the development of swamps peat deposits were formed. Such conditions existed over wide areas at different periods during Allegheny time. Plants of different types flourished in these swamps, and their remains fell into the shallow water, where they were preserved from subaerial decay. Subsidence progressed at a rate approximately that at which the vegetal débris accumulated, until vast deposits resulted. The swamps from time to time expanded and contracted in area, giving rise to widespread or smaller areas in which vegetal matter accumulated. During periods of temporary flooding thin layers of sand or clay, which form the partings found in coal beds, were washed in and laid down on the vegetal débris, and these relatively brief periods were followed by further accumulation of vegetal matter. This accumulation differed in amount at different places, so that the deposits are of irregular thickness. In some places the peat was eroded away before other deposits were laid down, and its place was taken by sand deposited by the streams that flowed over parts of the swamp; in other places the peat bogs were encroached on by sand bars or other accumulations of clastic material, which caused the barren areas in coal beds that are locally found in the mines.

During the formation of the peat subsidence progressed at an extremely slow rate, barely sufficient to keep pace with vegetal deposition, for the peat-making plants were not able to live in deep water. Therefore, when at intervals the basin subsided at a faster rate, vegetal accumulation stopped and was succeeded by the deposition of mud and sand. Recurrence of swamp conditions and renewed accumulation of peat followed the renewed filling of the basin, and thus the alternating beds of coal, shale, and sandstone that constitute the Allegheny formation were formed.[4]

CONEMAUGH TIME

During Conemaugh time there was continued subsidence of the Appalachian trough and deposition of lenticular beds of clay, sandy mud, sand, and peat. Beds of fossiliferous limestone at several horizons in the lower half of the formation mark incursions of the sea. Other beds of limestone, which bear brackish or fresh water faunas, indicate that the sea was cut off from certain areas from which for a time terrestrial sediments were excluded. There were also several periods during Conemaugh time when coastal swamps existed, in which peat accumulated as in Allegheny time. One of the characteristic features of the Conemaugh formation is the presence of red beds at several horizons. These deposits indicate the presence of oxidizing and dehydrating conditions as contrasted with the deoxidizing environment that characterized the accumulations of peat.

MONONGAHELA AND DUNKARD TIME

Only the lower part of the Monongahela formation, including the Pittsburgh coal and associated beds, occupies a small area in the Somerset quadrangle. The Dunkard group (Permian) is entirely absent. Both these divisions are well developed in other parts of western Pennsylvania, and presumably they once extended over the Somerset and Windber quadrangles, from which they have been removed by erosion.

Monongahela time was marked by another great period of coal deposition, similar to that of the Allegheny. At the beginning of this period many thousand square miles of the Appalachian region was occupied by a vast swamp, in which the Pittsburgh coal accumulated. This bed is the most persistent as well as the most valuable coal bed in the bituminous region, and its great regularity indicates that uniformity of conditions attended its deposition. The accumulation of the Pittsburgh coal was followed by the deposition of alternating layers of sandstone, shale, limestone, and thinner coal beds that constitute the Monongahela formation and the overlying Dunkard group.

POST-CARBONIFEROUS DEFORMATION

With the close of Dunkard deposition sedimentation in the Appalachian trough came to an end, and a series of events of a totally different kind began. From Cambrian time intermittent subsidence of the region had been going on until tens of thousands of feet of sediments were deposited in the interior sea; but from the end of Carboniferous deposition until the present time the reverse conditions of uplift and erosion have prevailed, and dry land has existed in the greater part of the Appalachian region. The period of uplift was begun by an epoch of diastrophism, the Appalachian revolution.

The crustal movements that characterized this event were the result of compressive stresses that bent the strata into great folds. The movement was most severe along the east side of the Appalachian region, where the rocks were intensely folded and faulted. West of this greatly disturbed zone the movement was less severe and the folds are smaller. The bituminous coal basin seems to have acted as a buttress against which the rocks were thrust, but the coal basin also was thrown into low folds, which decrease in magnitude westward. These folds are exemplified by the anticlines and synclines of the Somerset and Windber quadrangles.

MESOZOIC AND CENOZOIC ERAS

In western Pennsylvania there is no sedimentary record of the long interval between the Carboniferous and Quaternary periods. If any sediments were deposited in this area during the Triassic, Jurassic, Cretaceous, or Tertiary periods they have been removed by erosion. The history of Cenozoic time is indicated by records of erosion that are preserved in the surface features.

Study of the surface features in different parts of the Appalachian region has resulted in the recognition of a number of uplifts and intervening periods of quiescence, during which much of the region was eroded nearly to plains. At least two peneplains have been recognized, but studies have not gone far enough to establish correlations throughout the region.

In the Somerset and Windber quadrangles the oldest topographic record is marked by the summits of Allegheny Mountain and Laurel Hill, the concordant altitudes of which suggest that they represent a peneplain. This old surface was subsequently uplifted, but as the Somerset and Windber quadrangles lie in the interior of the Appalachian region, on the divide between the Atlantic and Gulf drainage systems, their surface was not reduced to base-level in the same degree as the marginal areas of the region. However, in the area here considered there was at least one stage of partial peneplanation below the level of the tops of the highest ridges. The undulating hilly portions

[4] White, David, and Thiessen, Reinhardt, The origin of coal: U. S. Bur. Mines Bull. 38, 1913.

of both quadrangles contain several flats that have altitudes of about 2,000 feet, and a number of hilltops rise between 200 and 400 feet higher.

The divide between the Monongahela and Allegheny drainage basins in the southern part of the Somerset quadrangle is inconspicuous for a divide separating the headwaters of streams so large. It is marked by a curved line of hills, which for the most part rise to an altitude of about 2,300 feet, and some uncommon drainage features are associated with the general level of the divide. Laurel Hill Creek rises on the southern border of the quadrangle and flows northeastward toward the Monongahela-Allegheny divide for a distance of about 4 miles, turns northwestward and flows in a gorge for about a mile, and then turns abruptly and flows southwestward along the base of Laurel Hill parallel to its original course but in a direction opposite to that course and less than 2 miles from it. Beyond the quadrangle Laurel Hill Creek continues its southwestward course and joins Youghiogheny River at Confluence. The anomalous course of the upper part of the creek may have originated on the old surface mentioned above.

No lower peneplains have been recognized in this area, although there is evidence of local base-leveling.

Parts of the valleys of some of the streams in both quadrangles are so poorly drained as to be more or less swampy, as, for instance, the valley of Roaring Run above Pilltown, north of Boswell. Apparently these areas are local base-leveled plains caused by retardation of stream cutting by beds of hard sandstone at the outer margins of the swampy tracts.

MINERAL RESOURCES

The mineral resources of the Somerset and Windber quadrangles include coal, natural gas, clay, sandstone, limestone, soils, and water.

COAL

PRODUCTION AND OCCURRENCE

Coal is the most valuable mineral resource of the quadrangles. Extensive deposits of low-volatile, so-called smokeless (semibituminous) coal underlie most of the area of both quadrangles and constitute part of the largest reserve of high-rank bituminous coal in Pennsylvania. This area was comparatively late in being opened, but after the construction of railroad outlets, exploitation was rapid, and at the time of the beginning of the World War intensive development of the coal was well under way. In 1917 the output of the coal mines in the Somerset and Windber quadrangles, according to figures compiled by the State Department of Mines, amounted to 7,122,298 net tons, which was equivalent to 4.1 per cent of the total production of bituminous coal in Pennsylvania for that year. Ten years later, when the production of the State had considerably decreased, the output of the mines of these quadrangles increased to 8,818,128 net tons, equivalent to 6.6 per cent of the State's total bituminous production.

Because of the location of the quadrangles adjacent to the Appalachian Valley and Ridge province, in a region of pronounced folding, the coal-bearing rocks have been removed by erosion in parts of the area, along anticlinal folds and where creeks have cut deep valleys. The main barren zones, which are not underlain by coal, are along the Allegheny Front and on Laurel Hill.

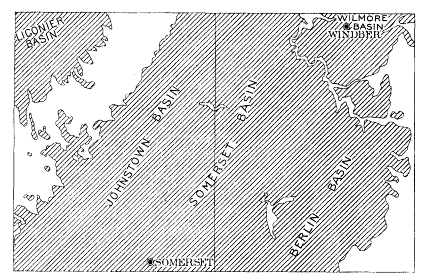


FIGURE 6.—Sketch map of the Somerset and Windber quadrangles showing by diagonal ruling areas in which there are workable coal beds.

The coal-bearing areas of these quadrangles are conveniently subdivided into the several synclinal folds or basins named from east to west the Berlin, Wilmore, Somerset, Johnstown, and Ligonier Basins. (See fig. 6.) In these basins the coal beds crop out along the upper flanks and dip toward the axes of folding, along which they are under a considerable cover of rocks.

The structure of the basins, the location of their axes, the outcrops of the more valuable coal beds, and the depth of these beds beneath the surface are shown on the structure and economic-geology maps. The stratigraphic occurrence of the coal beds and the intervals between them are outlined in the description of the formations and are illustrated in the columnar section and the plotted records of diamond drilling at the end of the text.

In general the coal is irregular in its occurrence. The beds thicken and thin and locally disappear. In some areas the Lower Kittanning is the most valuable bed; in others the Upper Kittanning and in still others the Upper Freeport is the most valuable. In this area a common practice is to prospect by core drilling in advance of development, which results in mining out first the most valuable coal, leaving the less desirable for the future.

The coal beds occur in the Pottsville, Allegheny, Conemaugh, and Monongahela formations, but the most valuable are members of the Allegheny formation, or "Lower Productive Coal Measures."

SO-CALLED "FAULTS" OR BARREN AREAS

Faults, or dislocations of the rocks, in the area under consideration have not been observed, although at certain localities contiguous to the Allegheny Front, notably in the Houtzdale quadrangle, in central Pennsylvania, such displacements are common.[5] But what the miners call "faults" are frequently encountered in the mines of the Somerset and Windber quadrangles. These "faults" are barren areas in coal beds, where there is no coal, the place the coal normally would fill being occupied by noncarbonaceous deposits. For instance, in mining the Upper Kittanning coal this bed has been found to disappear and its place to be taken by sandstone. The local absence of this coal bed from an area of several square miles has been found by drilling. Although the coal is absent the underlying Johnstown limestone occurs beneath the barren area. The absence of coal in such places is due either to nondeposition or to erosion before covering by shales or other sediments. Knowledge of occurrences of this kind in a number of drill holes was obtained confidentially, and details may not be published, but it should be stated that certain parts of the coal field in these quadrangles are valueless on this account.

POTTSVILLE COAL

In the area under consideration a few drill holes record the presence of thin beds of coal in the Mercer member of the Pottsville formation, but in these quadrangles, so far as known, the formation does not contain beds of coal workable under present conditions.

ALLEGHENY COALS

Designation of beds.—The Allegheny formation contains some of the most valuable coal beds of the Appalachian region, and in the area considered in this folio these beds constitute the main coal reserve. The chief Allegheny coal beds have long been known by certain names or letters, which have had widespread application in western Pennsylvania and adjacent States. These beds from the bottom up are the Brookville (A), Clarion (A'), Lower Kittanning (B), Middle Kittanning (C), Upper Kittanning (C'), Lower Freeport (D), and Upper Freeport (E) coals. Use of these names, unless qualified, implies widespread continuity of the beds, but as detailed stratigraphic work has progressed and as diamond-drill records have accumulated it has become evident that the Allegheny coals were not deposited as continuous beds throughout the extent of the formation. Although some beds are more persistent than others, they are all more or less lenticular and interfinger with layers of sandstone and shale. It is doubtful that the bed called Upper Kittanning, for instance, in widely separated areas in western Pennsylvania is actually one and the same stratum of coal. Nevertheless the principal beds of the Allegheny formation, when considered as a whole, correspond in sequence and general stratigraphic position, and when properly qualified the long-established names serve a useful purpose.

In this folio these long-established names of the Allegheny coals are used to indicate only the sequence of the beds and their approximate stratigraphic position and do not imply precise correlation with beds of coal in the type localities, from which the names are derived. In some areas certain beds are clearly persistent over many square miles. For example, the bed of coal that almost immediately overlies the Johnstown limestone, which has been exploited at a number of places and found in many drill holes in both the Somerset and Windber quadrangles undoubtedly extends over a few hundred square miles. So, too, the coal bed approximately 100 feet above the Johnstown limestone, the Upper Freeport, likewise has a widespread distribution and the same is true of the Lower Kittanning coal, which lies about 90 feet beneath the Johnstown limestone. Besides their stratigraphic position each of these beds has certain physical properties which persist rather widely and which tend to confirm its identity in different parts of the quadrangle. But both drill holes and mining operations show the absence of these beds in certain places, which proves that they are not absolutely persistent, even in the relatively small area included in these two quadrangles. The columnar sections of diamond-drill holes on the back of the columnar-section sheet show clearly the variability of the coal beds in this area.

Brookville or A coal.—The Brookville or A coal occurs interbedded with shale at the base of the Allegheny formation and is underlain by the Homewood sandstone member of the Pottsville formation. The line of division between the Pottsville and Allegheny in places in western Pennsylvania is not satisfactorily determined and must be finally drawn by aid of a regional study of paleobotany. Meanwhile, for the Somerset and Windber quadrangles, the coal lying between 175 and 200 feet below the Johnstown limestone is provisionally assumed to correspond to the Brookville. In this area the Brookville coal is banded with a number of shale partings and in general is of little present value. (See fig. 7.) It crops out along the

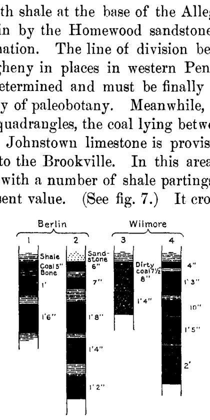


FIGURE 7.—Sections of Brookville coal in Berlin and Wilmore Basins.
1, Hitchew mine; 2, 1¼ miles northwest of Sharksville; 3, Parks Improvement; 4, below Scalp Level.

western base of Allegheny Mountain, along both flanks of Laurel Hill, and in parts of the valleys of Stony, Shade, Paint, and Quemahoning Creeks, where the streams have cut deep enough to reach its horizon. In the greater part of all the basins this coal is deeply buried by overlying strata.

The Brookville bed is mined in the valley of Paint Creek below Scalp Level, in the Phillips (18)[6] and Paint Creek (19) mines and at the Hitechew country bank 2½ miles southeast of Cairnbrook.

Clarion or A' coal.—The Clarion or A' coal generally is not of workable thickness in this area. The records of several diamond-drill holes show only a few inches of coal occurring irregularly between the Brookville and Lower Kittanning beds, but in places a bed of coal in this zone is more than 2 feet thick, as at the clay pit south of Windber, where the underclay is quarried. There the Clarion coal is, where locally mined, 2 feet 6 inches thick.

Lower Kittanning or B coal.—The Lower Kittanning or B coal throughout western Pennsylvania is one of the most valuable coal beds of the Allegheny formation. So far as known it is persistent in the area here considered, although its thickness is variable. In this area the Lower Kittanning coal lies between 75 and 115 feet below the top of the Johnstown limestone, a common distance being about 90 feet.

In the Wilmore Basin the Lower Kittanning coal crops out on the flanks of Allegheny Mountain and in several areas isolated by erosion. Some of the largest mines and the most extensive operations of the entire area considered in this folio are located in the vicinity of Windber, where the Berwind-White Coal Mining Co. works the following mines: Eureka Nos. 42 (No. 1 on the map), 41 (6), 36–B (7), 35–B (13), 30 (17), 31 (15), 32 (12), 33 (10), and 34 (11). In addition to these mines there are a number of others on this bed as shown on the map.

The extension of the Windber branch of the Pennsylvania Railroad to Cairnbrook, Central City, and southward in the Berlin Basin, has made available a fine body of the Lower Kittanning coal, which is mined by the Loyal Hanna Coal & Coke Co. at Loyal Hanna No. 6 (86), by the Reitz Coal Co. at Reitz Nos. 2, 3–B, and 4 (88, 94, 92), and by others. This coal bed crops out in several isolated areas on the eastern flank and underlies the main part of the basin at moderate depths.

In the northern part of the Somerset Basin the Lower Kittanning coal is also well developed. It is exposed in the valley of Stony Creek and its branches and is operated at the Eureka Nos. 38–B and 39–B (30 and 28) Thermal No. 9 (27), Maple Ridge No. 3 (31), Haws No. 3 (34), Consolidation No. 116 (40), Knickerbocker Nos. 1, 2, 3, 5, and 6 (51, 49, 47, 41, and 42), Elma Nos. 1 and 2 (52 and 53), Ralphton Nos. 8, 9, and 15 (58 and 56), and other mines. In the southern part of the Somerset Basin, in the Somerset quadrangle, the Lower Kittanning coal does not crop out, and drill records indicate that the bed is less valuable than others in the upper part of the Allegheny formation.

In the Johnstown Basin, throughout most of the area here considered, the Lower Kittanning coal is apparently of secondary value and at the time of Survey was not worked at any

[5] Ashley, G. H., and Campbell, M. R., Geologic structure of the Punxsutawney, Curwensville, Houtzdale, Barnesboro, and Patton quadrangles, central Pennsylvania: U. S. Geol. Survey Bull. 531, pp. 82–84, 1913.

[6] Numbers given in parentheses after names of coal mines are the numbers by which the mines are designated on the economic-geology maps. During the long interval between the field work on which this folio is based and the time of publication there have been changes in names of mines and considerable new development. In 1926 J. D. Sisler, of the Topographic and Geologic Survey of Pennsylvania, kindly assisted in supplying locations of coal mines that have been opened since the work was finished.

shipping mine. In most of the basin this coal is deeply covered; in places the overburden amounts to more than 1,000 feet. On the east side of the basin the bed crops out in a few isolated localities, and on the west it crops out continuously along the flanks of Laurel Hill, where, however, on account of the steep slopes and thick cover of vegetation its position is concealed and it is difficult to prospect. Drill-hole records show this bed to be extremely variable in thickness in the Johnstown Basin, and commonly it is interbedded with a number of shale partings.

In that part of the Ligonier Basin situated in the Somerset quadrangle the Lower Kittanning coal crops out chiefly along the steep wooded flanks of Laurel Hill. The bed has been prospected at several places, and country banks have been opened in some of the valleys that are relatively easy of access. For considerable distances the position of the outcrop is not known and its location shown on the map is only an approximation. In the central part of the Ligonier Basin this coal bed is deeply covered and has not been tested by the drill.

Measurements of the Lower Kittanning coal bed made in mines in the several basins are shown in figure 8.

Middle Kittanning or C coal.—The Middle Kittanning or C coal is not known to be of commercial value in the Somerset and Windber quadrangles. In some of the drill holes a few inches of coal is present at one or two horizons between the Lower and Upper Kittanning beds.

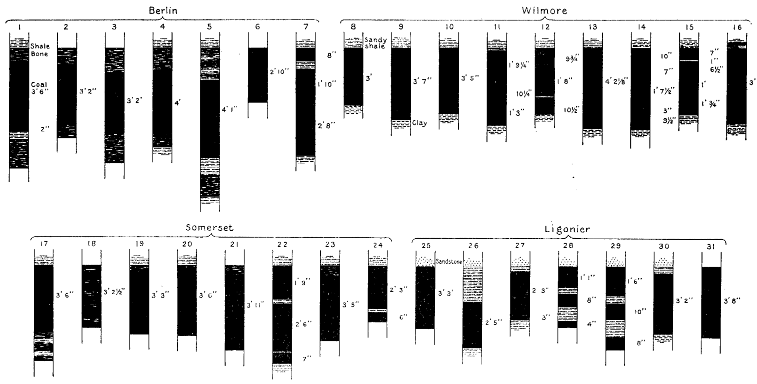


FIGURE 8.—Sections of Lower Kittanning coal in Berlin, Wilmore, Somerset, and Ligonier Basins.

1, Shade Creek No. 1; 2, 3, Loyalhanna No. 6; 4, Egolf; 5, Reitz No. 3; 6, Long; 7, Heinemeyer; 9, Eureka No. 36; 10, 11, Eureka No. 34; 12, 13, Eureka No. 33; 14, 15, Eureka No. 30; 16, Eureka No. 35 B; 17, Thermal B; 18, Consolidation No. 116; 19, Old Colony; 20, 21, Knickerbocker No. 3; 22, Knickerbocker No. 4; 23, Standard Quemahoning No. 1; 24, Thomas; 25, Eiseman; 26, Hall; 27, Allen; 28, Saltzman; 29, Aiken; 30, Miller; 31, Bricker.

Upper Kittanning or C′ coal.—The bed locally known as the Upper Kittanning or C′ coal is one of the most valuable and persistent beds in this area. It is mined at a few places in the Berlin and Wilmore Basins and attains its chief development in the Johnstown and Somerset Basins, where it is extensively mined. The position of this bed is marked by the Johnstown limestone, by which it is almost immediately underlain.

In the Wilmore Basin the Upper Kittanning coal crops out on the hillsides north and south of Paint Creek, about 90 feet above the Lower Kittanning bed and has been mined in only a few places. Among the mines on this bed are the Eureka Nos. 35–C and 36–C (14 and 8), and the Reitz No. 5 (20).

In the Berlin Basin only a few shipping mines have yet been opened on the Upper Kittanning coal, among which are Arrow No. 6 (84), Loyal Hanna No. 7 (87), and Reitz No. 7 (95).

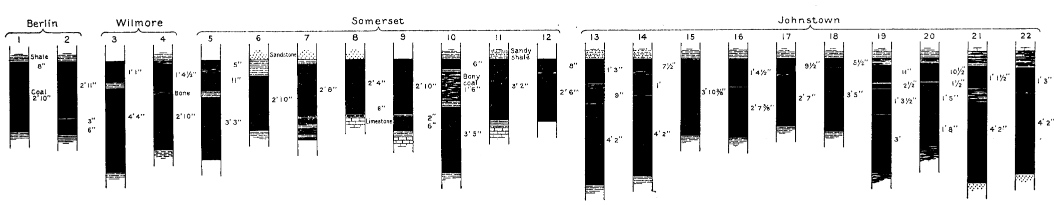


FIGURE 9.—Sections of Upper Kittanning coal in the various basins.

1, Wagner; 2, Walker; 3, Reitz No. 5; 4, Eureka No. 35; 5, Consolidation No. 115; 6, Adams No. 1; 7, Reading No. 3; 8, Miller; 9, Reiwinger; 10, Standard Quemahoning No. 2; 11, Thermal; 12, Eureka No. 39; 13 and 14, Orenda No. 2; 15, Consolidation No. 118; 16, Consolidation No. 119; 17, Belmont Nos. 4 and 5; 18, Belmont Nos. 2 and 3; 19, 20, 21, and 22, Jerome.

In the Somerset Basin, particularly in the southern part, the Upper Kittanning apparently is the principal coal bed. It crops out along Wells, Stony, and Quemahoning Creeks and their tributaries and underlies a large area in the central part of the basin. The mines that are located on the Upper Kittanning coal in the Somerset Basin include the Consolidation No. 115 (48), Stauffer No. 2 (74), Adams No. 1 (75), Reading No. 1 (68), Reading No. 3 (62), Randolph (45), Standard Quemahoning No. 2 (43), Haws Nos. 1 and 2 (35 and 33), Maple Ridge No. 2 (32), and Eureka No. 39–C (29).

In the Johnstown Basin also the Upper Kittanning coal is extensively mined. The position of the coal is well known throughout a considerable part of the basin as a result of drilling, but along the western flanks, on the wooded foothills of Laurel Hill, the outcrop has been prospected in only a few places, and for many miles the position of the bed is not known. The principal mines on this coal in the Johnstown Basin are the Jerome Nos. 1 and 2 (36), the Orenda Nos. 2 and 3 (15 and 4), the Consolidation Nos. 118 and 119 (18) and 125 (12), Forge No. 6 (8), and Belmont Nos. 2 and 4 (22 and 21). Except the Jerome mines, which are operated through shafts, these are drift mines situated on the eastern or western limb of the Johnstown syncline. At the Orenda mine No. 2 the workings extend down the eastern limb a distance of about 9,000 feet to the axis of the syncline, where the coal is under a cover of more than 900 feet, and the workings of the mine also extend across the axis and up the western limb to the outcrop of the coal in Orenda mine No. 3.

A number of mine measurements of the Upper Kittanning coal bed in the several basins are shown in figure 9.

Lower Freeport or D coal.—The Lower Freeport or D coal is of variable occurrence in this area; in some places it is of workable thickness, and elsewhere it is either absent or worthless. It occurs between 35 and 60 feet above the Johnstown limestone. So far as known the best development of the Lower Freeport coal is in the southwestern part of the Windber quadrangle, in the Berlin and Somerset Basins. Formerly the bed was mined at Reading mine No. 2 (67), at Kimmelton. A mine, Stauffer No. 3 (77), has been opened on this coal three-quarters of a mile southeast of Wells Creek, and the Madeira Hill Smithing Coal Co. has opened a mine on the Lower Freeport coal at Friedens (71). This coal is also worked at the Adams No. 2 mine (76) and at a number of country banks.

In the Wilmore Basin, within the area described, the Lower Freeport coal is not mined. Drill records, however, show that the bed is usually present, but it appears to be generally thin and dirty, although one record, the location of which can not be given, shows a thickness of 3 feet 7 inches of coal. Likewise in the Johnstown Basin the bed is not mined. Three drill records show that the bed ranges in thickness from 6 inches to 1 foot 4 inches.

Sections of the Lower Freeport coal are shown in figure 10.

Upper Freeport or E coal.—The Upper Freeport or E coal, like all the other beds of this region, is of variable occurrence. In some places it is commercially mined, and in other places it is absent. It lies between 90 and 120 feet above the Johnstown limestone, and in many places the interval is almost exactly 100 feet. In parts of this area the Upper Freeport is the most valuable of all the coal beds.

In the Wilmore Basin, within the area under consideration, the Upper Freeport coal is not mined, and the drill records that were examined show that the bed here is poorly developed. Likewise in the Berlin Basin, in the area examined, little is known of the Upper Freeport coal, and in places it appears to be absent. A few country banks have been opened on this bed, however, in the Berlin Basin.

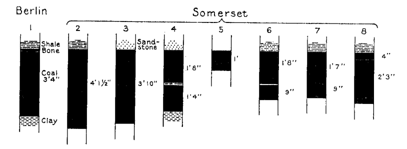


FIGURE 10.—Sections of Lower Freeport coal in Berlin and Somerset Basins.

1, Ream; 2, 3, 4, and 5, Staufer No. 3; 6, Trent; 7, Lambert; 8, Kimmel.

In the Somerset Basin the Upper Freeport coal crops out in the valleys of Coxes, Wells, Stony, and Quemahoning Creeks and their tributaries, also on several isolated hills on the eastern flank of the syncline, and underlies a considerable part of the central area. The Upper Freeport coal is mined at the Neva (45), Stauffer No. 1 (47), Ralphton No. 7 (35), and Reading No. 4 (63) mines and at a number of country banks.

In the Johnstown Basin the Upper Freeport coal crops out in the valley of Quemahoning Creek for a few miles north and south of Boswell, along the base of Laurel Hill, and in a small area in the valley of the South Fork of Bens Creek, and it underlies a large part of the syncline, in the central part of which it occurs under a considerable cover of rocks. The Upper Freeport coal is mined by the Quemahoning Coal Co. by a shaft at a depth of 273 feet at Husband, Ralphton No. 6 (40), and in 1913 the Consolidation Coal Co. began the construction of a camp 2 miles northwest of Acosta No. 123 (5), where the Upper Freeport coal is mined by a shaft 300 feet deep, favorably located for economical haulage and drainage on the axis of the Johnstown syncline. This bed is also mined in connection with the Upper Kittanning coal by the Consolidation Coal Co. at Consolidation mines Nos. 118 and 119 (18). The Upper Freeport coal has been prospected in a number of places, and country banks have been opened where shown on the map.

The extension of the Baltimore & Ohio Railroad up the north branch of Quemahoning Creek has resulted in the development on the Upper Freeport coal of the Ralphton No. 14 (6), Forge Nos. 4 and 5 (7 and 9), Consolidation Nos. 126 and 127 (11 and 10), Berkey (13), and Antoinette (14). The coal field south of these mines has not been sufficiently tested by drilling to establish correlations, and the identification of the coal beds on the southeastern flank of Laurel Hill, as shown on the map, is tentative.

In that part of Ligonier Basin which is included in the Somerset quadrangle there are no mines that have railroad connections. The valuable Pittsburgh coal bed has been extensively mined west of Ligonier, and the underlying Allegheny coals have been comparatively neglected. Country banks have been opened at several places, as shown on the map, but the coal has not yet been tested by core drilling.

The Upper Freeport coal has been prospected at a number of places. It passes beneath Laurel Run near its junction with Loyalhanna Creek 2 miles southeast of Ligonier, at an altitude of about 1,200 feet, and southeastward the bed rises to an altitude of more than 1,900 feet on the Mill Creek divide. Southwest of Laurel Run the coal crops out at lower altitudes and passes under Loyalhanna Creek southwest of Rector post office. Isolated outliers of the Upper Freeport coal underlie the hills south of Laughlintown. There are no shipping mines on any of the Allegheny coals in this part of the basin, but country banks have been opened at several places, as shown on the map. The area has not been adequately tested by drilling.

Measurements of the Upper Freeport coal bed made in a number of mines in the several basins are shown in figure 11.

CONEMAUGH COALS

The Conemaugh formation has been called the "Lower Barren Measures" on account of the relatively poor development of coal in it. In Somerset County, however, the Conemaugh contains several beds of coal, and in the southern part of the county and also in Maryland the formation contains beds of workable thickness extending over considerable areas. Although several beds of coal occur in this formation, in the Somerset and Windber quadrangles, so far as known, they are poorly developed.

Brush Creek coal.—Coal in the approximate position of the Brush Creek bed, between 90 and 120 feet above the Upper Freeport coal, has been encountered in several drill holes in the Johnstown Basin, but in most places it is not of workable thickness. In the valley of Laurel Hill Creek, in the southwestern part of the Somerset quadrangle, a bed of coal at or near the Brush Creek horizon has been opened at several country banks. The Weyand country bank, half a mile south of Bakersville, and other openings on the ridge east of Laurel Hill Creek are probably on the Brush Creek bed.

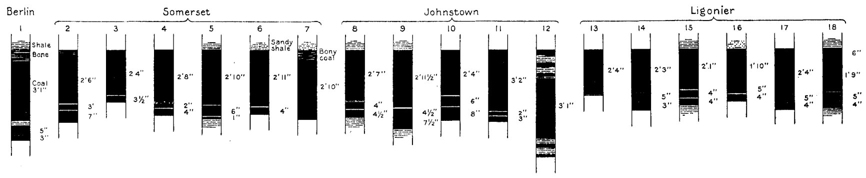


FIGURE 11.—Sections of Upper Freeport coal in the various basins.
1, E. Grove; 2, Auman; 3, Neva; 4, McBurney; 5, Staufer No. 1; 6, Mostoller; 7, Reading No. 4; 8, Ralphton No. 6; 9, Berkey; 10, Fritz; 11, Darr; 12, Thomas; 13, Müller; 14, Roble; 15, Dyer; 16, Burnett; 17, Proncho; 18, Clark.

Bakerstown coal.—The Bakerstown coal is not mined in these quadrangles, although the records of some drill holes show a few inches of coal between 230 and 260 feet above the Upper Freeport bed between the Buffalo and Saltsburg sandstones. Coal in this zone was formerly opened near the top of the hill immediately south of Beaverdam Creek, close to the border of the two quadrangles, but the thickness of the bed is not known.

Harlem coal.—The Harlem coal, which occurs immediately below the Ames limestone, was identified at the outcrop in only one locality—in the cut of the Pittsburgh, Westmoreland & Somerset Railroad three-quarters of a mile northwest of Allenvale, where a bed of coal 12 inches thick lies under a fossiliferous calcareous shale. At other places where the Ames was found, notably in Ligonier Basin, the Harlem coal was not observed. It is, however, reported in a number of records of diamond-drill holes.

Other coals.—Other thin beds of coal in the Conemaugh formation are shown in the record of the diamond-drill holes on page 5. In general they have not been prospected in these quadrangles and are known chiefly from drill records.

MONONGAHELA COALS

Pittsburgh coal.—The Pittsburgh coal, by far the most valuable bed in western Pennsylvania, is of little economic importance in the area under consideration because of its small extent and its thin cover. The bed crops out on hilltops on each side of Roaring Run, between 2 and 3 miles northwest of Boswell, in the center of the Johnstown syncline. There the coal has been mined in small country banks for many years, but the tonnage was too small to justify railroad construction and the development of shipping mines.

CHARACTER AND USE OF THE COAL

The coal of the Somerset and Windber quadrangles is characteristically friable. In the vicinity of Windber in particular the coal is extremely soft and readily breaks into small prisms along joints that have been developed as a result of the pressure to which the rocks have been subjected.

Analyses of coal from the Somerset and Windber quadrangles are given in the accompanying table. Mine samples of the Upper Freeport and Lower Freeport beds were collected in the Somerset Basin and of the Upper Freeport coal in the Ligonier Basin, of the Upper Kittanning bed in the Somerset and Johnstown Basins, and of the Lower Kittanning bed in the Berlin, Wilmore, and Somerset Basins. The samples were collected either by the Geological Survey or by the Bureau of Mines, and both the sampling and the analysis were performed under standard conditions.[7]

A proximate analysis was made of each sample and ultimate analyses of most of them, and the results are expressed in three forms. Form A shows the composition of the sample as received at the laboratory and represents the condition of the coal in the mine at the time of sampling. Form C shows the composition of the coal dried at a temperature of 105° C. Form D shows the composition of the coal calculated as theoretically free from moisture and ash. All the samples excepting five—Nos. 17690, 17695, 17901, 19850, and A-56329—were analyzed before the Bureau of Mines had changed its method of determining volatile matter from heating the sample over a gas flame to heating it in an electric furnace.[8] Results of the two methods are not strictly comparable. The new method tends to show a greater percentage of volatile matter, and this fact should be borne in mind in using the analyses. In these quadrangles samples from only one mine (Jerome No. 2) have been analyzed by both methods. By the old method (analysis No. 12224) the volatile matter on the sample "as received" was 15.2 per cent, and by the new method (analysis A-56329) the volatile matter "as received" was 16.7 per cent.

The analyses show that the coal of these quadrangles is a low-volatile (semibituminous), so-called "smokeless" coal. Its fuel ratio, the quotient of the percentage of fixed carbon divided by that of volatile matter, ranges from 3.0 to 6.5. However, it should be borne in mind that analyses by the new method, which increases the percentage of volatile matter as compared with analyses by the old method, may reduce the maximum fuel ratio to an amount less than 6.

On the basis "as received" the analyses show the following ranges in percentage: Volatile matter from 12.0 to 21.4; fixed carbon from 64.4 to 79.0; moisture from 0.9 to 4.6; ash from 4.7 to 10.0; and sulphur from 0.6 to 2.5. The analyses of the moisture-free and ash-free samples show a range in volatile matter from 13.5 to 25.0 per cent and a corresponding range in fixed carbon from 86.5 to 75.0 per cent.

The rank of the coal in these quadrangles is in accord with their location near the eastern margin of the bituminous field, contiguous to the Allegheny Front, where the coal is characteristically low in volatile matter. (See fig. 12.) The decrease in volatile matter in the coal from west to east in general varies with the westward decrease in the intensity of the forces that produced the post-Paleozoic diastrophism in the Appalachian region.[9]

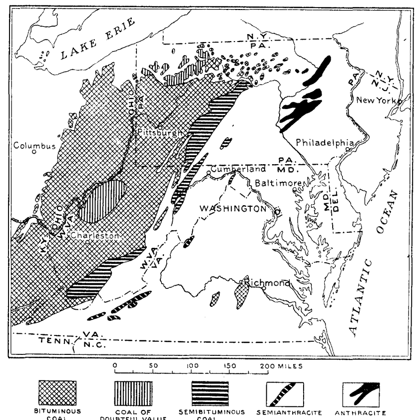


FIGURE 12.—Map of the Appalachian coal field, showing distribution of coals of different rank.

Adjacent to the Allegheny Front, however, there are local variations in the degree of devolatilization of the coals. In the vicinity of Windber, for instance, the coal is less volatile than in areas along the strike of the rocks to the northeast and southwest. The cause of this difference is not clear, but it is of possible significance that the Windber area is in a zone in which the rocks are relatively less folded than in the area immediately north and south. North of Windber, between the Allegheny Front and the Johnstown syncline (see fig. 5), two folds are developed—the Wilmore syncline and the Viaduct anticline. South of Windber, in the same interval, there are four folds—the Berlin syncline, the Negro Mountain anticline, the Somerset syncline, and the Boswell dome. In the Windber district, however, there is a continuous monocline between the Allegheny Front and the Johnstown syncline. This difference in the degree of folding suggests that in the Windber district the pressure which was not relieved by folding the rocks was exerted in metamorphosing the coal to a greater degree than in adjacent areas.

The low volatile coals of the Somerset and Windber quadrangles are comparable with other high-rank coals of the Appalachian bituminous region, such as the best product of Clearfield and Cambria Counties, Pa., of the Georges Creek Basin, Md., and of the New River and Pocahontas fields of West Virginia. Coal from the Windber district ranks as the best semibituminous coal in Pennsylvania.

The coal from the Somerset and Windber quadrangles is used mainly in generating steam by railroad locomotives, steamships, and manufacturing establishments, and it has an excellent reputation. The Lower Freeport coal mined in the vicinity of Friedens is highly regarded as a smithing coal. Much of the coal from the Somerset quadrangle and the western part of the Windber quadrangle is known under the trade name Quemahoning coal, and most of the product of the vicinity of Windber is known as Eureka bituminous coal. Other trade names of coal from these quadrangles are Somerset smokeless, Orenda, Knickerbocker, and Scalp Level coal.

A table of coal analyses is given on page 14.

NATURAL GAS

Natural gas was found in 1904 in a well on the Long farm in the valley of Beaverdam Creek, Quemahoning Township, Somerset County, 6½ miles northeast of Somerset. (See economic-geology map of Somerset quadrangle.) Only a small quantity was obtained from this well, but enough, it is reported, to use in drilling two other wells and to supply for some time the needs of a near-by family. The gas was obtained at a depth of 2,561 feet in a bed of sand near the middle of the Catskill formation. The hole was deepened to 1,000 feet below the gas-bearing bed with negative results. Two other test wells were sunk on the near-by Boytz and Bowman farms, but both wells, respectively 2,668 and 2,629 feet deep, were dry holes.

These wells are located in the Somerset syncline not far from its axis, as determined by contours based on the outcropping rocks. The gas-bearing beds, however, which occur below the unconformity at the base of the Pottsville formation, are not strictly parallel to the surface strata. Nevertheless, the logs of the wells that have been put down indicate general agreement in dip between the rocks above and below the unconformity. But when the deeper-lying beds are considered, such as the Oriskany sandstone, the effect of the pronounced eastward thickening of the rocks causes a marked divergence between the surface strata and the deep-lying rocks. The location of these wells in the valley of Beaverdam Creek, in a synclinal basin, was chosen without reference to the structure of the rocks, which at the time the wells were put down had not been determined.

No further tests in this general area were made for 25 years, but in 1929 another period of exploitation was begun, and the writer is indebted to W. R. Dougan, of Somerset, for information concerning the location of the wells and the results of drilling. Four test holes were put down in the upper part of the structurally well-developed Boswell dome, between 2 and 3½ miles northwest of the gas well on the Long farm. These were on the Rhoads, Mull, Lohr, and Moore farms. Showings of gas associated with salt water were found in the Big Injun sand, in the upper part of the Pocono formation, in the Moore and Rhoads wells, but all four wells were abandoned as dry holes. The well on the Moore farm, which was sunk to a depth of 4,695 feet, is the deepest of these tests. The record of this well, which was started in the Allegheny formation, shows that it passed through the Pottsville, Mauch Chunk, Pocono, and Catskill formations and penetrated about 900 feet into the Chemung formation.

As the wells on the Boswell dome were practically dry holes, attempts to exploit that dome further were abandoned, and tests were made of the area adjacent to that in which gas was originally obtained on the Long farm (later the O. S. Miller farm), northeastward and southwestward approximately along the strike of the rocks. Wells were sunk on the O. S. Miller, W. H. Miller, Irwin Maust, Robert Herwig, and E. W. Emert farms (see economic-geology map) to depths between 2,925 and 3,685 feet, all of the holes passing through and below the horizon in which gas was obtained in the original Long well. In the O. S. Miller well gas was found at a depth of 2,548 feet. The initial capacity of this well is reported to have been 750,000 cubic feet with a reservoir pressure of about 800 pounds per square inch. The gas was used in the Miller farmhouse and in firing the boiler used in drilling the well on the W. H. Miller farm in which gas was found at a depth of 2,660 feet. A reservoir pressure of 850 pounds and an estimated capacity of 1,500,000 cubic feet were reported for this well. The tests on the Irwin Maust and on the Robert Herwig farms resulted in finding only "shows" of gas at depths respectively 2,892 and 2,743 feet; and a well 2,925 feet deep on the E. W. Emert farm 2½ miles southwest of the Long well was a dry hole. In a well on the C. S. Roy farm a "show" of gas was encountered at a depth of 2,285 feet. This well, located in Somerset Township about 1½ miles southeast of Friedens, is on the flank of the Negro Mountain anticline a mile northwest of the axis. Apparently the natural gas in the vicinity of Beaverdam Creek occurs in "pockets" in lenticular sandstone, the stratigraphic position of which is near the middle of the Catskill formation.

A sample of gas from the well on the W. H. Miller farm was analyzed in the Pittsburgh laboratory of the United States Bureau of Mines with the results given on page 12.

This is a dry gas, containing methane as the only combustible constituent and an unusually high percentage of nitrogen. As

[7] Lord, N. W., and others, Analyses of coals in the United States: U. S. Bur. Mines Bull. 22, 1913.

[8] Fieldner, A. C., and others, Analyses of mine and core samples of coal: U. S. Bur. Mines Bull. 85, pp. 6–9, 1914.

[9] White, David, Progressive regional carbonization of coals: Am. Inst. Min. and Met. Eng. Trans., vol. 71, pp. 253–281, 1925.

some nitrogen-rich gases contain helium, tests for that element should be made.

Analysis of natural gas from well on W. H. Miller farm (laboratory No. 54762)

Carbon dioxide (CO_2)	0.0
Oxygen (O_2)	0.0
Methane (CH_4)	84.1
Nitrogen (N_2)	15.9
	100.0
Unsaturated hydrocarbons (C_2H_4, etc.)	0.0

Other test wells in the vicinity of the Somerset and Windber quadrangles have been drilled as follows: A deep hole was put down along the axis of the Laurel Hill anticline in 1927, near the crest of the ridge, in Fairfield Township, Westmoreland County, about 9 miles southwest of Johnstown and 1½ miles north of the Somerset quadrangle. The test started in the Pocono formation; the lowest depth at which water was reported was in the Catskill formation at 2,500 feet; a showing of gas was found at 5,612 feet and the well was sunk to a depth of 6,711 feet, where it was abandoned as a dry hole. Drilling ended in a black shale, which may be the Hamilton formation or possibly the Marcellus shale. The test therefore stopped a relatively short but undetermined distance above the Oriskany sandstone, in which gas occurs in the Tioga County field in Pennsylvania and possibly in the wells below Ligonier.

Between 1918 and 1920 several deep wells were sunk immediately east of the axis of the Chestnut Ridge anticline, the first anticline west of Laurel Hill, succeeding the Ligonier syncline. (See fig. 5.) These wells were drilled in the valley of Loyalhanna Creek about 4 miles below Ligonier. One well, the Peoples Natural Gas Co. No. 1588, was started near the top of the Pocono sandstone and sunk to a depth of 6,822 feet. Gas was found in the bottom of this well in a bed of sand that has been correlated with the Oriskany sandstone. The initial open flow was about 500,000 cubic feet a day. Mr. J. French Robinson, geologist of the company, states that the rock pressure in this well was never taken, as it was deemed advisable not to close the hole for the purpose of measuring the high pressure. Another deep hole sunk near by to a depth of 7,756 feet, at the time it was completed was the deepest well in the world. In this well small quantities of gas were encountered at two horizons, at 6,827 feet (Oriskany?) and at 7,428 and 7,440 feet in the Cayuga group? (Silurian). The record of this well, as reported by the driller, is given below as an indication of the rocks that may be penetrated in deep drilling in this area.

Another test of the Chestnut Ridge anticline was made about 15 miles southwest of the wells below Ligonier, in Bullskin Township, Fayette County, about 5 miles southwest of Donegal. This well was reported abandoned as a dry hole at a depth of 3,900 feet.

Record of Booth & Flinn well No. 3 (Peoples Natural Gas Co.'s well No. 1842), 4 miles northwest of Ligonier, Westmoreland County, Pa.

[Record, as reported by the driller, supplied by Peoples Natural Gas Co. Top of well about 200 feet below top of Pocono formation; bottom of well presumably in the Cayuga group (Silurian)]

	Feet
Sand	0–40
Slate	40–60
Sand	60–250
Slate and shells	250–330
Lime	330–388
Sand	388–475
Slate and shells	475–577
Sand	577–600
Slate and shells	600–637
Pink rock	637–645
Lime	645–687
Red rock	687–707
Lime	707–719
Red rock and shells	719–830
Lime	830–880
Red rock	880–900
Gray shale	900–920
Sand	920–980
Red rock	980–990
Sand	990–1,075
Red slate	1,075–1,080
Sand	1,080–1,104
White slate	1,104–1,135
Hard sand	1,135–1,165
Slate	1,165–1,260
Slate and shells	1,260–1,360
Hard white lime	1,360–1,432
White slate	1,432–1,445
White lime	1,445–1,475
Slate	1,475–1,760
Red rock	1,760–1,780
Slate and shells	1,780–1,800
Sand	1,800–1,820
Slate	1,820–1,825
Hard sand	1,825–1,855
Slate and shells	1,855–1,885
Hard sand	1,885–1,920
Shells	1,920–1,985
White slate	1,985–2,025
Slate and shells	2,025–2,100
Slate and sand shells	2,100–2,120
Sand; show of gas at 2,130 feet	2,120–2,135
Shells	2,135–2,250
Lime, dark	2,250–2,280
Hard sand	2,280–2,380
Slate	2,380–2,410
Sand shells	2,410–2,413
Slate	2,413–2,450
Shells	2,450–2,470
Sand	2,470–2,488
Slate and shells	2,488–2,495
Dark sand	2,495–2,610
Slate and shells	2,610–2,670
Dark lime sand	2,670–2,728
Slate	2,728–2,732
Sand	2,732–2,785
Broken sand	2,785–2,825
Slate and shells	2,825–2,910
Hard sand	2,910–2,925
Slate and shells	2,925–2,948
Hard sand	2,948–2,965
Slate and shells	2,965–2,985
Hard lime sand	2,985–3,020
Slate	3,030–3,085
Hard sand	3,085–3,100
Slate and shells	3,100–3,125
Lime sand	3,125–3,155
Slate	3,155–3,175
Sand	3,175–3,185
Slate and shells	3,185–3,225
Sand	3,225–3,255
Slate	3,255–3,420
Sand shells	3,420–3,425
Slate	3,425–3,435
Sand	3,435–3,450
Slate	3,450–3,478
Sand	3,478–3,493
Slate and shells	3,493–3,570
Sand	3,570–3,590
Slate	3,590–3,635
Slate and shells	3,635–3,725
Slate	3,725–3,856
Sandy lime	3,856–3,860
Slate and shells	3,860–4,065
Lime and sand	4,065–4,090
Slate and shells	4,090–4,430
Lime	4,430–4,465
Slate and shells; show of gas at 4,502 feet	4,465–4,810
Sand	4,810–4,820
Slate and shells	4,820–4,840
Hard sand	4,840–4,852
Slate and shells	4,852–5,095
Hard lime	5,095–5,112
Slate and shells	5,112–5,190
Hard lime	5,190–5,225
Gray sand	5,225–5,250
Hard lime	5,250–5,270
Slate and shells	5,270–5,405
Hard lime	5,405–5,440
Slate	5,440–5,445
Lime and sand	5,445–5,460
Black slate	5,460–5,575
Lime	5,575–5,715
Slate	5,715–5,735
Shale	5,735–5,820
Lime	5,820–5,835
Slate	5,835–5,950
Lime	5,950–6,000
Shells and sand	6,000–6,070
Sand	6,070–6,135
Slate	6,135–6,155
Hard lime	6,155–6,205
Slate	6,205–6,250
Slate and shells	6,250–6,315
Hard lime	6,315–6,330
Slate and shells	6,330–6,390
Slate	6,390–6,575
Shale	6,575–6,580
Bad hole	6,580–6,625
Shale	6,625–6,630
Slate	6,630–6,720
Shale	6,720–6,725
Black shale	6,725–6,745
Shale	6,745–6,748
Slate	6,748–6,778
Lime	6,778–6,807
Hard sand (?)	6,807–6,827
Broken sand (?); gas at 6,827 feet	6,827–6,835
Hard gray sand	6,835–6,885
Hard dark sand and flint rock	6,885–7,000
Yellow rock	7,000–7,025
Hard gray sand	7,025–7,075
Dark lime	7,075–7,085
Hard gray and brown sand	7,085–7,120
Sand	7,120–7,145
Black sand	7,145–7,185
Black lime	7,185–7,255
Light-gray sand	7,255–7,260
Hard reddish sand	7,260–7,265
Dark-gray sand	7,265–7,280
Black shale	7,280–7,285
Gray sand lime	7,285–7,370
Hard gray sand (?), close	7,370–7,384
White sand (?); gas at 7,428 feet	7,384–7,428
Dark sand (?); gas at 7,440 feet	7,428–7,756

A satisfactory delimitation of the formations in this well can not be made from the record. A few tentative correlations, however, are suggested. The base of the Pocono formation may be at 637 feet; the presence of "pink rock" and "red rock" between 637 and 1,780 feet indicates the Catskill formation; the black shale between 6,725 and 6,745 feet presumably is Marcellus; "lime" between 6,778 and 6,807 feet suggests the Onondaga limestone; "sand," beginning at 6,807 feet, if it is reported correctly, suggests the Oriskany group; and the gas found at 6,827 feet has been considered to occur in the Oriskany, though doubt is cast on this correlation by C. R. Fettke, who states, in a personal communication to the writer, based on an examination of incomplete cuttings from this well: "From 6,785 to 6,835 feet the cuttings consisted of a cherty limestone practically free from magnesia, which I believe represents the Onondaga." The gas found at 7,428 and 7,440 feet presumably occurs in the Cayuga group (Silurian). Below 5,000 feet the hole is considerably inclined from the vertical, so that the stratigraphic intervals are less than those shown by the record.

The classification of the strata below the Chemung formation, exposed east of the Allegheny Front in Blair and Huntingdon Counties, in the following section measured by Butts,[10] will be helpful in correlating the rocks encountered in deep wells in the Somerset and Windber quadrangles. It should be borne in mind, however, that the beds decrease in thickness toward the west and that differences in lithology are to be expected.

Section of beds below Chemung formation east of Allegheny Front

Age	Formation		Thickness (feet)
Upper Devonian.	Chemung formation.		
	Portage group.	Brallier shale; gray sandy shale	1,350–1,800
		Harrell shale; black fissile shale	250
Middle Devonian.	Hamilton formation; greenish and dark shale and sandstone; some limestone		800–1,200
	Marcellus shale; black fissile shale		150
	Onondaga formation; dark shale and limestone [so called "Corniferous" (source of petroleum in Kentucky)]		50
Lower Devonian.	Oriskany group.	Ridgeley sandstone; coarse sandstone [source of gas in Tioga County field, Pa.]	100
		Shriver limestone; thin bedded siliceous limestone	200
	Helderberg limestone; thick-bedded gray limestone		150
Silurian.	[Cayuga group.]	Tonoloway limestone; thin-bedded dark limestone	450
		Wills Creek shale; dove-colored fissile shale; a little limestone; red and green shale at base	600
		McKenzie limestone; thin-bedded limestone; greenish and red shale	275±
	[Niagara group.]	Clinton formation; greenish shale, some sandstone, thin limestone, and thin beds of iron ore	800
	Tuscarora quartzite; thick-bedded white or gray sandstone [equivalent of Albion sandstone ("White Medina") of New York; this formation is the source of gas in New York and of oil and gas in Ohio]		400
[Ordovician.]	Juniata formation; red or brown shale or sandstone		850

The presence of natural gas in a number of places southeast of the Chestnut Ridge anticline indicates that other occurrences may be found in that region. The results of drilling thus far, however, do not offer much encouragement that large commercial production will be obtained in the Somerset and Windber quadrangles. Nevertheless, the quantity of gas found in a few wells serves as a stimulus to further drilling.

The apparent scarcity of petroleum and natural gas near the eastern margin of the Appalachian Plateaus has been explained by the hypothesis that the progressive metamorphism of the rocks, increasing from west to east in the direction of the more intense diastrophism, has driven out of the strata oil and gas which may originally have been present. The degree of progressive metamorphism is quantitatively indicated by the decrease eastward in volatile matter and the corresponding increase in fixed carbon in the coal as shown by the proximate analyses. From west to east across the bituminous coal field of Pennsylvania the beds pass from high-volatile coal, containing less than 60 per cent of fixed carbon in pure coal, on an ash-free and moisture-free basis, near the western border of the State, to low-volatile coal, in which there is more than 80 per cent of fixed carbon and correspondingly less volatile matter, in the eastern part of the field. David White[11] has called attention to the relation of the occurrence of oil and gas to the quantity of fixed carbon in coal beds. In the Appalachian region the oil fields are mostly west of the line of 65 per cent fixed carbon, and large gas fields have not been found east of the line of 75 per cent. Analyses of coals in these quadrangles show a range in fixed carbon from 75 per cent in the vicinity of Ligonier to 86 per cent in the vicinity of Windber. (See p. 14.)

Other explanations of the apparent scarcity of oil and gas in the area adjacent to the Allegheny Front are as follows: (1) The sands in the eastern part of the Appalachian Plateaus may have had their possible original content of oil and gas flushed out by circulating ground water. However, general conditions are not favorable for vigorous circulation of ground water in the lenticular oil and gas sands of the spoon-shaped Pittsburgh-

[10] Butts, Charles, Geologic section of Blair and Huntingdon Counties, central Pennsylvania: Am. Jour. Sci., 4th ser., vol. 46, pp. 523–537, 1918.
[11] White, David, Some relations in origin between coal and petroleum: Washington Acad. Sci. Jour., vol. 5, pp. 189–212, 1915.

Huntingdon Basin, in which the producing sands are far below the discharge outlet. (2) Abundant deposits of organic matter, from which oil and gas are derived, may not have been laid down in this area.

CLAY AND SHALE

The Somerset and Windber quadrangles contain extensive deposits of clay and shale, but they are little developed, and when the area was surveyed only one clay pit was in operation.

Almost every coal bed is underlain by clay, but the deposits are lenticular and differ in quality, some being very valuable and others practically useless. These deposits are plastic or flint clays according to their chief characteristics. Both varieties are more or less refractory, and the fire clays are adapted for the manufacture of fire brick, crucible linings, and other substances that must stand a high temperature. This quality is due to the low percentage of alkalies, alkaline earths, and iron contained in the clays, these substances presumably having been removed from the soils, now the clay beds, during the growth of the plants that formed the overlying coal. The plastic clays are characterized by the fact that they can be readily molded; the flint clays, on the other hand, can not be molded and are typically hard and brittle and break with a conchoidal fracture. The purer varieties of flint clay closely approach in composition the mineral kaolinite, which is a hydrous silicate of aluminum, and are more refractory than the soft clays.

In these quadrangles clay is reported in many drill records, and doubtless prospecting at the chief horizons will reveal the presence of valuable deposits. The principal horizons of clay are a few feet below the Upper Freeport coal, where locally there is a valuable bed known as the Bolivar clay; near the Upper Kittanning coal; almost immediately below the Lower Kittanning coal, where there is a widespread deposit of soft clay; about 60 feet below the Lower Kittanning coal, immediately below a bed of coal in the approximate position of the Clarion; and in the Mercer member of the Pottsville formation. Drill records show that clay at all these horizons in places in these quadrangles attains a thickness greater than 5 feet.

The only clay pit that was in operation when this area was surveyed, in 1913 and 1914, was that of the Windber Clay Manufacturing Co., at the southeast end of the borough of Windber, where rather extensive operations have been conducted. This pit was first opened about 1900. The following section is exposed:

Section at Windber Clay Manufacturing Co.'s pit

	Ft.	in.
Shale, gray	10+	
Coal, Clarion	1	10
Clay, gray, hard	9	
Base not exposed.		

This clay bed is approximately 60 feet below the Lower Kittanning coal. A sample of the clay, collected by the writer in 1914, was tested by P. H. Bates, of the Bureau of Standards, who reports as follows:

It required only 12.2 per cent of water to make the clay plastic, which is very much below the average. The plasticity of the material is low, and difficulty would be experienced in molding it in the auger machine or sewer-pipe press. Specimens of this clay were fired to different temperatures and the following results obtained:

Temperature (°C)	Porosity (per cent)	Color
1,150	13.37	Buff.
1,175	8.55	Do.
1,200	9.00	Do.
1,225	10.18	Dark gray.
1,250	11.80	Dark gray, overburned.
1,275	15.25	Do.
1,300	16.50	Do.

This clay also seemed to carry an appreciable amount of carbonaceous material, which would increase somewhat the difficulty and time of burning. The results obtained seem to indicate that the clay is a low-grade No. 3 fire clay that readily overburns and develops a vesicular structure. It seems that the clay can not be readily burned to a vitrified and dense product. The color is not very desirable. From these facts it appears that although the clay might be employed in the manufacture of common brick, hollow blocks, fireproofing, and similar materials, it does not appear to be adapted for the manufacture of face brick and sewer pipe.

By mixing the clay with shale in the proportions of two parts clay to one part shale, paving brick can be made, and in 1915 about half the product of this plant consisted of paving brick.

Clay at the same horizon as the bed at Windber—below the Clarion coal—has been prospected along the railroad at Reitz, 7 miles south of Windber, and about a mile south of Arrow.

Shale in practically inexhaustible quantity is available in these quadrangles for making brick. The chief horizons from which shale is obtained for brick-making in adjacent areas are in the lower third of the Conemaugh formation. The shale ranges in texture from fine to coarse and in composition from argillaceous to sandy.

SANDSTONE

The supply of sandstone in these quadrangles suitable for rough structural work is abundant. The most valuable beds are the Morgantown and Mahoning members of the Conemaugh formation, the Kittanning member of the Allegheny formation, the Homewood and Connoquenessing members of the Pottsville formation, and sandstones in the Pocono, Catskill, and Chemung formations. Some of these sandstones have been used locally in the construction of houses and rather generally in foundations and bridge culverts.

Most of the sandstones are gray to buff and varitextured, ranging from fine to coarse grained. The Catskill sandstone is red. They are arkosic and are composed chiefly of quartz and kaolinized feldspar. Some of the beds, notably the Kittanning, Homewood, and Connoquenessing, contain less feldspar and are more indurated than the others, and locally they consist of almost pure quartz grains in a siliceous matrix.

The sandstones of these quadrangles have been but little developed, and only two quarries were in operation when the writer examined the area. In the eastern part of the town of Boswell the Kittanning sandstone, which in that vicinity is unusually thick, is crushed for use in making concrete. At Rowena, a station on the Baltimore & Ohio Railroad south of Hooversville, the Kittanning sandstone is crushed, washed to remove clay, and shipped to Johnstown. A number of small quarries have been opened on the Morgantown sandstone in the vicinity of Ligonier. In general even the prevailingly quartzose sandstones of this area contain too much iron to render them desirable for use in making glass, although certain selected beds in the whiter portions of the Homewood and Connoquenessing members of the Pottsville formation may be suitable for this purpose. Beds of sandstone in the Pottsville and Pocono formations are quarried locally for road metal.

LIMESTONE

A number of beds of limestone occur in the Somerset quadrangle, the most valuable of which are the Loyalhanna, a bed in the overlying Mauch Chunk shale, the Johnstown, Upper and Lower Freeport, Brush Creek, Ewing (?), Clarksburg, and Upper Pittsburgh. Each of these beds has been quarried at one place or another within the quadrangle, principally for making lime for fertilizing. Lime is needed on the soils of this region and is much used. On most of the farms where limestone is known to crop out it has been quarried and burned. There is a tendency, however, for the farmers to buy their lime already burned, derived from places outside the quadrangles.

Most of the beds of limestone are thin, none except the Loyalhanna being much more than 10 feet thick; in general the thickness averages 5 feet or less. The Loyalhanna limestone, on the other hand, is 40 feet thick and has been quarried in several places for use as road metal and along the Pittsburgh, Westmoreland & Somerset Railroad 3 miles southwest of Laurel Summit for use chiefly as a paving stone. This rock does not stand the weather well, and for that reason it is not a good building stone.

The following analyses show the composition of some of the beds of limestone:

Composition of limestone from Somerset quadrangle

[Analyst, W. C. Wheeler]

	Loyalhanna	Limestone bed in Mauch Chunk shale	Johnstown	Ewing (?)	Clarksburg	Upper Pittsburgh
Insoluble	47.60	22.22	3.48	4.21	3.37	3.43
$Fe_2O_3+Al_2O_3$	2.58	12.32	2.44	2.72	2.05	2.46
MgO	.42	1.12	.69	1.23	.69	5.30
CaO	27.08	33.35	51.30	49.72	51.76	45.60
Loss on ignition	22.41	29.39	41.92	41.64	42.04	43.07
	100.09	98.40	99.83	99.52	99.91	99.86

The table shows that the samples of the Johnstown, Ewing (?), and Clarksburg beds are limestones of low-magnesium content, and so far as composition is concerned they are adapted for most of the uses to which limestone is put. The considerable magnesium in the sample of Upper Pittsburgh limestone indicates that it is not well adapted for making Portland cement. The large amount of insoluble matter in the sample from the Mauch Chunk shale presumably is not typical, because limestone from that formation has a local reputation for making good lime. The large quantity of insoluble matter chiefly sand, in the Loyalhanna limestone is characteristic. It might with equal propriety be called a calcareous sandstone or a siliceous limestone. The stone makes good road metal and railroad ballast and is also used for paving blocks.

IRON ORE

Iron carbonate, the mineral siderite, in this region occurs at several horizons in the Conemaugh and Allegheny formations either associated with limestone or as disseminated nodules in shale. The iron carbonate occurs in two forms—clay ironstone and black band. Both forms contain considerable earthy matter. The clay ironstone is gray where freshly broken and the black band is discolored by the presence of organic matter in thin streaks or bands parallel to the bedding. The most prominent horizons are in the Mahoning sandstone, the Johnstown limestone, and the Lower Kittanning and Clarion coal beds. The clay ironstone occurs chiefly disseminated in shale as nodules or concretionary masses, which in places coalesced to form irregular beds. In some places iron carbonate is associated with limestone, which seemingly it has replaced. Likewise the nodular ore presumably is of secondary origin. Apparently it was originally disseminated through the beds and was segregated around nuclei by percolating solutions. On exposure to the atmosphere the ore tends to oxidize to limonite and hematite.

The Somerset and Windber quadrangles contain the remains of several old iron furnaces that were operated during the first half of the last century. In Westmoreland County the Washington furnace stood a few hundred feet north of the Pittsburgh and Philadelphia road, 4½ miles southeast of Ligonier, and the Westmoreland and California furnaces were in the valley of Furnace Run, about 1½ miles south of Laughlintown. In Somerset County the Shade furnace on Shade Creek, 4½ miles east of Hooversville, and an old furnace at Forwardstown and another on Pickings Run, half a mile up from Klines Mill, were small charcoal furnaces that reduced carbonate ores. Mining was conducted by stripping the outcrop. The ore supply, however, was small and of irregular occurrence, and after the introduction of the coking furnace and of the Lake Superior ores the old iron furnaces in western Pennsylvania were abandoned. The deposits can not be worked profitably under present conditions.

WATER

The annual rainfall of 40 to 50 inches insures the water supply, which is derived from streams and wells.

The streams of this region, although small, generally furnish potable water in their upper courses. Some of those that head in the uninhabited portions of Allegheny Mountain and Laurel Hill are impounded in reservoirs within the upland area above sources of contamination, and they furnish supplies acceptable for town use. Windber and Ligonier are supplied with impounded water in this manner. Windber obtains its water from Clear Shade Creek, and Ligonier from Furnace Run north of the Pittsburgh and Philadelphia road. The streams that flow through populated districts become contaminated and are unfit for domestic use.

The acid wastes from coal mines cause trouble by inducing corrosion of pipes, formation of boiler scale, and general destruction of metal. Streams polluted in this manner are recognizable by a greenish, reddish, or brownish coloration of the water caused by the precipitation of iron. Stony Creek, for example, above Mostoller is clear, but below the mouth of Wells Creek, which carries the drainage of several mines, its water is distinctly brownish red.

Springs are numerous, although generally small. They emerge at the outcrops of porous beds of sandstone that overlie relatively impervious beds of limestone, clay, or coal.

Quemahoning Reservoir, in the northwestern part of the Windber quadrangle, is one of the large artificial bodies of water in Pennsylvania. The waters of Quemahoning Creek are impounded by an earth dam with cement core constructed in the narrows 2 miles above Hollsopple. The water is piped to Johnstown, where it is used by the Johnstown Water Users Association in manufacturing plants.

Water in wells is obtainable, chiefly from the more persistent beds of sandstone, especially from those lying near the surface. Most of the wells yield good supplies, and if they are located toward the axes of synclines the water in many places is under sufficient pressure to flow; in fact, flowing wells have been obtained in all the basins.

In general wells less than 100 feet deep are the chief source of water. One of the deepest water wells, on the farm of Isaiah Buechley 1 mile west of Ralphton, is reported to have been drilled 344 feet to the Homewood sandstone before an adequate supply was found. The town of Somerset derives its water supply from wells. In 1913 three wells, 120 to 150 feet deep, drilled into the Mahoning sandstone, were sufficient to supply the needs of the town.

The water from the shallow wells is generally low in its content of dissolved mineral matter. Salt water, however, was reported in the Pocono formation in the deep wells sunk in search of natural gas northeast of Somerset, but little or no water was reported in the underlying Catskill beds.

SOILS

The soils of the Somerset and Windber quadrangles are practically all residual and result from the disintegration and decomposition of the immediately underlying rocks. The gently rolling country that forms the greater part of the quadrangles, in which the shale and thin-bedded sandstone of the Allegheny and Conemaugh formations crop out, is characterized by sandy and clay loams. These soils are commonly fine grained and moderately fertile and, when properly fertilized and tilled, yield excellent returns. The chief crops are corn, oats, wheat, rye, buckwheat, and hay.

The areas that are directly underlain by the massive sandstones of the Pottsville and Pocono formations, conspicuously Allegheny Mountain and Laurel Hill, are characterized by sandy soils, and large tracts in the mountains are strewn with blocks of sandstone. On account of the rough topography and lean soil these uplands are not adapted for farming but remain a forested wilderness in the midst of a rather thickly populated region. Likewise, where beds of massive sandstone crop out in steep, narrow valleys adjacent to Stony Creek and some of its tributaries, neither the soil nor the lay of the land is suitable for cultivation, and such areas also are occupied by forest. However, a few small patches on the tops of Allegheny Mountain and Laurel Hill that are underlain by erosion remnants of red shale of the Mauch Chunk formation are cultivated. The Catskill red beds east of Allegheny Mountain also yield a loamy soil. At the immediate base of the mountain the slopes are too steep to afford the best conditions for agriculture, but where the surface is more undulating the soils derived from the Catskill formation yield good crops. In the southeast corner of the Windber quadrangle the soils, which are derived from the Chemung formation, are sandy and clay loams that are similar to those derived from the Allegheny and Conemaugh formations.[12]

Because of the absence of broad valleys and large streams in these quadrangles there are no extensive areas of bottom lands filled with transported alluvial soils. Only in a few places, as in the valley of Loyalhanna Creek in the vicinity of Ligonier, are considerable areas of alluvium under cultivation.

[12] Shaw, C. F., and Byers, W. C., A reconnaissance soil survey of south-central Pennsylvania: U. S. Dept. Agr. Bur. Soils Field Operations, 1910, pp. 193–265, 1912.

Analyses of samples of coal from the Somerset and Windber quadrangles, Pa.

[Made by the Bureau of Mines]

Name of mine and coal	No. on map[a]	Laboratory No.	Form of analysis[b]	Proximate: Moisture	Proximate: Volatile matter	Proximate: Fixed carbon	Proximate: Ash	Ultimate: Sulphur	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Heating value (British thermal units)
Wilmore Basin													
Eureka No. 30	W 17	9019	A	3.1	15.0	74.8	7.07	1.85	4.58	80.78	1.32	4.40	14,100
Lower Kittanning (B)		(Composite of	C		15.5	77.2	7.30	1.91	4.37	83.37	1.36	1.69	14,550
		8945–8948)	D		17.0	83.0	....	2.06	4.71	89.93	1.47	1.83	15,690
Eureka No 33	W 10	9023	A	4.6	13.5	76.7	5.18	.75	4.68	81.68	1.35	6.39	14,360
Lower Kittanning (B)		(Composite of	C		14.0	80.6	5.43	.79	4.38	85.66	1.42	2.37	15,060
		8954–8958)	D		15.0	85.0	....	.84	4.58	90.58	1.50	2.50	15,920
Eureka No. 34	W 11	9024	A	3.2	14.0	75.9	6.90	1.31	4.47	80.57	1.24	5.51	14,140
Lower Kittanning (B)		(Composite of	C		14.5	78.4	7.12	1.35	4.25	83.24	1.28	2.76	14,610
		8961–8963)	D		15.5	84.5	....	1.45	4.58	89.62	1.38	2.97	15,730
Eureka No. 32	W 12	9022	A	3.3	13.0	79.0	4.66	.78	4.48	83.67	1.24	5.17	14,550
Lower Kittanning (B)		(Composite of	C		13.5	81.7	4.82	.81	4.25	86.53	1.28	2.31	15,050
		8949–8953)	D		14.0	86.0	....	.85	4.47	90.91	1.34	2.43	15,810
Eureka No. 35–B	W 13	8939	A	3.5	12.4	77.6	6.43	1.31	4.61	81.17	1.21	5.27	14,130
Lower Kittanning (B)		(Composite of	C		13.0	80.3	6.66	1.36	4.37	84.12	1.25	2.24	1,6504
		8873–8876)	D		14.0	86.0	....	1.46	4.68	90.13	1.34	2.39	15,690
Eureka No. 36–B	W 7	9026	A	4.3	12.0	78.1	5.59	1.36	4.48	81.76	1.26	5.55	14,300
Lower Kittanning (B)		(Composite of	C		12.5	81.7	5.84	1.42	4.19	85.41	1.32	1.82	14,940
		8920–8921 and 8925)	D		13.5	86.5	....	1.51	4.45	90.71	1.40	1.93	15,860
Berlin Basin													
Loyal Hanna No. 6	W 86	19850	A	3.4	17.2	73.0	6.45	0.83	4.75	81.53	1.43	5.01	14,100
Lower Kittanning (B)		(Composite of	C		17.7	75.6	6.68	.86	4.52	84.39	1.48	2.07	14,600
		19848 and 19849)	D		19.0	81.0	....	.92	4.84	90.43	1.59	2.22	15,640
Somerset Basin													
Stauffer No. 1	S 47	10455	A	0.9	17.2	73.9	8.00	0.71	4.51	81.72	1.35	3.71	14,160
Upper Freeport (E)		(Composite of	C		17.4	74.5	8.07	.72	4.45	82.48	1.36	2.92	14,470
		305–307)	D		18.9	81.1	....	.78	4.84	89.72	1.48	3.18	15,750
Stauffer No. 3	W 77	17695	A	2.9	18.7	73.2	5.19	.63	4.82	82.90	1.42	5.04	14,350
Lower Freeport (D)			C		19.3	75.4	5.34	.65	4.63	85.37	1.46	2.55	14,780
			D		20.4	79.6	....	.69	4.89	90.18	1.54	2.70	15,620
Ralphton No. 4	S 34	12202	A	1.3	14.9	75.8	7.95	.66	4.28	81.59	1.35	4.17	14,210
Upper Kittanning (C′)		(Composite of	C		15.2	76.7	8.06	.67	4.19	82.69	1.37	3.02	14,400
		W19633–W19635 and W19637)	D		16.5	83.5	....	.73	4.56	89.94	1.49	3.28	15,660
Eureka No. 39–C	W 29	9030	A	3.3	13.0	75.4	8.34	1.50	4.29	79.79	1.81	4.77	13,980
Upper Kittanning (C′)		(Composite of	C		13.5	77.9	8.63	1.55	4.05	82.53	1.85	1.89	14,410
		8969–8974)	D		14.5	85.5	....	1.70	4.43	90.33	1.48	2.06	15,770
Haws No. 3	W 34	15082	A	3.0	16.6	73.3	8.15	2.46	4.37	80.24	1.28	3.50	14,110
Lower Kittanning (B)		(Composite of	C		16.9	74.8	8.32	2.51	4.23	81.87	1.31	1.76	14,400
		15079–15081)	D		18.5	81.5	....	2.74	4.61	89.30	1.43	1.92	15,700
Johnstown Basin													
Belmont No. 2	S 22	12209	A	1.2	15.6	74.2	8.97	1.39	4.31	80.74	1.36	3.23	14,100
Upper Kittanning (C′)		(Composite of	C		15.8	75.1	9.08	1.41	4.23	81.72	1.38	2.18	14,270
		19536–19539 and 19943)	D		17.4	82.6	....	1.55	4.65	89.88	1.52	2.40	15,690
Jerome No. 2	W 36	12224	A	1.4	15.2	73.4	9.97	.90	4.17	79.43	1.34	4.19	13,800
Upper Kittanning (C′)		(Composite of	C		15.4	74.5	10.12	.91	4.07	80.59	1.36	2.95	14,000
		W19638–W19642)	D		17.2	82.8	....	1.01	4.53	89.66	1.51	3.29	15,580
Jerome No. 2	W 36	A56329	A	3.0	16.3	73.3	7.4	.7	4.7	80.2	1.4	5.6	13,990
Upper Kittanning (C′)			C		16.8	75.5	7.7	.7	4.5	82.6	1.5	3.0	14,410
			D		18.2	81.8	....	.8	4.8	89.5	1.6	3.3	15,610
Consolidation Nos. 118 and 119	S 18	6266	A	4.2	15.7	73.8	6.29	.63	....	....	....	....	14,090
Upper Kittanning (C′)			C		16.4	77.1	6.57	.66	....	....	....	....	14,720
			D		17.5	82.5	....	.71	....	....	....	....	15,750
Orenda No. 2	S 15	6268	A	3.4	15.5	74.8	6.32	.70	....	....	....	....	14,160
Upper Kittanning (C′)			C		16.0	77.5	6.54	.72	....	....	....	....	14,660
			D		17.2	82.8	....	.77	....	....	....	....	15,680
Ligonier Basin													
John Dyer, 3 miles southeast of Ligonier	....	17901	A	2.6	21.4	64.4	11.6	1.9	4.6	75.8	1.3	4.8	13,370
Upper Freeport (E)			C		22.0	66.1	11.9	2.0	4.5	77.8	1.3	2.5	13,720
			D		25.0	75.0	....	2.3	5.1	88.4	1.5	2.7	15,580

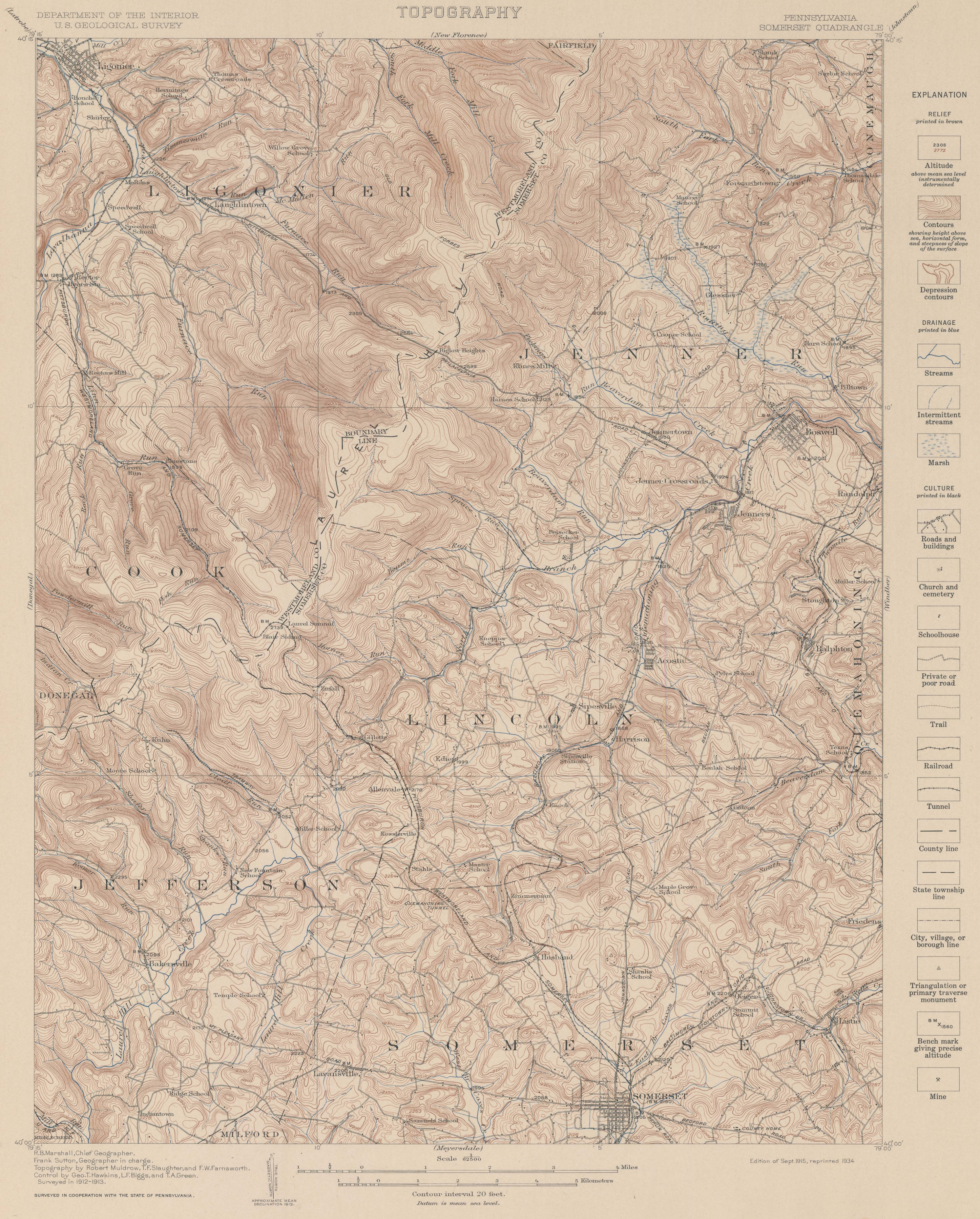
[a] S, Somerset quadrangle; W, Windber quadrangle.

[b] A, Sample "as received" at the laboratory; C, sample dried at a temperature of 105° C.; D, sample free from moisture and ash.

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

TOPOGRAPHY

PENNSYLVANIA
SOMERSET QUADRANGLE



R.B.Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by Robert Muldrow, T.F.Slaughter, and F.W.Farnsworth.
Control by Geo.T.Hawkins, L.F.Biggs, and T.A.Green.
Surveyed in 1912-1913.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

APPROXIMATE MEAN DECLINATION 1913.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.

Edition of Sept. 1915, reprinted 1934

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

AREAL GEOLOGY

PENNSYLVANIA
SOMERSET QUADRANGLE

EXPLANATION

SEDIMENTARY ROCKS

(subaqueous deposits shown by parallel lines)

CARBONIFEROUS

Pennsylvanian

Cm — **Monongahela formation**
(sandy and clay shale with Pittsburgh coal at base; only the lower few feet of formation present)

Cam, Ccm, Ce — **Conemaugh formation with Ames and Ewing (?) limestone members**
(gray shale, sandstone, and clay, including some red shale and thin beds of limestone and coal; the Ames limestone member, Cam is mapped in the Ligonier Basin, and the Ewing (?) limestone member Ce is mapped in part of the Johnstown Basin)

Ca — **Allegheny formation**
(chiefly gray and dark shale with local beds of clay and sandstone and several workable beds of coal; Upper Freeport coal at top; Johnstown limestone member directly underlies the Upper Kittanning coal)

Cpv — **Pottsville formation**
(heavy-bedded gray sandstone with interbedded shale, clay, and thin beds of coal)

UNCONFORMITY

Mississippian

Cmc — **Mauch Chunk shale**
(red and green shale with subordinate sandstone and thin lenses of limestone)

Clh — **Loyalhanna limestone**
(siliceous limestone)

Cpo — **Pocono formation**
(gray sandstone and sandy shale)

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TRUE NORTH — MAGNETIC NORTH — APPROXIMATE MEAN DECLINATION 1926

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

Edition of Mar. 1934

Geology by G. B. Richardson.
Surveyed in 1913.

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

ECONOMIC GEOLOGY

PENNSYLVANIA
SOMERSET QUADRANGLE

EXPLANATION

SEDIMENTARY ROCKS

(*subaqueous deposits shown by parallel lines*)

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ECONOMIC AND STRUCTURE DATA

Coal outcrops

pb *Pittsburgh coal*
uf *Upper Freeport coal*
uk *Upper Kittanning coal and underlying Johnstown limestone member*
lk *Lower Kittanning coal*

2500 / 2400 — Structure contours drawn on horizon of Johnstown limestone member of Allegheny formation, immediately underlying the Upper Kittanning coal (*contour interval, 50 feet; datum, mean sea level*)

Coal mine shaft
Coal mine (*unless otherwise specified*)
Country coal bank
ss *Sandstone quarry*
LS *Limestone quarry* (*mostly abandoned*)
Gas well
Dry hole

LIST OF COAL MINES

Location indicated on the map by numbers

1. Saylor
2. Orenda No. 5
3. Orenda No. 4
4. Orenda No. 3
5. Consolidation No. 123
6. Ralphton No. 14
7. Forge No. 4
8. Forge No. 6
9. Forge No. 5
10. Consolidation No. 127
11. Consolidation No. 126
12. Consolidation No. 125
13. Berkey
14. Antoinette
15. Orenda No. 2
16. Hurd
17. Kelly
18. Consolidation Nos. 118 and 119
19. Crescent
20. Alex
21. Belmont Nos. 4 and 5
22. Belmont Nos. 2 and 3
23. Consolidation Nos. 120 and 121
24. Quamahoning Creek No. 1
25. Quamahoning Creek No. 2
26. Alexander
27. Horner
28. Thermal No. 3
29. Steffey No. 2
30. Steffey No. 3
31. Premier
32. Ralphton No. 2
33. Consolidation No. 117
34. Ralphton No. 4
35. Ralphton No. 7
36. Ralphton No. 5
37. Ralphton No. 1
38. Ralphton No. 3
39. Brant
40. Ralphton No. 6
41. Auman
42. Davis
43. Highland
44. Woy
45. Neva
46. Thermal No. 2
47. Stauffer Nos. 1 and 4
48. Consolidation No. 115
49. Louise
50. Junior

LIST OF WELLS

Location indicated on the map by numbers

1. Rhoads
2. Lohr
3. Mull
4. Moore
5. Herwig (show of gas)
6. Maust (show of gas)
7. W. H. Miller
8. O. S Miller
9. Long
10. Bowman
11. Boytz
12. Emmert

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TRUE NORTH / MAGNETIC NORTH / $5\frac{1}{2}°$
APPROXIMATE MEAN DECLINATION 1926

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

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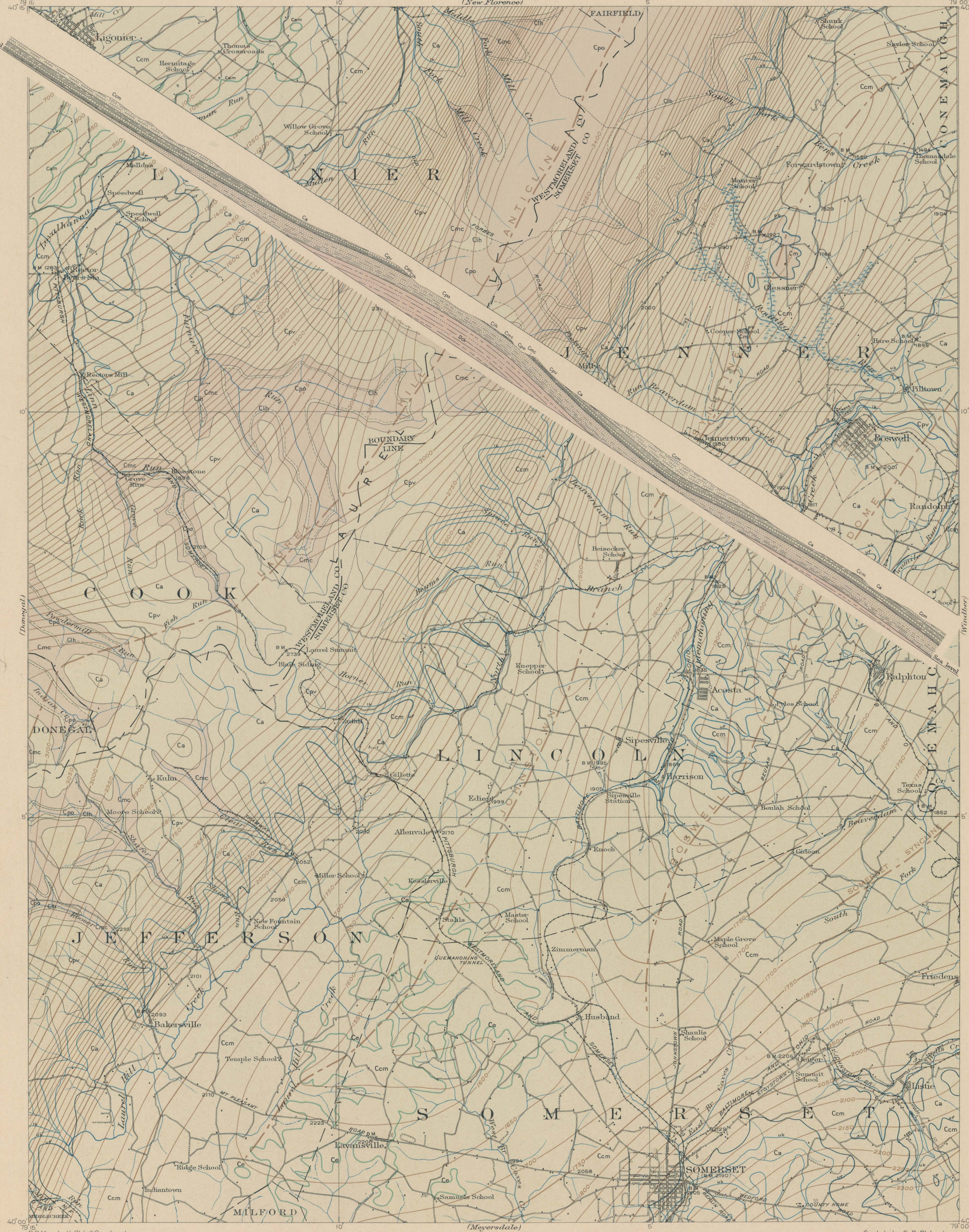
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

STRUCTURE SECTION

PENNSYLVANIA
SOMERSET QUADRANGLE



EXPLANATION

SEDIMENTARY ROCKS

SHEET SYMBOL — SECTION SYMBOL

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UNCONFORMITY

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(red and green shale with subordinate sandstone and thin lenses of limestone)

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(siliceous limestone)

Cpo — Pocono formation
(gray sandstone and sandy shale)

DEVONIAN — Upper Devonian

Dck — Catskill formation

ECONOMIC AND STRUCTURE DATA

Coal outcrops
pb *Pittsburgh coal*
uf *Upper Freeport coal*
uk *Upper Kittanning coal and underlying Johnstown limestone member*
lk *Lower Kittanning coal*

Structure contours drawn on horizon of Johnstown limestone member of Allegheny formation, immediately underlying the Upper Kittanning coal
(contour interval, 50 feet; datum, mean sea level)

R.B.Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by Robert Muldrow, T.F.Slaughter, and F.W.Farnsworth.
Control by Geo.T.Hawkins, L.F.Biggs, and T.A.Green.
Surveyed in 1912-1913.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH — MAGNETIC NORTH — APPROXIMATE MEAN DECLINATION 1926.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

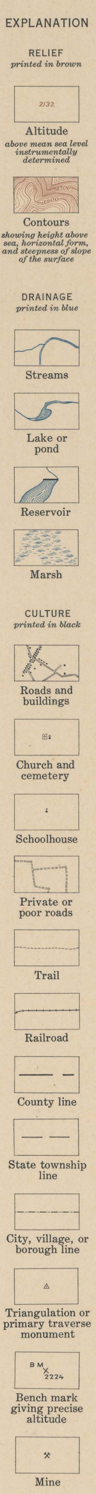
Edition of Mar. 1934

Geology by G. B. Richardson.
Surveyed in 1913.

DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

TOPOGRAPHY

PENNSYLVANIA
WINDBER QUADRANGLE



ENGRAVED 1916 BY U.S.G.S.

R.B. Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by Robert Muldrow, Oscar Jones,
E.E. Witherspoon, and E.D. Monroe.
Control by Geo. T. Hawkins and T.A. Green.
Surveyed in 1913-1914.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1913.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

Edition of 1916, reprinted 1934.

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

AREAL GEOLOGY

PENNSYLVANIA
WINDBER QUADRANGLE

(New Florence) (Johnstown) (Ebensburg)

(Somerset) (Bedford) (Meyersdale)

R.B. Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
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TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1926.

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1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.
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Surveyed in 1914.

EXPLANATION

SEDIMENTARY ROCKS

(subaqueous deposits shown by parallel lines)

CARBONIFEROUS

Pennsylvanian

Ccm — Conemaugh formation
(gray shale, sandstone, and clay, including some red shale and thin beds of limestone and coal)

Ca — Allegheny formation
(chiefly gray and dark shale with local beds of clay and sandstone and several workable beds of coal; Upper Freeport coal at top; Johnstown limestone member directly underlies the Upper Kittanning coal)

Cpv — Pottsville formation
(heavy-bedded gray sandstone with interbedded shale, clay, and thin beds of coal)

UNCONFORMITY

Mississippian

Cmc — Mauch Chunk shale
(red and green shale with subordinate sandstone and thin lenses of limestone)

Clh — Loyalhanna limestone
(siliceous limestone)

Cpo — Pocono formation
(gray sandstone and sandy shale)

DEVONIAN

Upper Devonian

Dck — Catskill formation
(red sandstone and shale)

Dch — Chemung formation
(greenish-gray sandstone and shale)

ECONOMIC GEOLOGY

R.B.Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by Robert Muldrow, Oscar Jones, E.E.Witherspoon, and E.D.Monroe.
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TRUE NORTH
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ECONOMIC AND STRUCTURE DATA

Coal outcrops
uf *Upper Freeport coal*
uk *Upper Kittanning coal and underlying Johnstown limestone member*
lk *Lower Kittanning coal*

2700 2800 — **Structure contours drawn on horizon of Lower Kittanning coal**
(contour interval, 50 feet; datum, mean sea level)

Coal mine shaft
Coal mine (unless otherwise specified)
Country coal bank
ss *Sandstone quarry*
Clay or shale pit
18° *Strike and dip of stratified rocks*
Dry hole, show of gas

LIST OF COAL MINES

Location indicated on the map by numbers

1. Eureka No. 42
2. Murphy Hill
3. Lochrie No. 1
4. Heckler-Faust
5. Allison
6. Eureka No. 41
7. Eureka No. 36-B
8. Eureka No. 36-C
9. Egolf No. 3
10. Eureka No. 33
11. Eureka No. 34
12. Eureka No. 32
13. Eureka No. 35-B
14. Eureka No. 35-C
15. Eureka No. 31
16. Windber Fuel
17. Eureka No. 30
18. Phillips
19. Paint Creek
20. Reitz No. 5
21. Lehman & Estep
22. Cambria No. 1
23. Cambria No. 2
24. Knickerbocker No. 7-C
25. Knickerbocker No. 7-B
26. Thermal No. 10
27. Thermal No. 9
28. Eureka No. 39-B
29. Eureka No. 39-C
30. Eureka No. 38
31. Maple Ridge No. 3
32. Maple Ridge No. 2
33. Haws No. 2
34. Haws No. 3
35. Haws No. 1
36. Jerome Nos. 1 and 2
37. Hiyasota
38. Eash
39. Pretoria
40. Consolidation No. 116
41. Knickerbocker No. 5
42. Knickerbocker No. 6
43. Standard Quemahoning No. 2
44. Standard Quemahoning No. 1
45. Randolph
46. Somerset Creek Nos. 1 and 2
47. Knickerbocker No. 3
48. Old Colony
49. Knickerbocker No. 2
50. Custer
51. Knickerbocker No. 1
52. Elma No. 1
53. Elma No. 2
54. Rowena
55. Knickerbocker No. 4
56. Ralphton No. 15
57. Hillcrest
58. Ralphton Nos. 8 and 9
59. Bowman No. 2
60. Roy No. 7
61. Bowman No. 1
62. Reading No. 3
63. Reading No. 4
64. Hite No. 1
65. Hite No. 2
66. Sanner
67. Reading No. 2
68. Reading No. 1
69. Ritter No. 1
70. Ritter No. 2
71. Madeira
72. Boswell
73. Big Six
74. Stauffer No. 2
75. Adams No. 1
76. Adams No. 2
77. Stauffer No. 3
78. Hagevo No. 4
79. Hagevo No. 1
80. Arrow No. 1
81. Huskin No. 1
82. Shade Creek No. 3
83. Shade Creek No. 1
84. Arrow Nos. 5 and 6
85. Thermal No. 11
86. Loyal Hanna No. 6
87. Loyal Hanna No. 7
88. Reitz No. 2
89. Reitz No. 1
90. Inez
91. Egolf
92. Reitz No. 4
93. Reitz No. 3-C
94. Reitz No. 3-B
95. Reitz No. 7
96. Huskin No. 3

STRUCTURE SECTION

EXPLANATION

SEDIMENTARY ROCKS

SHEET SYMBOL	SECTION SYMBOL	Formation		
Ccm	Ccm	**Conemaugh formation** (gray shale, sandstone, and clay, including some red shale and thin beds of limestone and coal)	Pennsylvanian	CARBONIFEROUS
uk uf Ca lk	Ca	**Allegheny formation** (chiefly gray and dark shale with local beds of clay and sandstone and several workable beds of coal; Upper Freeport coal at top; Johnstown limestone member directly underlies the Upper Kittanning coal)	Pennsylvanian	CARBONIFEROUS
Cpv	Cpv	**Pottsville formation** (heavy-bedded gray sandstone with interbedded shale, clay, and thin beds of coal)	Pennsylvanian	CARBONIFEROUS
		UNCONFORMITY		
Cmc	Cmc	**Mauch Chunk shale** (red and green shale with subordinate sandstone and thin lenses of limestone)	Mississippian	CARBONIFEROUS
Clh	Clh	**Loyalhanna limestone** (siliceous limestone)	Mississippian	CARBONIFEROUS
Cpo	Cpo	**Pocono formation** (gray sandstone and sandy shale)	Mississippian	CARBONIFEROUS
Dck	Dck	**Catskill formation** (red sandstone and shale)	Upper Devonian	DEVONIAN
Dch	Dch	**Chemung formation** (greenish-gray sandstone and shale)	Upper Devonian	DEVONIAN

ECONOMIC AND STRUCTURE DATA

Coal outcrops

uf Upper Freeport coal
uk Upper Kittanning coal and underlying Johnstown limestone member
lk Lower Kittanning coal

2700 — 2800

Structure contours drawn on horizon of Lower Kittanning coal
(contour interval, 50 feet; datum, mean sea level)

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APPROXIMATE MEAN DECLINATION 1926.

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1 ½ 0 1 2 3 4 Miles

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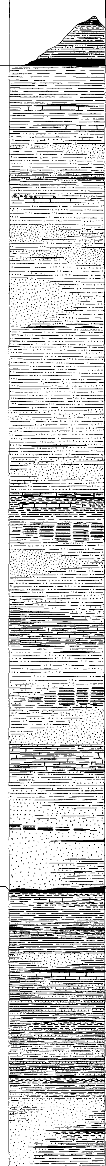
COLUMNAR SECTIONS

SECTION OF CONEMAUGH AND ALLEGHENY FORMATIONS IN THE SOMERSET AND WINDBER QUADRANGLES.

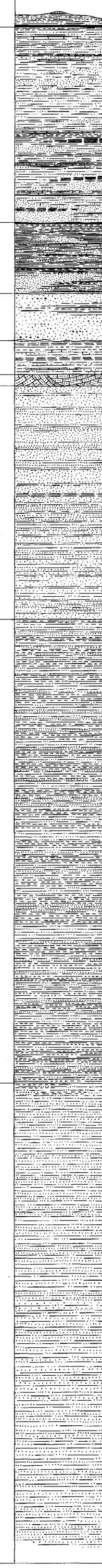
SCALE: 1 INCH = 100 FEET.



System.	Series.	Formation.	Section.	Thickness in feet.	Minor Divisions.
CARBONIFEROUS	PENNSYLVANIAN	Monongahela formation.		0-80	Pittsburgh coal.
		Conemaugh formation.		850-870	Upper Pittsburgh limestone member. Connellsville sandstone member. Clarksburg limestone member. Morgantown sandstone member. Ames limestone member. Harlem coal. Ewing (?) limestone member. Red shale ("Pittsburgh Reds.") Saltsburg sandstone member. Cambridge (?) limestone member. Buffalo sandstone member. Brush Creek limestone member. Brush Creek coal. Upper Mahoning sandstone member. Mahoning coal. Lower Mahoning sandstone member.
		Allegheny formation.		300±	Upper Freeport coal. Upper Freeport limestone member. Lower Freeport coal. Lower Freeport limestone member. Freeport sandstone member. Upper Kittanning coal. Johnstown limestone member. Middle Kittanning coal. Lower Kittanning coal. Lower Kittanning clay. Kittanning sandstone member. Clarion coal. Clarion clay. Clarion sandstone. Brookville coal.

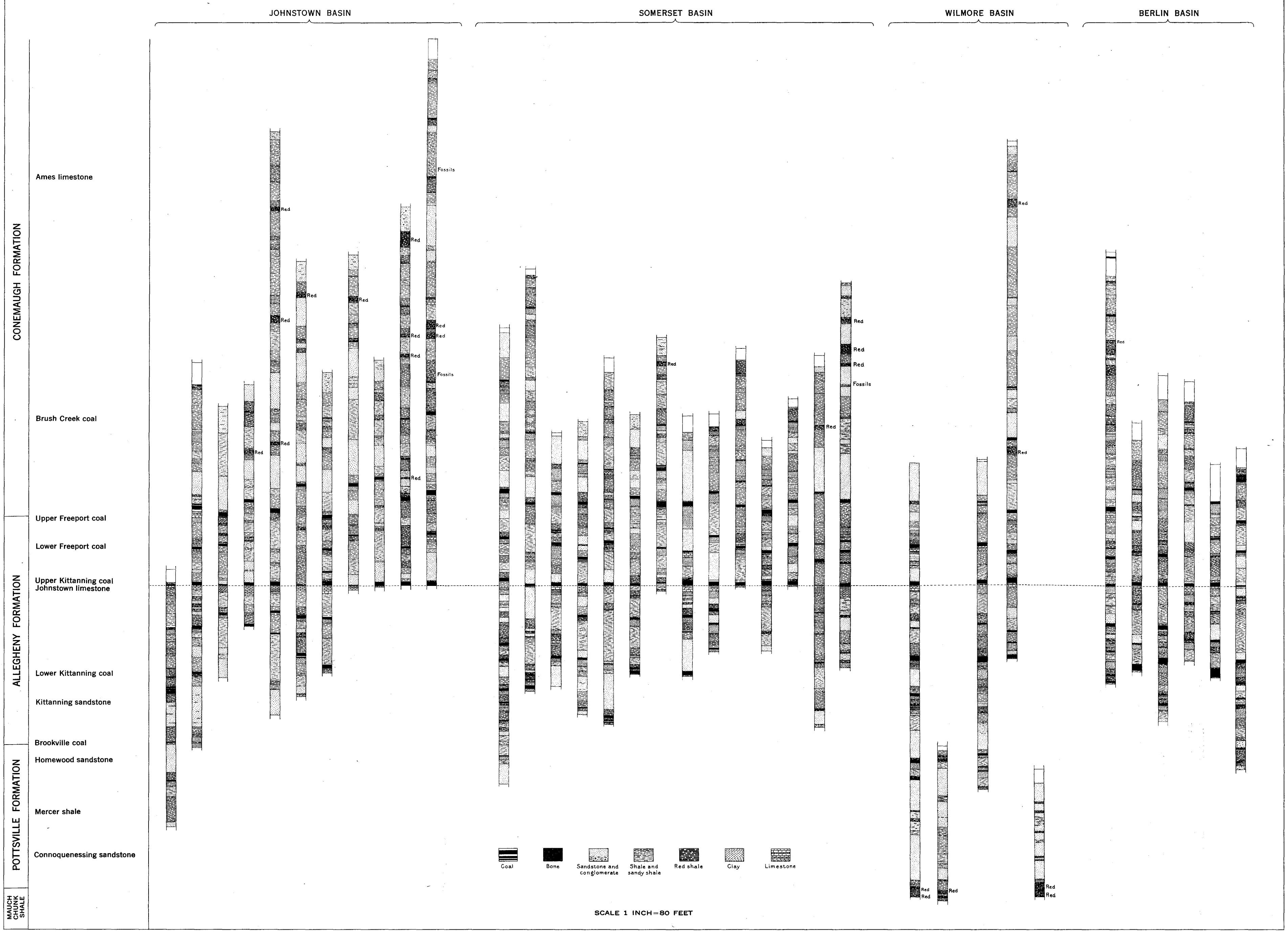
GENERALIZED SECTION OF ROCKS IN THE SOMERSET AND WINDBER QUADRANGLES.

SCALE: 1 INCH = 400 FEET.



System.	Series.	Formation.	Section.	Thickness in feet.	Character of Formation.
CARBONIFEROUS	PENNSYLVANIAN	Monongahela formation.		0-80	Sandstone and clay shale with the Pittsburgh coal at the base.
		Conemaugh formation.		850-870	A variable sequence of sandstone, shale, and clay, with thin beds of limestone and coal; characterized by the occurrence of red beds and of several calcareous beds that contain marine fossils.
		Allegheny formation.		300±	A variable sequence of sandstone, shale, limestone, and clay, with several workable beds of coal, including the Upper Freeport coal at top.
		Pottsville formation.		200	Thick-bedded gray sandstone with some shale and clay and thin beds of coal.
		UNCONFORMITY			
	MISSISSIPPIAN	Mauch Chunk shale.		150±	Brownish-red, locally green and drab sandy and clayey shales, subordinate thin-bedded sandstone, and lenses of gray and reddish limestone.
		Loyalhanna limestone.		40	Blue-gray cross-bedded siliceous limestone.
		Pocono formation.		1,000	Gray sandstone and subordinate sandy shale.
DEVONIAN	UPPER DEVONIAN	Catskill formation.		1,800-2,000	Bright-red sandy and clayey shale, thin-bedded fine-grained red sandstone, and subordinate gray sandstone and shale.
		Chemung formation.		2,000	Alternating beds of fine-grained fossiliferous greenish-gray sandstone and sandy shale.

SECTIONS OF DIAMOND-DRILL HOLES IN SOMERSET AND WINDBER QUADRANGLES



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97	Parker	South Dakota	25
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99	Mitchell	South Dakota	25
100	Alexandria	South Dakota	25
101	San Luis	California	Out of stock.
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103	Nampa	Idaho-Oregon	do.
104	Silver City	Idaho	do.
105	Patoka	Indiana-Illinois	do.
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107	Newcastle	Wyoming-South Dakota	do.
108	Edgemont	South Dakota-Nebraska	do.
109	Cottonwood Falls	Kansas	do.
110	Latrobe	Pennsylvania	do.
111	Globe	Arizona	do.
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113	Huron	South Dakota	Out of stock.
114	De Smet	South Dakota	25
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119	Fayetteville	Arkansas-Missouri	do.
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121	Waynesburg	Pennsylvania	do.
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130	Rico	Colorado	do.
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132	Muscogee	Oklahoma (Ind. T.)	do.
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134	Beaver	Pennsylvania	do.
135	Nepesta	Colorado	do.
136	St. Marys	Maryland-Virginia	do.
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152	Patuxent	Md.-D. C	do.
153	Ouray	Colorado	do.
154	Winslow	Ark.-Okla. (Ind. T.)	do.
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159	Independence	Kansas	do.
160	Accident-Grantsville	Md.-Pa.-W. Va	do.
161	Franklin Furnace	New Jersey	do.
162	Philadelphia	Pa.-N. J.-Del	do.
163	Santa Cruz	California	do.
164	Belle Fourche	South Dakota	do.
[c]165	Aberdeen-Redfield	South Dakota	50
166	El Paso	Texas	Out of stock.
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168	Jamestown-Tower	North Dakota	do.
169	Watkins Glen-Catatonk	New York	do.
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