UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
W. E. WRATHER, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

HOLLIDAYSBURG-HUNTINGDON FOLIO

PENNSYLVANIA

BY

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WASHINGTON, D. C.
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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.

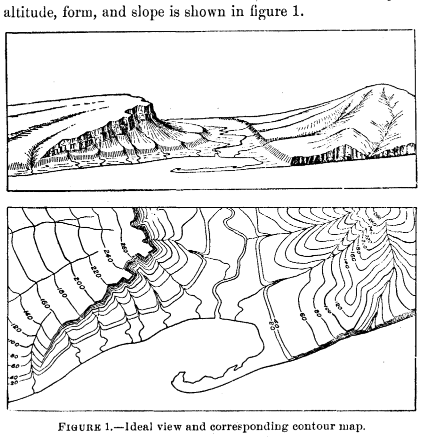


FIGURE 1.—Ideal view and corresponding contour map.

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; Paleocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		℞	Peacock-blue.
Paleozoic	Permian		P	Light blue.
	Carboniferous	Pennsylvanian; Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		€	Brick-red.
Proterozoic	Pre-Cambrian		p€	Brownish red and 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*.

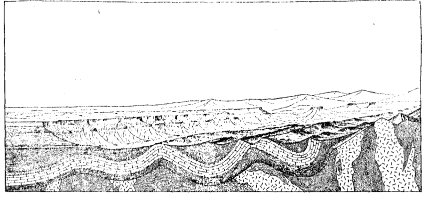


FIGURE 2.—Sketch showing a vertical section below the surface at the front and a view beyond.

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.

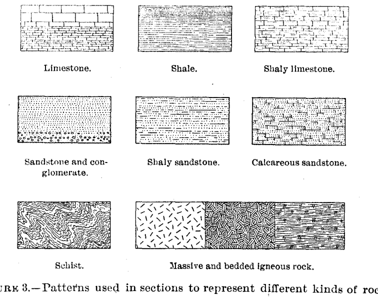


FIGURE 3.—Patterns used in sections to represent different kinds of rock.

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.

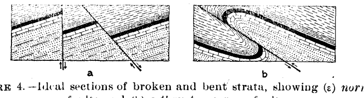


FIGURE 4.—Ideal sections of broken and bent strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

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.

W. E. WRATHER,
Director.

December, 1945.

DESCRIPTION OF THE HOLLIDAYSBURG AND HUNTINGDON QUADRANGLES

By Charles Butts

INTRODUCTION[1]

SITUATION

The Hollidaysburg and Huntingdon quadrangles are adjoining areas in the south-central part of Pennsylvania, in Blair, Bedford, and Huntingdon Counties. (See fig. 1.) Taken as

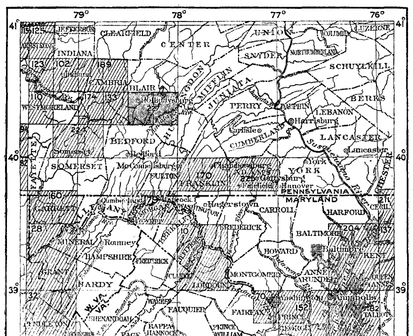


FIGURE 1.—Index map of south-central Pennsylvania and parts of adjacent States.

The location of the Hollidaysburg and Huntingdon quadrangles is shown by darker ruling (No. 227). Published folios describing other quadrangles are indicated by lighter ruling and are listed on the back cover of this folio.

a unit they are bounded by parallels 40°15′ and 40°30′ and meridians 78° and 78°30′. Each quadrangle includes one-sixteenth of a "square degree" of the earth's surface, and its area is approximately 228 square miles. These quadrangles form a part of the Appalachian Highlands, which extend from the Atlantic Coastal Plain on the east to the Interior Plains on the west and from Canada to central Alabama.

APPALACHIAN HIGHLANDS

SUBDIVISIONS

Differences in topography, rocks, and geologic structure form the basis for a natural division of the Appalachian Highlands into several parts called provinces. These are, from southeast to northwest, the Piedmont province, the Blue Ridge province, the Valley and Ridge province, and the Appalachian Plateaus. The boundaries of these provinces are shown on Figure 2. West of the Appalachian Plateaus are the Interior

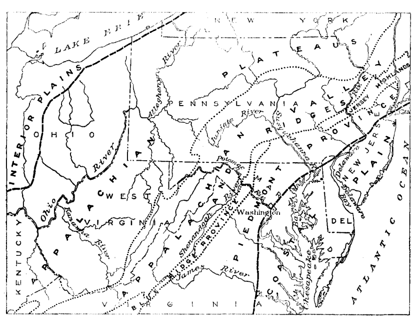


FIGURE 2.—Map of the central part of the Appalachian Highlands showing its physiographic divisions.

Low Plateaus, which are included in the Interior Plains by the United States Geological Survey but which in the opinion of some, of whom the writer is one, should be included in the Appalachian Highlands.

PIEDMONT PROVINCE

The Piedmont province is a rolling upland 1,100 feet above sea level at the east foot of the Blue Ridge and 500 feet or less above sea level along the "fall line." Its generally flat surface has been deeply trenched by the streams that flow across it. Most of its area is underlain by very ancient and crumpled crystalline rocks, both igneous and metamorphic.

[1] Field work on the Hollidaysburg and Huntingdon quadrangles was done in 1908, 1913, and 1915. The text was written shortly thereafter, but publication was unavoidably delayed. Later publication has involved some revision.

BLUE RIDGE PROVINCE

The Blue Ridge province, narrow at its north end in Virginia and Pennsylvania, is over 60 miles wide in North Carolina. It is a rugged region of hills and ridges and deep, narrow valleys. The altitude of the higher summits in Virginia is 3,000 to 5,700 feet, and in western North Carolina Mount Mitchell, 6,711 feet high, is the highest point east of the Mississippi River. Throughout its extent this province stands up conspicuously above the bordering provinces, from each of which it is separated by a steep, broken, rugged front from 1,000 to 3,000 feet high. In Pennsylvania, however, South Mountain, the northeast end of the Blue Ridge, is less prominent. The rocks of this province are closely folded quartzite, slate, schist, gneiss, granite, and greenstone.

VALLEY AND RIDGE PROVINCE[2]

The Valley and Ridge province is a belt of country 50 to 80 miles wide extending from New York to Alabama in a general direction about S. 40° W. and bounded by the Blue Ridge on the southeast and the Appalachian Plateaus on the northwest. This belt is characterized by broad valleys separated by high ridges trending parallel with the belt. These ridges, however, are grouped more along the northwest half of the valley, leaving a broader valley on the southeast side known as the Cumberland Valley in Pennsylvania and the Shenandoah Valley or the Valley of Virginia on the southeast side of the belt. In Pennsylvania the Allegheny Front, which bounds the Valley and Ridge province on the west, rises from 1,000 to 1,500 feet above the main valley levels, but only its highest knobs rise much above the highest of the valley ridges. Blue Knob, on the Allegheny Front, in the northern part of Bedford County, stands 3,136 feet above sea level and 1,500 feet above the surface of Nittany Valley. (See pl. 1.) South Mountain, on the southeast side of the Valley and Ridge province, in Franklin, Adams, and Cumberland Counties rises 1,000 feet above the valley level. Near Big Stone Gap, Va., the crest of Black Mountain is 3,000 feet above the valley on the northwest side, and in northern Tennessee Holston Mountain, near the northwest front of the Blue Ridge province, rises nearly 3,000 feet above the valley on the southeast side. These features are exhibited in the profile section of Figure 2.

The rocks in these quadrangles, as in the entire Valley and Ridge province, are limestone, dolomite, conglomerate, sandstone, and shale, which have been greatly disturbed by folding and faulting.

APPALACHIAN PLATEAUS

The Appalachian Plateaus, which are practically coextensive with the Appalachian coal fields, are relatively high, ranging from 800 feet above sea level in parts of Alabama to more than 4,500 feet in Pocahontas County, W. Va., whence they descend through Pennsylvania to about 2,000 feet in western New York. Sandstone, conglomerate, shale, and coal beds make up most of the rocks of the Appalachian Plateaus. In contrast with those of the Valley and Ridge province the strata of the plateau province have been but slightly disturbed from their original horizontal attitude.

TOPOGRAPHY

The Hollidaysburg and Huntingdon quadrangles lie in a region of mature topography. The great limestone valley between Dunning and Tussey Mountains has advanced to the stage of early old age, as shown by the complete adjustment of the drainage as to both the distribution of the streams and the gradation of their beds. The stream beds are nearly free from rock shoals and waterfalls, and uniform slopes prevail in them. The extremes of relief are considerable, and there is a moderate degree of diversity in surface forms. The dependence of topography upon the lithologic character and the attitude of the underlying strata is abundantly and strikingly illustrated. The quadrangles lie almost wholly in the Valley and Ridge province, in the belt of ridges along its west side. The northwest corner of the Hollidaysburg quadrangle lies in the Appalachian Plateaus. The characteristic features of the topography are therefore prominent ridges separated by deep valleys, all trending northeastward.

[2] The Valley and Ridge province has long been known as the Appalachian Valley because in general it is lower than the margins of the bounding provinces on each side. In all discussions of mountain systems throughout the world this belt is designated "the Appalachians," because it is the worn-down remains of a once mighty mountain system. Although recognizing the appropriateness of the descriptive designation Valley and Ridge province, the present writer prefers the old name Appalachian Valley.

RELIEF

The lowest point in the quadrangles is at Huntingdon, where the altitude of the river bed is about 610 feet above sea level, and the highest point is the southern extremity of Brush Mountain, north of Hollidaysburg, which is 2,520 feet above sea level. The extreme relief is thus 1,910 feet. The Allegheny Front and Dunning, Short, Loop, Lock, Tussey, Terrace, and Broadtop Mountains rise boldly 800 to 1,500 feet above the valley bottoms in a distance of 1 to 2 miles and are the dominating features of the landscape. The relief in the broad intervening valleys ranges from 100 to 600 feet but is generally 200 to 300 feet.

PRINCIPAL TOPOGRAPHIC FEATURES

The Allegheny Front, generally known as Allegheny Mountain, the great eastward-facing escarpment of the Appalachian Plateaus, is the most impressive feature of these quadrangles. It crosses the west side of the Hollidaysburg quadrangle and rises to a height of 3,136 feet above sea level in Blue Knob, in the southeast corner of the adjoining Ebensburg quadrangle (pl. 1). The eastern foothills of this escarpment descend to a valley continuous with Bald Eagle Valley on the northeast and with the valley of Frankstown Branch on the southwest. From a point opposite Hollidaysburg through Altoona this valley is known as Logan Valley. Nearly inclosed by Brush, Lock, Loop, and Short Mountains is a deep topographic depression known as Scotch Valley. Point View knob in the northwest corner of the Huntingdon quadrangle is another striking topographic feature (pl. 2). The broad lowland between Lock and Dunning Mountains on the west and Tussey Mountain on the east, known as Morrisons Cove (pl. 3), is really a somewhat offset continuation of Nittany Valley, Centre County. Raystown Valley is the broad, undulating, relatively low land between Tussey and Terrace Mountains, marked by northeastward-trending narrow ridges and drained by Raystown Branch of the Juniata River. Southeast of Raystown Valley Terrace Mountain and Sideling Hill with the north end of Broad Top Mountain, which together inclose the Great Trough Creek Valley (pl. 4), are the principal topographic features.

All the great ridges are caused by hard sandstones which, with the exception of that forming the summit of the Allegheny Front, are steeply inclined. The softer shales and the soluble limestones have been eroded away faster than the hard sandstones, which are left in high relief. The slopes of these ridges in places are more than 20°, as for example the east slope of Loop Mountain near the middle, where there is a descent of 1,200 feet in half a mile. About the middle of the southeast slope of Lock and Dunning Mountains and the northwest slope of Tussey Mountain is a series of flat-topped spurs, which are formed by another hard sandstone cropping out at that level. The coincidence of these features of relief with the outcrops of the several hard sandstone formations is clearly displayed on the geologic maps.

A notable feature of the ridges is their parallelism, which is due to the geologic structure. (See pl. 5.) All the ridges are essentially hogbacks, the Allegheny Front, Dunning Mountain, and some minor ridges being on the west limb and Tussey and Terrace Mountains on the east limb of the great Nittany arch. (See structure sections.) Sideling Hill is a hogback on the Jacks Mountain anticline, whose crest is just east of the southeast corner of the Huntingdon quadrangle. (See pl. 6.) Dunning and Tussey Mountains and Sideling Hill are symmetrical, having equal slopes on their two sides, owing to the erect attitude of the rocks; the Allegheny Front and Terrace Mountain are unsymmetrical, having steep slopes facing the Nittany arch and low slopes facing in the opposite directions, owing to the low dip of the strata in those directions.

Several deep gaps or notches through the high ridges are notable features of the topography. The largest of these are McKee Gap, 800 feet deep, and Point View Gap, 900 feet deep, through the Dunning-Lock Mountain ridge; Trough Creek Gap, 900 feet deep, and Tatman Gap, 700 feet deep, through Terrace Mountain; and Burgoon and Sugar Run Gaps, each about 1,000 feet deep, through the Allegheny Front. The origin of these features is explained under "Geologic history."

The topographic maps show that the highest ridges and the crest of the Allegheny Front approach a common altitude of 2,000 to 2,400 feet; the foothills of the Allegheny Front and the flat-topped spurs on the east side of Lock and Dunning Mountains and the west side of Tussey Mountain approach a common altitude of 1,600 to 1,750 feet; and the general altitude of Morrisons Cove and Raystown Valley is 1,200 to 1,400 feet. The summits of the high ridges, the spurs and terraces at 1,600 to 1,750 feet, and the tracts at the next lower level (Morrisons Cove, etc.) are believed possibly to be remnants of former more or less extensive peneplains, the highest of which is the Kittatinny peneplain, named from Kittatinny Mountain, in New Jersey; the intermediate one the Schooley peneplain, named from Schooley Mountain, in New Jersey; and the lowest one the Harrisburg peneplain, named from the Harrisburg region, Pennsylvania. The origin of these features is explained under "Geologic history."

DRAINAGE

These quadrangles lie in the Susquehanna River drainage basin, and the principal streams are the Juniata River, Raystown and Frankstown Branches of the Juniata, Clover Creek, Piney Creek, and Plum Creek, in Morrisons Cove, and Great Trough Creek, in the Trough Creek Valley. The part of the quadrangles west of Tussey Mountain is drained by Frankstown Branch; the part east of Tussey Mountain, except a small area east of Sideling Hill, is drained by Raystown Branch. Raystown Branch is the largest stream in the area and is remarkable for its meandering course.

The fall of the larger streams is moderate, but the slope of the smaller streams heading close to the high escarpments is rather steep, even along their lower courses. The range of grade is shown in the following table:

Amount and rate of fall of principal streams in the Hollidaysburg and Huntingdon quadrangles

Stream	Length (miles)	Total fall (feet)	Fall (feet per mile)
Raystown Branch	35	160	4.6
Frankstown Branch	31.5	340	10.8
Clover Creek	19	550	29
Great Trough Creek	18.5	510	28
Beaverdam Creek (to Altoona)	9	190	21
Poplar Run	5.5	340	62

The average rate of fall shown in the last column fails to express a significant feature of the stream beds—the diminishing rate of fall downward. For example, Frankstown Branch falls 160 feet in the first 7 miles of its course, which is 23 feet to the mile, 100 feet in the next 9 miles, which is 11 feet to the mile, and 80 feet in the next 14 miles, which is 6 feet to the mile.

DESCRIPTIVE GEOLOGY

STRATIGRAPHY

SYSTEMS REPRESENTED

Except the alluvial deposits along the streams, the rocks that crop out in the Hollidaysburg and Huntingdon quadrangles are of Paleozoic age. The total thickness is 23,000 to 25,000 feet, and all the Paleozoic systems except the Permian are well represented.

CAMBRIAN SYSTEM

The rocks of Cambrian age include, in ascending order, the Waynesboro formation, the Pleasant Hill limestone, the Warrior limestone, and the Gatesburg formation.

WAYNESBORO FORMATION

Name and definition.—The Waynesboro formation was named for its exposures at Waynesboro, in Franklin County. It is the oldest exposed formation in these quadrangles, where it is overlain by the Pleasant Hill limestone.

Distribution.—The formation crops out only on the north half of the low ridge that extends south from a point 1 mile west of Clover Creek, in the southeast quarter of the Hollidaysburg quadrangle. The rocks along this ridge have been thrust up as a wedge between two faults, and the Waynesboro is out of its normal relations to the adjacent rocks, except at the south edge of its outcrop, where it dips normally south under the Pleasant Hill limestone.

Character.—The part of the Waynesboro that crops out in this area consists of green and dark shale, some bands of purple shale, thin-bedded fine-grained greenish micaceous sandstone, layers of hard quartzite, and layers of quartz conglomerate containing abundant pebbles from the size of millet grains to that of peas. Surficial pieces of porous, highly ferruginous sandstone with traces of fossils indicate calcareous sandstone bands from which the calcium carbonate has been leached out in weathering.

Thickness.—The conditions of exposure do not permit a close determination of the thickness of the exposed part of this formation, which may not exceed 200 or 300 feet, and, as its bottom is not exposed, its full thickness here is unknown. At Waynesboro, in Franklin County, the formation is 1,000 to 1,500 feet thick.

Age and correlation.—According to Stose, the upper part of the Waynesboro in Franklin County is composed of shale, part of it purple, and sandstone. The beds described here have a similar lithologic character and the same stratigraphic position, which justify their identification as Waynesboro. The fossils include *Olenellus*, *Bonnia?*, and *Hyolithes communis?*. The Waynesboro is correlated with the Rome formation of the southern Appalachian region, which, because it carries *Olenellus* and other genera of the same family, is classed as Lower Cambrian.

PLEASANT HILL LIMESTONE

Name and definition.—The Pleasant Hill limestone was named for the excellent exposures of its upper part at Pleasant Hill Church, 1 mile northwest of Henrietta. It is underlain by the Waynesboro formation and overlain by the Warrior limestone.

Distribution.—There are only two small tracts of the Pleasant Hill limestone in this area—one about a mile northeast of Henrietta, in the southeast corner of the Hollidaysburg quadrangle, and the other on the high knob about three-quarters of a mile northeast of Ganister, in the northwest corner of the Huntingdon quadrangle.

Character.—The lower part of the Pleasant Hill limestone is composed of thin-layered argillaceous, sandy, and micaceous limestone with some calcareous shale, and the upper part of thick-bedded fine-grained dark-gray limestone. On weathering the argillaceous layers turn to clay shale or to greenish sandy, micaceous, shaly rock, pieces of which 1 foot square and smaller are scattered plentifully upon the surface of its outcrop. Some layers of the limestone have dark oolitic grains and larger rounded dark inclusions that look like pebbles and are fossiliferous.

Thickness.—As delimited the total thickness is about 600 feet, of which the lower argillaceous part makes up 400 feet and the upper pure limestone part 200 feet.

Age.—The following fossils identified from a larger number of species collected at Pleasant Hill are believed to indicate the Middle Cambrian age of the Pleasant Hill limestone: *Hyolithes princeps?*, *Alokistocare* sp., *Blainia* and *Olenoides* sp.

WARRIOR LIMESTONE

Name and definition.—The Warrior limestone was named for Warriorsmark Creek, in the northern part of Huntingdon County, along which it crops out. The formation occupies the stratigraphic interval between the Pleasant Hill limestone below and the Gatesburg formation above.

Distribution.—The Warrior limestone crops out in a strip 1½ miles west of Williamsburg, in a small area northwest of Drab, in the fault block half a mile northwest of Henrietta, and in a triangular area in the southwestern part of the Hollidaysburg quadrangle.

Character.—The Warrior formation is predominantly fine-grained dark-gray limestone, in layers 1 foot or less thick, commonly separated by shaly partings. A large part is highly magnesian, even dolomite, but the formation includes considerable pure limestone, some thin quartzite beds, and layers full of rounded quartz grains. The following section illustrates the various phases:

Section of the Warrior limestone on Frankstown Branch midway between Williamsburg and Ganister

	Feet
Gatesburg formation.	
Warrior limestone:	
22. Not exposed, about	200
21. Limestone, bluish, thin bedded; contains trilobites, about	50
20. Dolomite or magnesian limestone, dark, fine grained, about	300
19. Limestone, gray, full of rounded quartz grains; projects prominently like a dike on face of bluff	10
18. Not exposed	50
17. Dolomite or magnesian limestone, blue, sandy	10
16. Dolomite or magnesian limestone, sandy, cross-bedded; weathers to sandstone	4
15. Dolomite or magnesian limestone, with sandy streaks and layers 6 inches or less thick	8
14. Quartzite, core of dikelike projection on face of bluff	6
13. Dolomite or magnesian limestone, sandy	2
12. Dolomite or magnesian limestone, some cross-bedded	5
11. Quartzite	1
10. Dolomite or magnesian limestone	10
9. Dolomite or magnesian limestone, with quartzite layers	5
8. Dolomite or magnesian limestone, thick bedded	150
7. Not exposed	50
6. Dolomite or magnesian limestone, blue, thick bedded	30
5. Not exposed	100
4. Dolomite or magnesian limestone, bluish, thick bedded	10
3. Limestone, argillaceous, siliceous, shaly, with quartz grains	20
2. Dolomite, sandy, flaggy	50
1. Dolomite or magnesian limestone, dark, fine grained, about	180
	1,251

The quartzite layers of this section are composed of subangular to well-rounded translucent quartz grains like those so abundant in some of the limestone layers. The grains are 0.1 to 1 millimeter in diameter.

Thickness.—The thickness of the Warrior limestone is 1,250 feet.

Age and correlation.—The Warrior limestone carries cryptozoons (see pls. 7–9), brachiopods, and trilobites but not in abundance. Collections have been made in the southwestern part of the Hollidaysburg quadrangle and the adjoining northwestern part of the Everett quadrangle, on the bluff of Frankstown Branch between Williamsburg and Ganister, at points on the road along Warriorsmark Creek within 2 miles southeast of Warriorsmark, north of the Huntingdon quadrangle, and within a radius of a mile or two southeast to southwest of Waddle, in the Bellefonte quadrangle, Centre County. From these localities probably as many as 20 species of trilobites belonging to several genera have been collected and examined by Walcott, Ulrich, and Resser, and a few species have been identified. The following species have been described from this formation: *Blountia kindlei* Resser, *Coosella brevis* Resser, *Kingstonia ara* (Walcott), *Kingstonia kindlei* Resser, *Menomonia avitas* (Walcott). Other undescribed species have been referred to *Blountia*, *Modocia*, *Loncho cephalus*, *Kingstonia*, and *Genevievella*. *Pemphigaspis bullata*, a peculiar and problematic fossil described by Hall,[3] has been found at two localities, at one of which the containing beds are near the top of the Warrior.

This fauna is clearly of early Upper Cambrian age. Identical or related species are found in the upper part of the Nolichucky shale and Conasauga formations of the southern Appalachian region; in the Eau Claire sandstone of Wisconsin; the Bonneterre dolomite of Missouri; the Cap Mountain limestone of Texas, and the Pilgrim limestone and its equivalents in the western United States.

GATESBURG FORMATION

Name and definition.—The Gatesburg formation was named for Gatesburg Ridge, in Centre County, Pa., on which is strikingly displayed the characteristic mantle of sand and sandstone boulders derived from the formation by weathering. It includes the Stacy dolomite member at the bottom and the Ore Hill limestone member in the middle.

Distribution.—The Gatesburg crops out west and southwest of Williamsburg, on the Woodbury anticline northeast of Martinsburg, near Ore Hill, and in the fault block just west of Henrietta. The best exposures are on the river bluffs near Williamsburg and along the Pennsylvania Railroad east of Birmingham, a few miles north of the Huntingdon quadrangle. The quartzite layers are best displayed at the Birmingham locality.

Character.—Exclusive of the Ore Hill limestone member, the Gatesburg formation is composed predominantly of thick-bedded, coarsely crystalline dark-bluish dolomite with layers of quartzite, which are especially abundant in the upper 1,200 feet. Some light-colored and finer-grained layers of dolomite occur. Oolitic layers and layers full of rounded sand grains abound. The distinctive characteristic, however, is the quartzite in layers 1 to 10 feet thick. The surficial sand, boulders, and cobblestones resulting from the weathering of these layers give the impression that the underlying rocks are sandstone only. In places the residual sand is as much as 20 feet thick. The sand grains are from 0.1 to 1 millimeter in diameter. Silicified oolite, abundant near the top of the formation, resembles a mass of millet grains embedded in a sandy matrix. The oolite grains range from 0.5 to 1.25 millimeters in diameter. The Gatesburg yields practically no chert, a character by which it can be easily distinguished from the Mines dolomite, next overlying it. At the top of the formation is a layer of dolomite full of poorly preserved gastropods belonging mainly to the genus *Sinuopea*.

Thickness.—The thickness of the Gatesburg formation is 1,750 feet. Of this thickness the Ore Hill limestone member makes up 100 feet and the Stacy dolomite member, at the bottom, 500 feet.

Topographic expression.—Owing to the resistant character of the formation it everywhere forms rather high ridges within the comparatively level limestone valleys. Most of the area of these ridges is forested.

Stacy dolomite member.—The Stacy dolomite member was named for Stacy Knob, 1 mile west of Larke, in the Huntingdon quadrangle. It makes up the lower 500 feet of the Gatesburg formation and is distinguished by the absence or relative fewness of quartzite beds.

There are no complete or even good exposures of the Stacy member in the area, but a very good idea of its general character can be obtained from the soil, dolomite débris, and scattered exposures of the beds on the summit and west side of Stacy Knob.

Ore Hill limestone member.—The Ore Hill limestone member was named for Ore Hill, in the southwestern part of the Hollidaysburg quadrangle, where it has been quarried. It lies about at the middle of the upper two-thirds of the Gatesburg

[3] Hall, James, Supplementary note on some fossils of the lower beds of the Potsdam sandstone of the upper Mississippi Valley: New York State Cab. Nat. Hist. Sixteenth Ann. Rept., p. 221, pl. 5, A, figs. 3-5, 1863.

formation and is known from Larke to a point $1\frac{1}{2}$ miles northwest of the town of Clover Creek, thence northward along both flanks of the Woodbury anticline about to the latitude of Larke, and at a number of points on the east limb of the Roaring Springs anticline from Ore Hill southward beyond the limits of the Hollidaysburg quadrangle.

It is best displayed just north of the road half a mile northwest of Drab, at a quarry on the same outcrop on the ridge 2 miles north of Drab, and at a quarry by the roadside three-quarters of a mile southwest of Ore Hill, where road metal was obtained for the State highway.

The Ore Hill is a thin-bedded bluish to dark-gray, mostly fine-grained limestone, with a few coarse-grained layers. It is about 100 feet thick.

Age and correlation.—The only described species are *Pelagiella hoyti?*, *Elvinia roemeri*, *Cheilocephalus buttsi*, *Burnetia cava*, and *B. pennsylvanica*. Among the described genera are species of *Irvingella*, *Housia*, *Plethopeltis*, and *Saratogia*.

Two faunal horizons representing widely separated horizons in the middle and late Upper Cambrian appear to be represented in the collections from this member. *Elvinia*, *Burnetia*, *Irvingella*, and *Housia* are all characteristic of the Franconia sandstone of Wisconsin and its equivalents, such as the Davis formation of Missouri, the Honey Creek limestone of Oklahoma, the lower part of the Wilberns formation of Texas, a portion of the Deadwood formation of the Black Hills, and the Dunderberg shale of the Eureka district, Nevada, and its equivalents elsewhere in western North America. *Elvinia roemeri* also occurs in the Theresa dolomite of New York.

Plethopeltis, *Saratogia*, and *Pelagiella hoyti* also occur in the Hoyt limestone of New York, which some consider to be late Upper Cambrian equivalent to the Jordan and Madison formations of the Upper Mississippi Valley and the Eminence dolomite of Missouri, whereas others make the Hoyt equivalent to a portion of the Franconia. The close association of these forms with fossils of early Franconia age in the Ore Hill limestone member lends support to this view. On the ground of stratigraphic relations the Gatesburg is also tentatively correlated with the Conococheague limestone of Cumberland Valley, Pa., and the Copper Ridge dolomite of Virginia, Tennessee, and Alabama.

ORDOVICIAN SYSTEM

In these quadrangles the rocks of Ordovician age consist predominantly of dolomite and limestone but end above with a thick shale formation. They include the following formations, named in ascending order: Mines dolomite, Larke dolomite, Stonehenge limestone (?), Nittany dolomite, Axemann limestone, Bellefonte dolomite, Carlim, Lowville, Rodman, and Trenton limestones, Reedsville shale, Oswego sandstone, and Juniata formation—in all about 5,900 feet thick.

BEEKMANTOWN GROUP

The Beekmantown group of the Champlain Valley is represented in the Hollidaysburg and Huntingdon quadrangles by the Mines dolomite, the Larke dolomite, the Nittany dolomite, the Axemann limestone, and the Bellefonte dolomite.

MINES DOLOMITE

Name and definition.—The Mines dolomite was named for the town of Mines, 5 miles southwest of Williamsburg. Its outcrop, marked by abundant chert, passes about a quarter of a mile east of Mines. It extends from the top of the Gatesburg to a bed of light-gray fine-grained siliceous dolomite with brachiopods (*Lingula*) that crops out on the east brow of the ridge between the eastern two of the three roads leading southward from Williamsburg.

Distribution.—The Mines dolomite has the same distribution as the Gatesburg formation. It is best displayed just south of Williamsburg on the crest of the ridge above mentioned.

Character.—The dolomite of the Mines resembles closely in outward appearance that of the Gatesburg formation. However, the Mines yields abundant chert and has no sandstone, whereas exactly the reverse is true of the Gatesburg. Much of the Mines chert is very rough or scoriaceous; some of it is oolitic; most of it is light gray but is made very dark by characteristic black oolite grains. The pieces of chert are of all sizes up to a foot or more in diameter. Many pieces consist of silicified specimens of *Cryptozoon*, the individuals ranging from 1 inch to more than 1 foot in diameter. These chertified specimens of *Cryptozoon* and the black oolite grains are confined to the Mines dolomite, occur everywhere on its outcrop, and serve to identify it with certainty.

Thickness.—The Mines is about 250 feet thick.

Age and correlation.—At the bottom of the Mines on the point of the spur just south of Williamsburg is a layer of its characteristic dolomite about 2 feet thick crowded with the remains of gastropods of the genus *Sinuopea*. These are hardly if at all distinguishable from *S. vera* and *S. planibasalis* of the cherty dolomite which in the past has been assigned to the lower part of the Gasconade dolomite of Missouri but which is treated by H. S. McQueen as a separate unit, under the name Van Buren formation, in a report issued by the

Missouri Bureau of Mines and Geology in March, 1930.[4] This horizon has also been recognized in central Texas and is probably present in the lower portion of Chepultepec dolomite of the southern Appalachian region.

LARKE DOLOMITE

Name and definition.—The Larke dolomite is well exposed at Larke, 3 miles south of Williamsburg, and the formation was named for that place. It includes the dolomite between the cherty Mines dolomite below and the light-gray and fossiliferous Nittany dolomite above.

Distribution.—The areal distribution of the Larke is the same as that of the Mines and Gatesburg. The best exposures are at Larke, along the railroad just east of Williamsburg, half a mile southeast of Williamsburg on the road to Sparr, and on the crossroad just west of the railroad track about a mile south of Roaring Spring.

Character.—The Larke dolomite is composed mainly of thick-bedded, coarsely crystalline dark-blue dolomite with a very little sandstone in thin layers and light-gray chert in thin plates. The lower 50 feet is light gray, fine grained, and thin bedded or laminated, with siliceous matter in thin laminae that appear as fine raised lines on weathered surfaces.

Thickness.—The total thickness of the Larke is 250 feet.

Age and correlation.—*Helicotoma uniangulata*, a very widely distributed gastropod, diagnostic of the Chepultepec dolomite of Alabama, the Gasconade dolomite of Missouri, the Oneota dolomite of Wisconsin, and equivalent beds elsewhere in North America, and a species of *Finkelnbergia*, apparently identical with a species common in the Gasconade dolomite of Missouri, occur in the Larke. The type specimen of *H. uniangulata* was found in the vicinity of Saratoga Springs, N.Y., in chert believed to be derived from cherty beds in the top of the Little Falls dolomite. All these formations are overlain by limestone or dolomite of Beekmantown age, which, except in Wisconsin, corresponds to a portion of the Nittany dolomite, which overlies the Larke. The Larke is therefore correlated with the Gasconade, Chepultepec, Oneota, and upper part of Little Falls dolomites.

HIATUS BETWEEN LARKE DOLOMITE AND NITTANY DOLOMITE

At Bellefonte, in Centre County, the Mines dolomite is succeeded above by the Stonehenge limestone, which is 662 feet thick. Throughout most if not all of these quadrangles, however, the Stonehenge limestone is absent and the Larke dolomite is unconformably overlain by the Nittany dolomite.

NITTANY DOLOMITE

Name and definition.—The Nittany dolomite was named for its exposures in the vicinity of Nittany Furnace, near Bellefonte, in Centre County. In this area it extends from the top of the Larke dolomite to the bottom of the Axemann limestone, the intervening Stonehenge limestone not being certainly identified.

Distribution.—Beginning at the fault in Bloomfield Township, near the southwest corner of the Hollidaysburg quadrangle, the Nittany dolomite crops out in a broad zigzag belt running to the north line of the Huntingdon quadrangle 3 miles north of Williamsburg. There are also two small areas at the quadrangle boundary north of Ganister. The best exposure of the Nittany is along the south bank of Frankstown Branch 1 mile northeast of Williamsburg, where nearly every foot is visible. In these quadrangles the Stonehenge, which underlies the Nittany farther east, is not certainly known, but it may be represented by a few feet of dark, compact limestone at the base of Nittany exposed about four-fifths of a mile southeast of Ore Hill. About 10 feet of thin-bedded dolomite is exposed immediately beneath this limestone at that point.

Character.—The Nittany is all dolomite, mostly light gray or bluish gray, fine grained, and in layers as much as 2 feet thick. (See pl. 10.) It has a few layers of coarse-grained dark-gray dolomite and a few with quartz grains. The bottom 50 to 100 feet, as exposed north of Williamsburg, is thin bedded, argillaceous, and slightly ferruginous, weathering to clay with thin rusty slabs of dolomite. Much dense residual chert in pieces, the largest 6 feet in diameter, is scattered over the surface underlain by the Nittany. Chert full of rhombohedral cavities from which crystals of calcite or dolomite have been dissolved out is common. A little of the chert is oolitic, but in contrast to the oolitic chert of the Mines, the oolitic grains are generally white in a black matrix. There is, however, but little chert in the dolomite itself. In a completely exposed section of about 1,000 feet along the river bank about 1 mile northeast of Williamsburg only two beds, one 5 feet and the other 1 foot thick, were seen. Elsewhere only a few thin layers of oolitic chert and scattered plates, stringers, and nodules were observed. On the broad, flat spur 1 mile southwest of Clover Creek post office spheroidal masses of chert, the largest 8 inches in diameter, attract attention. These chert balls may be of organic origin, being perhaps another form of *Cryptozoon*, either *C. steeli* or *C. minnesotense*.

[4] The Missouri Geological Survey now (1943) considers the Van Buren to be the basal member of the Gasconade dolomite.

Thickness.—The Nittany is about 1,000 feet thick as measured southwest of Roaring Spring, where the rocks are vertical and the limits can be determined closely.

Age and correlation.—Fossils are scarce in the Nittany, being liberated from the dolomite matrix and brought to view only in the residual chert. Search in a pile of chert usually results in the discovery of a few specimens, mostly gastropods (snail shells), generally so badly preserved as not to be identifiable with certainty. The most common and best preserved of these fossils are species of *Lecanospira*. This form marks the lower beds of the Beekmantown limestone at Beekmantown, N. Y.; a horizon near the middle of the Knox dolomite in Virginia and Tennessee; the Longview limestone of Alabama; the Roubidoux formation of Missouri; and a horizon near the middle of the Ellenburger limestone of Texas. Throughout the geographic range mentioned *Lecanospira* is present in and confined to the lower 1,000 feet or less of the dolomite of Beekmantown age. This same characteristic fossil is known through Quebec to Newfoundland and even in the Durness limestone of northwestern Scotland and marks a continuous ancient seaway from Scotland to Missouri. Another gastropod, *Roubidouxia umbilicata*, characteristic of the Roubidoux formation of Missouri, and known from the same horizon in the southern Appalachians and Texas, has been found in the Nittany of the Tyrone quadrangle, north of the Huntingdon quadrangle.

AXEMANN LIMESTONE

Name and definition.—The Axemann limestone was named for its outcrops about 1 mile east of Axemann, in Centre County. As the Axemann is a limestone in the midst of dolomite, it is very serviceable as a horizon marker. It separates the Nittany dolomite below from the Bellefonte dolomite above.

Distribution.—The Axemann limestone crops out in a sinuous belt marked by quarries from a point near Barbara, in the northeastern part of the Hollidaysburg quadrangle, to a point about 1 mile south of Roaring Spring. Another strip offset by the Henrietta faults extends from Shelleytown, in the Huntingdon quadrangle, 4 miles south of Williamsburg, to the south boundary of the Hollidaysburg quadrangle.

About 1 mile south-southwest of Roaring Spring the Axemann limestone can be distinguished between the Nittany and Bellefonte dolomites, but it could not be traced farther south, notwithstanding the fact that at one place there is a continuous exposure of 200 or 300 feet of dolomite apparently including the Axemann horizon. It likewise appears to be absent in a belt stretching from a point less than half a mile north of Shelleytown to the north edge of the Huntingdon quadrangle, but at Mount Etna, $2\frac{1}{2}$ miles due north of Cove Forge, it is present and has its usual thickness and character.

The best exposures of the Axemann are in the broad outcrop where it swings around the south end of the Scotch Valley syncline $1\frac{1}{2}$ miles southwest of Curryville and at Shelleytown, where the section given below is exposed.

Character.—The Axemann consists mainly of limestone but contains a few thin layers of dolomite. The limestone is thin bedded and dark bluish gray, and its several layers range in texture from coarse grained to nongranular. Some layers contain small rounded pebbles of black limestone and others flat pebbles of considerable size. The limestone weathers to a smooth bluish surface easily distinguishable from the gray-weathering, sandy-looking dolomite above and below it. Fossils are common in the layers that have the black pebbles and are present throughout the formation. Below is a detailed section of the limestone measured at Shelleytown:

Section of the Axemann limestone at Shelleytown

	Ft.	in.
Bellefonte dolomite.		
48. Dolomite	5	
Axemann limestone:		
47. Limestone, thin bedded, dark, fine-grained, banded; contains fossils	10	
46. Dolomite or magnesian limestone	1	3
45. Limestone, dark blue, granular		6
44. Not exposed	3	
43. Limestone?		10
42. Dolomite	1	
41. Not exposed	1	
40. Limestone, blue		6
39. Limestone, dark, granular, thin bedded; weathers blue; contains fossils	15	
38. Partly exposed; shows blue limestone layers and at least one thin layer of dolomite	25	
37. Limestone, dark, coarse grained; contains fossils	8	
36. Not exposed	3	
35. Limestone, dark, granular, partly exposed	4	
34. Not exposed	(?)	
33. Dolomite, light blue, fine grained, shaly	1	
32. Limestone, coarse grained; crinoidal joints abundant	4	
31. Not exposed	4	
30. Limestone, dark, fine grained	1	
29. Dolomite, light bluish, fine grained	1	
28. Limestone, dark blue, mostly coarse grained	12	
27. Limestone, dove-colored, glassy texture	1	2
26. Dolomite	1	
25. Limestone, dark, granular, thin bedded	8	
24. Dolomite	2	
23. Limestone, dark blue, fine grained	1	
22. Dolomite, light, fine grained, thick bedded	6	

	Ft.	in.
21. Limestone, dark, coarse grained	2	6
20. Not exposed	2	
19. Limestone, dark blue, fine grained, thin bedded	15	
18. Dolomite	1	
17. Limestone, like No. 19	20	
16. Limestone, shaly	3	
15. Limestone, dark, coarse grained	1	6
14. Dolomite	2	
13. Limestone, dark, thick bedded	2	6
12. Dolomite	1	
11. Limestone, dark, thick bedded	7	
10. Dolomite, light and dark gray, fine grained	1	6
9. Limestone, dark, granular, thin bedded	6	
8. Dolomite, banded with siliceous layers	4	
7. Limestone, dark, granular, thin bedded	5	
6. Dolomite	1	3
5. Limestone, dark, granular, thin bedded	6	
4. Not exposed	2	
3. Dolomite	2	
2. Not exposed	2	
1. Limestone or dolomite, shaly	1	
Nittany dolomite.		
	203	6

Thickness.—According to the preceding section, the Axemann is 203 feet thick. This thickness appears to be the maximum. Its upper and lower limits can not everywhere be accurately determined, but most observations seem to indicate a thickness of about 150 feet.

Fossils and correlation.—Fossils are fairly abundant in the Axemann limestone. The species are largely undescribed, but some have been identified either specifically or generically, including one species of brachiopod, nine species of gastropods, and seven species of trilobites.

Of the trilobites two species are identical with or very close relatives of species that occur in the fossiliferous beds at Fort Cassin, Vt., somewhat above the middle of the Beekmantown limestone. Most of the gastropods likewise are Beekmantown forms known from Newfoundland to Alabama, where they occur in the lower part of the Newala limestone and beneath the *Ceratopea* zone described under the Bellefonte dolomite. *Maclurites affinis* is especially notable for the persistence of its occurrence at this general horizon throughout the Appalachian Valley, and it occurs also in the limestone at Fort Cassin. It seems, therefore, that the Axemann may occupy a horizon substantially equivalent to the lower part of the Newala limestone of Alabama and beneath the horizon of the Cotter dolomite of Arkansas, in which *Ceratopea* is very abundant. Owing to the common elements in the faunas of the Axemann limestone and the limestone at Fort Cassin the two horizons have been tentatively correlated, but Ulrich seems inclined at present to correlate the Axemann limestone with the Jefferson City dolomite of Missouri, which lies below the Cotter dolomite (*Ceratopea* zone) of that region and thus appears to hold the same stratigraphic position as the Axemann.

BELLEFONTE DOLOMITE

Name and definition.—The Bellefonte dolomite was named for Bellefonte, Centre County, a large part of the town being situated upon its outcrop. It includes all the dolomite of these quadrangles above the Axemann limestone and below the Carlim limestone.

Distribution.—There is a very small area in the northwest corner of the Huntingdon quadrangle; a long zigzag belt extending from Ganister to a point near Baker Summit, near the south line of the Hollidaysburg quadrangle, where its outcrop is faulted out; and a belt extending from Williamsburg to the vicinity of Henrietta. The best exposure is along Frankstown Branch about 1 mile northeast of Williamsburg.

Character.—Nearly all of the Bellefonte is dark fine-grained thin to thick bedded dolomite. There are a few light-gray beds and a little dove-colored nongranular limestone. A considerable thickness of light-gray fine-grained rock in the upper part of the Bellefonte, effervescing freely in acid and probably low in magnesia, is exposed on the railroad opposite the mouth of Clover Creek. In one section, through 200 feet of beds that are apparently in the upper half of the Bellefonte, the dolomite is blue and gray with thin layers of dark, apparently carbonaceous shale.

Although prevailingly dark internally, the rock weathers white with a mere chalky film, especially near the top of the formation, which gives the Bellefonte a rather distinct aspect by which it can generally be easily distinguished from the overlying Carlim limestone. Throughout the upper 800 feet or more exposed along the river northeast of Williamsburg are thin cherty layers here and there in the mass, much of the chert being black and in the form of nodules, less in thin plates or irregular stringers. The surfaces underlain by the Bellefonte dolomite are in places strewn with chert in scoriaceous slabs and large boulders. In the lower 200 feet quartz grains are fairly plentiful.

Thickness.—The Bellefonte is about 1,000 feet thick on Halter Creek south of Roaring Spring, where its limits are well defined and where, the layers being vertical, accurate measurement is possible. It is about 1,250 feet thick east of Williamsburg.

Age and correlation.—Fossils are even scarcer in the Bellefonte than in the Nittany dolomite. A few were found at three localities, at each place in residual chert, as in the Nittany. The only well preserved ones seem to be *Hormotonea gracilens*. *Ceratopea* was found a short distance west of Covedale in the Huntingdon quadrangle.

The most significant of the fossils, *Ceratopea*, is the operculum of a gastropod, although the shell to which it belongs has not yet been discovered. Several species of the genus have been differentiated, all apparently confined to that part of the Beekmantown group younger than the Nittany dolomite. They are especially abundant in the Cotter dolomite of Arkansas, where species of other genera found here are associated with them. The *Ceratopea* zone has been traced from Pennsylvania through Virginia and Tennessee into Alabama, where it is included in the Newala limestone. The discovery, since the above was written, in limestone of Bellefonte age in Virginia, of such characteristic Fort Cassin fossils as *Plethospira cassini*, *Fusispira obesa*, *Calaurops lituiformis* and several species of large coiled cephalopods, which are especially characteristic of the limestone in the Fort Cassin region of Vermont, proves conclusively the Fort Cassin age of a considerable part, at least, of the Bellefonte.

HIATUS BETWEEN BELLEFONTE DOLOMITE AND CARLIM LIMESTONE

So far as known there is a hiatus between the Bellefonte dolomite and the overlying Carlim limestone. A time interval of great length may be unrepresented by sediments in central Pennsylvania.

CARLIM LIMESTONE

Name.—The Carlim limestone was named for its exposures in the Carlim quarry in the northwestern part of the Huntingdon quadrangle. It overlies the Bellefonte dolomite and underlies the Lowville limestone. The exact bottom of the Carlim is somewhat difficult to locate in the field owing to the mixture of layers of sparsely fossiliferous blue limestone with layers of dolomite forming a transition zone from the Bellefonte to the Carlim. The lowest fossiliferous limestone layers are taken as the bottom of the Carlim. Such apparently gradational phenomena are probably the result of mixing of residual material from the rocks of the earlier formation with the first deposited material of the succeeding formation.

The Carlim limestone is of especial interest because of its large utilization as flux in the smelting furnaces at Pittsburgh.

Distribution.—The Carlim limestone crops out in a narrow band along the west foot of Tussey Mountain to Henrietta, where its outcrop is offset westward by the Henrietta faults. Farther west, beginning at a point on the Henrietta fault 1 mile north of Ganister, its outcrop follows the southeast base of the Lock-Dunning Mountain ridge nearly across the quadrangle, passing through Martinsburg and Roaring Spring.

Character.—The lithologic character of the Carlim limestone is indicated in the following section, which is typical for the region.

Section of Lowville and Carlim limestones at Clover Creek quarry

	Feet
Trenton limestone	500±
Rodman limestone:	
Limestone, thin bedded, dark gray, coarsely granular or crinoidal; contains clayey impurity, unfit for chemical uses	30
Lowville limestone:	
Limestone, thick to thin bedded (see pl. 11), dark, largely nongranular, conchoidal fracture, some very finely granular; weathers with white crust, very low in impurities; contains *Tetradium cellulosum*, *Cryptophragmus antiquatus*, *Streptelasma profundum;* about	140
Carlim limestone:	
Lemont limestone member:	
7. Limestone, dark, fine grained, argillaceous, siliceous, pyritiferous, fossiliferous; has shale partings, sun cracks and wave marks; rejected for flux	40
6. Limestone, dark, nongranular, highly fossiliferous	10
Beds beneath Lemont member:	
5. Limestone, dark, thick bedded, in large part finely crystalline; some nongranular like No. 6, some earthy layers (see pl. 12)	150
4. Dolomite	2
3. Limestone	2
2. Dolomite	2
1. Limestone, banded	2
	208
Bellefonte dolomite:	
Dolomite, dark, fine grained; tends to conchoidal fracture; weathers with filmy white crust.	

The main body of the Carlim limestone is dominantly dark bluish gray, finely crystalline, and in layers 1 to 2 feet thick. At the bottom are a few feet to 20 feet of alternating limestone and dolomite layers. The limestone of the basal layers is light or dark gray and fine grained or compact. At Carlim some of these limestone layers are sun cracked and ripple marked.

The chemical character of the Carlim is indicated by the fact that all of it except the Lemont member is used for flux. The average composition at one quarry is silica and alumina 4.75, magnesia 4.5, phosphorus 0.08–1, sulphur 0.04, calcium carbonate to make 100 per cent 90.6–90.63.

Thickness.—The thickness of the Carlim ranges from 100 to 200 feet. At the Clover Creek quarry it is 208 feet thick; at the Josephine quarry, 1½ miles north of the Clover Creek quarry, it appears to be about 100 feet; at Carlim, about 100 feet; at the Blair quarries, 2 miles north of Carlim, beyond the quadrangle line, 200 feet; at the St. Clair quarry, at Ganister, 175 feet; and at Roaring Spring the Carlim and Lowville limestones together have a thickness of about 430 feet, of which about 250 feet is believed to belong to the Carlim. The average thickness is about 180 feet.

Lemont argillaceous limestone member.—The upper 30 to 40 feet of the Carlim limestone in Blair and Huntingdon Counties is highly siliceous and argillaceous, weathering a dirty white or gray or yellowish color and appearing quite different from the rest of the Carlim. Some layers are reported to contain as much as 25 per cent of insoluble matter. On account of this difference in character these beds have been set off as a distinct member, to which the name Lemont was given, because of their exposure at Lemont, near State College in Centre County. Throughout central Pennsylvania the Lemont member is present wherever the Carlim is present. It is well known to quarrymen, as it is fit only for road metal or ballast and is an impediment to quarrying the better rock (Lowville and Carlim) above and beneath it. In some quarries it is left standing as a projecting rib owing to the removal of the good rock on both sides of it. (See Atlas of Pennsylvania No. 96, Tyrone Quadrangle, Plate 7A.)

Age and correlation.—The Lemont member of the Carlim is moderately fossiliferous in these quadrangles and more so at Lemont, Centre County, and at Naginey, Mifflin County. The lower part of the Carlim is less fossiliferous. Twenty-eight species from the Carlim have been identified, the most useful of which for correlation are *Mimella vulgaris* and *Opikina champlainensis*, with which *Maclurites magnus* is associated at Lemont and Naginey. These forms characterize limestone in the middle Chazy at Crown Point, N. Y., on Lake Champlain, and *Maclurites magnus* is abundant in and characteristic of the Lenoir limestone of Tennessee and Alabama. Another species, *Ancistrorhyncha* (*Protorhyncha*) cf. *A. ridleyana*, is a guide fossil of the Ridley limestone of the Stones River group of the Nashville Basin of Tennessee. The Lemont is therefore correlated with the Chazy beds at Crown Point, the Lenoir limestone of the southern Appalachian region, and the Ridley limestone of middle Tennessee. Two other fossils found in the lower part of the Carlim and somewhat doubtfully identified—*Salterella billingsi* and *Helicotoma subquadrata*—suggest the correlation of the lower part of the Carlim with the Murfreesboro limestone, the basal formation of the Stones River group of middle Tennessee.

HIATUS BETWEEN CARLIM AND LOWVILLE LIMESTONE

The Lenoir limestone of eastern Tennessee is of about the same age (middle Chazy) as the Lemont member of the Carlim, and the typical Bays sandstone of Tennesee is regarded as of about the same age as the Lowville limestone, which overlies the Lemont member. The Lenoir and the typical Bays, however, are separated by a considerable thickness of intervening rocks, none of which are represented in Pennsylvania. It thus appears that in the Hollidaysburg-Huntingdon region there exists between the Lemont and the Lowville an unconformity represented by several thousand feet of beds in eastern Tennessee. Notwithstanding this great hiatus, however, there is no discordance of bedding nor any irregularities of contact between the Lemont member of the Carlim limestone and the Lowville, as shown in Plate 12.

BLACK RIVER GROUP

The Black River group in this area is divided into two formations—the Lowville limestone below and the Rodman limestone above.

LOWVILLE LIMESTONE

Name and definition.—The Lowville limestone was named for its exposure in the village of Lowville, Lewis County, N. Y. In these quadrangles it overlies the Carlim limestone and underlies the Rodman limestone. Like the Carlim it is commercially valuable as a source of flux.

Distribution.—The Lowville limestone has the same distribution as the Carlim limestone. It is exposed in all the quarries of the Williamsburg district and can easily be identified by its position between the impure, worthless beds of the Lemont member of the Carlim limestone below and the Rodman limestone above.

Character.—The Lowville is a dark, mostly compact limestone and has a tendency to conchoidal fracture. (See pl. 11.) Here and there is a layer of fine-grained dark rock such as occurs in the Carlim limestone. At or near the bottom of the Lowville is a 5-foot bed crowded with fucoids (fossil seaweeds). (See pl. 13.) On weathering these fucoids are dissolved out, leaving the rock honeycombed. The rock is of high purity, probably purer than most of the Carlim limestone, so that it is much sought for in quarrying. No analyses from this region are available, but in Centre County, where it is the main quarry bed, many analyses show it to contain generally less than 2½ per cent of insoluble matter. The compact rock is seamed with minute veins and spotted with inclusions of calcite, owing to which it is sometimes called "calico rock."

Thickness.—The thickness of the Lowville is 140 to 180 feet.

Age and correlation.—The Lowville in this region is fairly fossiliferous. Among the 23 forms that have been identified are *Tetradium cellulosum* and *Cryptophragmus antiquatus* (*Beatricea gracilis*), which are common in the Lowville limestone or its equivalents from Canada to Alabama. They occur together also in the upper part of the Chickamauga limestone in the vicinity of Birmingham, Ala., and indicate that the Lowville is represented in the Chickamauga.

RODMAN LIMESTONE

Name and definition.—The Rodman limestone was named for its exposures at Rodman, 1 mile north of Roaring Spring. It is an impure limestone of a highly characteristic aspect and occupies the space between the thick-bedded Lowville below and the Trenton limestone above.

Distribution.—The Rodman has the same areal distribution as the Lowville, at the top of which it crops out throughout these quadrangles. It is exposed at the top of every quarry in the region and marks the top of the quarry rock, neither it nor any bed above it being quarried.

Character.—The Rodman limestone is dark, thin bedded, coarsely crystalline, and highly argillaceous or siliceous. It weathers with a dirty-gray or earth-colored and rough surface. The roughness is due to the coarse grain and the presence of crinoid plates and fragments of other fossils. The highly characteristic weathered surface and the fact that it marks the top of the quarry rock make its recognition easy. It has been recognized in the Bellefonte district also and is no doubt persistent throughout the Nittany Valley.

Age and correlation.—The Rodman is abundantly fossiliferous, but only in a few localities are well-preserved specimens at all plentiful. One such place is Rodman, the type locality.

Among the 43 recognized species the most interesting is the "ball cystid" *Echinosphaerites*, an ovoid form, with the largest diameter 2 inches, related to the modern sea urchins and sea lilies. The Rodman fauna shows sufficiently close relationship with that of the *Echinosphaerites*-bearing bed of the Chambersburg limestone of Pennsylvania as described in the Mercersburg-Chambersburg folio (No. 170, section, p. 8, column 1) to warrant the tentative correlation of the Rodman with that zone of the Chambersburg, which Ulrich has determined to be of upper Black River age. *Echinosphaerites* also occurs in the Baltic Sea region of Europe in beds regarded as of Black River age. The Rodman fauna is a distinctly upper Black River fauna somewhat closely related to that occurring in the Decorah shale of Iowa and Minnesota. Of related interest is *Aulopora? trentonensis*, of the Rodman, which is the only species of the genus so far reported from beds as old as Middle Ordovician and which also occurs in the Decorah shale of Minnesota. Other fossils of the Rodman important for correlation are *Plectoceras undatus* and *Gonioceras anceps*, which occur in the Watertown limestone of the Black River group of New York, the first being confined to that zone so far as reported. The Rodman is tentatively correlated with the Watertown.

HIATUS BETWEEN RODMAN AND TRENTON LIMESTONES

In the Chambersburg region about 600 feet of fossiliferous limestone, the Chambersburg limestone as now defined, which occupies a position apparently intermediate between the Black River and Trenton limestones of New York, intervenes between the *Echinosphaerites* zone referred to above and the base of the Martinsburg shale of that region, the lower part of which corresponds to the Trenton limestone. In the Hollidaysburg-Huntingdon region the Trenton limestone immediately succeeds the Rodman limestone, leaving a stratigraphic gap caused by the absence of the intermediate beds of the Chambersburg region, provided of course that the Rodman is correctly correlated with the *Echinosphaerites* zone.

TRENTON LIMESTONE

Name and definition.—The name Trenton is an old one and was taken from Trenton Falls, on West Canada Creek, in Herkimer County, N. Y. In these quadrangles the Trenton is bounded below by the Rodman limestone and above by a bed of black shale in the bottom of the Reedsville shale.

Distribution.—The Trenton has the same general surface distribution as the Carlim and Lowville at the west base of Tussey Mountain on the east and along the east base of the Lock-Dunning Mountain ridge on the west. It crops out just east of the quarries on Clover Creek and at Carlim and just west of the quarries on Piney Creek and at Roaring Spring.

Character.—The Trenton limestone is thin bedded, dark to black, nongranular or very fine grained, somewhat argillaceous and siliceous, and moderately fossiliferous. The thinnest layers are half an inch thick, and most of them are probably less than 6 inches thick. At some points exposed layers are cut by a multitude of cleavage or joint planes perpendicular to the bedding, which divide the layers into small blocky pieces that are characteristic of the Trenton of this region. Its outcrop can usually be detected through the abundance of these small blocks scattered upon the surface. The rock weathers invariably with a grayish exterior that contrasts strongly with the black interior. The layers generally seem to be in close contact and without conspicuous shaly partings. The quantity of impurities is so great that the rock is unfit for use as flux or lime, and it is not utilized for any purpose.

Thickness.—Fully reliable measurements of the thickness of the Trenton are not obtainable in this region, but estimates based on the dip and the width of outcrop give about 350 feet at the east base of Dunning Mountain and 500 feet at the west base of Tussey Mountain, showing that the thickness increases eastward.

Age and correlation.—In this region the Trenton is not a highly fossiliferous formation, as it is in New York, but 19 species have been collected from it, including such characteristic Trenton species as "*Dalmanella rogata*," *Dinorthis pectinella*, *Hesperorthis tricenaria*, *Parastrophina hemiplicata*, *Rhynchotrema increbescens*, *Sinuites cancellatus*, *Spyroceras bilineatum*, *Ceraurus pleurexanthemus*, *Cryptolithus tessellatus*, *Brongniartia* (*Homalonotus*) *trentonensis*, *Isotelus gigas*, and *Thaleops ovatus*. Besides these are a few species in the base of the Trenton or in the top of the underlying Rodman limestone that are rare in American Ordovician faunas. *Brongniartia trentonensis* has been found only in central Pennsylvania, where it occurs about 60 to 75 feet above the bottom of the Trenton. As this species does not occur in the typical Trenton of New York the beds carrying it in central Pennsylvania may be somewhat older than the basal beds of the New York Trenton.

REEDSVILLE SHALE

Name and definition.—The Reedsville shale was named for Reedsville, Pa., near which is a fairly good exposure of the formation. It extends from the top of the Trenton to the base of the Oswego sandstone.

Distribution.—The Reedsville shale crops out in a belt half a mile wide along the west flank of Tussey Mountain, where it dips east, and in another belt along the east side of the Dunning-Lock Mountain ridge, where it dips west.

Character.—The Reedsville has at bottom a stratum of black shale, 40 feet or less thick, which includes thin layers of black limestone, showing a gradual passage from the Trenton to the Reedsville. Above the black shale is a considerable body of olive-green shale, much of which is minutely jointed, so that it weathers out into small prisms, the smallest of which are the size of shoe pegs. Above the olive-green shale lies several hundred feet of dark shale with many sandy and highly fossiliferous limestone bands 1 foot or less thick. The top stratum of the formation, in immediate contact with the overlying Oswego sandstone, is a thick-bedded siliceous, fossiliferous rock 50 feet thick. (See pl. 14.) This bed, called the *Orthorhynchula* zone from the rather abundant occurrence in it of *Orthorhynchula linneyi*, a distinctive fossil, is persistent in both lithologic and paleontologic character southward to northern Tennessee and is thus a very important horizon marker.

The basal black shale is well displayed in the old ore bank at Henrietta, in the highway southeast of the point of Loop and Lock Mountains about 2 miles north of Martinsburg, and along the east base of Dunning Mountain, where pits have been dug into it in search of coal. The olive-green shale is exhibited at Martinsburg and along the highway east of Short Mountain from McKee Gap to Dry Gap. In fact, débris of this shale is more or less in evidence everywhere on the outcrop of the formation. The dark shale with limestone bands forming the upper part of the formation is best exposed in the cut of the Pennsylvania Railroad between Point View and Franklin Forge.

Thickness.—The total thickness of the Reedsville is 1,000 feet.

Of the 42 species of fossils from the Reedsville that have been identified, *Diplograptus foliaceus vespertinus*, *Climacograptus* aff. *C. typicalis*, and *Triarthrus becki* occur in the basal black shale and suggest that it is of Utica age. *Aspidopora newberryi*, *Hallopora sigillaroides*, *Dalmanella multisecta*, *Lingula nicklesi*, *Orthorhynchula linneyi*, *Plectorthis fissicosta*, *Strophomena hallie*, *Zygospira cincinnatiensis*, *Byssonychia radiata?*, *Lyrodesma poststriatum*, *Pterinea demissa*, and several more pelecypods correlate the Reedsville with the Lorraine group of New York, the Eden and Maysville groups of southwestern Ohio, and the upper two-thirds of the Martinsburg shale in other belts of the Appalachian Valley. *Orthorhynchula linneyi*, *Lingula nicklesi*, *Byssonychia radiata?*, and several other pelecypods form a persistent assemblage in the upper 50 feet of the Reedsville or the Martinsburg shale from central Pennsylvania to central east Tennessee, where this zone has been recognized on the northwest side of Clinch Mountain near the latitude of Morristown. The zone can be surely identified in every belt of outcrop of the Martinsburg or Reedsville along the northwest side of the valley within the limits defined and is called the *Orthorhynchula* zone.

OSWEGO SANDSTONE

Name and definition.—The Oswego sandstone was named for its exposures at Oswego, N. Y. It was called Oneida conglomerate by the Second Geological Survey of Pennsylvania in the mistaken belief that it is the same as the Oneida conglomerate of central New York and was later called "Bald Eagle conglomerate" by Grabau. In these quadrangles it overlies the Reedsville shale and underlies the Juniata formation.

Distribution.—The Oswego sandstone succeeds, with perfect accordance of bedding, the heavy siliceous and fossiliferous (*Orthorhynchula*) beds included in the top of the Reedsville shale. (See pl. 14.) It crops out along the west side of Tussey Mountain and the east side of Lock and Dunning Mountains, being marked by a distinct bench on the slopes of the ridges near the crest.

Character.—The Oswego is fairly thick bedded, fine grained, and steely blue-gray on fresh fracture and is speckled with iron rust as if from the decomposition of iron pyrites. Many of the layers are delicately cross-laminated. At Bellefonte, in Centre County, the Oswego includes layers of coarse conglomerate, but in this region pebbles are scarce; only a few small ones were seen on the spurs southeast of Cove Forge. It includes a few beds of greenish and red sandy shale, some of them 5 feet thick. A layer of red shale in the base is exposed in the railroad cut 1 mile southeast of Tyrone, about 14 miles northeast of Altoona.

In Pennsylvania the Oswego may be of sand flat or fresh water origin. The absence of fossils is one reason for this belief.

Thickness.—The thickness of the Oswego, as nearly as it can be determined, is 800 feet.

Age and correlation.—In New York the Oswego sandstone lies above the Lorraine group and below the Queenston shale. The upper half or so of the Lorraine group (Pulaski shale) is regarded by Foerste and Ulrich as being equivalent to the Fairview formation of the Maysville group of the Cincinnati region, Ohio. The Juniata formation, which overlies the Oswego in Pennsylvania, is correlated with the Queenston shale of New York. Further, the Juniata and Queenston are correlated with the Richmond group at Cincinnati, which overlies the Maysville. A few fossils reported by Ulrich from the basal part of the typical Oswego of New York would indicate an upper Fairview and lower McMillan age for that part, and it seems most probable that the remaining (upper) part of the Oswego corresponds to the upper McMillan part of the Maysville.

JUNIATA FORMATION

Name and definition.—The Juniata formation was named for the Juniata River, along which it is in places well exposed. It includes all the red shale and sandstone between the underlying Oswego sandstone and the overlying Tuscarora quartzite.

Distribution.—The Juniata crops out on the west side of Tussey Mountain and on the east side of the Lock-Dunning Mountain ridge, on both ridges just below the crest. Its outcrop is marked by a depression between the crest of the ridge made by the Tuscarora quartzite and the bench on the sides of the ridges made by the Oswego sandstone. There are no good exposures of the Juniata in the Hollidaysburg and Huntingdon quadrangles, although its presence beneath the areas of its outcrop can everywhere be detected by the red soil and débris and by an exposed bed of red shale or red sandstone here and there.

Character.—The Juniata formation is composed almost wholly of red or brown shale and sandstone. The sandstone is fine grained and carries flakes of mica. Many of its layers are delicately cross laminated. The shale is not fissile but lumpy and would be more properly designated a mudrock. It is slightly micaceous and appears to be sandy. The formation is not well enough exposed in this region to permit an estimate of the proportions of shale and sandstone, but a good exposure in the gap through Bald Eagle Mountain just east of Tyrone, about 12 miles north of Point View, shows a great preponderance of red sandstone. The formation is nonfossiliferous throughout.

Thickness.—In this region the average thickness of the Juniata formation is 850 feet.

Age and correlation.—The Juniata in this region is destitute of fossils and therefore contains no internal evidence of its geologic age. It is known, however, to be of the same age as the Queenston shale, which is exposed in Niagara Gorge in New York and Canada. The red rock was reached at a depth of about 5,500 feet in a deep well near Bradford, Pa., about midway between central Pennsylvania and Niagara Falls. Northwest of Niagara Falls through Ontario fossils appear in the Queenston that prove it to be of the same age as the highly fossiliferous Richmond group of the Cincinnati region of Ohio and Indiana.

SILURIAN SYSTEM

The Silurian system includes the Tuscarora quartzite, Clinton formation, McKenzie formation, Bloomsburg redbeds, Wills Creek shale, and Tonoloway limestone.

TUSCARORA QUARTZITE

Name and definition.—The Tuscarora quartzite was named for Tuscarora Mountain, Pa., a ridge made by an outcrop of the formation. It overlies the Juniata formation and underlies the Clinton formation. It is of special interest as the source of silica or ganister for the manufacture of silica brick and is thus the basis of a large industry in Blair and Huntingdon Counties.

Distribution.—The Tuscarora crops out only along the crests of ridges, such as Tussey, Lock, and Dunning Mountains.

Character.—The Tuscarora is a white or gray, medium thick bedded quartz sandstone, composed of medium-sized transparent grains of quartz. In some groups of layers the quartz grains are firmly cemented together by interstitial quartz deposited around the original grains in crystallographic continuity, making the rock a quartzite. It is these parts of the formation that constitute the best grade of ganister in the region. Some layers, probably amounting to but a small part of the whole, are composed of well-rounded, loosely cemented grains, a few of which exceed 1 millimeter in diameter. Curiously contrasted with the hard quartzite are occasional layers, as much as 18 inches thick, of soft white, unctuous, and apparently nonsiliceous clay. A number of such layers have been encountered in the quarry on the top of the south end of the western offset continuation of Lock Mountain in the northeast corner of the Hollidaysburg quadrangle.

The bedding and attitude of the Tuscarora are shown in Plate 15.

The hard, resistant character of this formation and its highly inclined attitude have caused the development of the sharp, steep mountain ridges of the region, such as Tussey and Dunning Mountains. These ridges are in general deeply covered near their crests with boulders ("scree") that have weathered off from the sandstone which crops out along the crests.

Thickness.—The Tuscarora has a thickness of 400 to 600 feet in these quadrangles.

Age and correlation.—Only one fossil, *Arthrophycus alleghaniensis*, supposed to be a cast of a worm burrow, occurs in the Tuscarora quartzite. It is abundant, locally at least, near the top of the formation. This fossil characterizes the top of the Albion sandstone (Thorold member) in New York and the Clinch sandstone of Virginia, so that the Tuscarora is correlated with the Albion on the north and with the Clinch on the south. The Albion sandstone is the upper part of the Medina sandstone as described in the older literature. The lower part of the old Medina is now known as the Queenston shale, which is correlated with the Juniata formation of Pennsylvania, and this correlation supports the above correlation of the Tuscarora.

NIAGARA GROUP

Only one formation of Niagaran age—the Clinton—is represented in this area.

CLINTON FORMATION

Name and definition.—The Clinton was named for its exposures in the town of Clinton, Oneida County, N. Y. Its stratigraphic limits in these quadrangles are the Tuscarora quartzite below and the McKenzie formation above.

Distribution.—The Clinton crops out in a narrow belt along the east side of the Tussey Mountain and the west side of Dunning and Lock Mountains and around the south end of Brush Mountain. Hollidaysburg is situated upon the Brush Mountain area of the formation. The best natural exposures of the formation are in the vicinity of Hollidaysburg, at Lakemont, at McKee Gap, and in the gorge of Frankstown Branch of the Juniata west of Point View.

Character.—The Clinton is composed of shale and a small proportion of sandstone and limestone. Most of the limestone is in thin layers in the upper part of the formation, and some of the sandstone is in thin layers in the middle part of the formation, but there are sandstone beds of considerable thickness near both the top and the bottom. There are several thin beds of hematite but not all are present at any one locality. A section of all but the upper 50 to 100 feet was obtained near Marklesburg, in the Huntingdon quadrangle, in a mine tunnel that extends horizontally 1,000 feet through the steeply dipping Clinton beds to a point within about 10 feet of the top of the Tuscarora quartzite. This section is supplemented by a section of the basal beds of the Clinton exposed in a railroad cut about half a mile west of Barree station, in the Tyrone quadrangle. Both sections are given below.

Section on the east slope of Tussey Mountain 1 mile north of Marklesburg

	Feet
McKenzie formation:	
Limestone and shale.	
Clinton formation:	
13. Shale, soft clay, weathers yellow (Rochester age)	61±
12. Sandstone, coarse, thick bedded, calcareous, ferruginous, fossiliferous; "Ore sandstone" of I. C. White (Keefer sandstone member)	10±
11. Ore, fossiliferous; "fossil ore" of White	2±
Section in tunnel:	
10. Shale, soft; sandstone layers, greenish, thin, fine-grained, yellowish, through 50 to 100 feet in middle; layer of "red" (keel) 2 inches thick reported near middle; "Middle Clinton shales" of White	615
9. Sandstone, hard, fine grained, grayish to greenish, medium thick bedded	40
8. Sandstone, ferruginous, blocky, yields red sandstone débris, Levant ore bed; "Iron sandstone" and "block ore" of White=Nos. 5 to 7 of railroad section below	1
7. Ore, oolitic, fine grained, local; degenerates to ferruginous sandstone elsewhere in area	4
6. Shale, bluish	3
5. Sandstone, argillaceous, hard, fine grained, greenish	2
4. Shale	2
3. Sandstone, hard 3-inch flags	1
2. Shale; may have some thin sandstone layers	30
1. Sandstone, greenish and bluish gray, siliceous, hard, fine grained to bottom (No. 3 of railroad section below)	5
	776

Section of the basal beds of the Clinton formation at a cut on the Pennsylvania Railroad about half a mile west of Barree station

	Ft.	in.
Clinton formation:		
9. Shale, weathering purplish above. Equivalent to lower part of No. 10 of tunnel section	50	
8. Shale, with sandstone layers 1 to 6 inches thick, fine grained, greenish gray (No. 9 of tunnel section)	15	
7. Sandstone, ferruginous, red; "iron sandstone" of I. C. White	4	
6. Shale, green	1	6
5. Sandstone, ferruginous, red, iron sandstone (Nos. 5–7 are equivalent to Nos. 8 and 7 of tunnel section)		4
4. Shale, with fine-grained sandstone layers 2 to 4 inches thick (Nos. 6–2 of tunnel section)	25	
3. Sandstone, hard, reddish and grayish green, fine grained (No. 1 of tunnel section)	5	6
2. Shaly beds with thin firmer layers (not exposed in tunnel section)	8	
Tuscarora quartzite:		
1. Sandstone, thick bedded to massive, with *Arthrophycus alleghaniensis*	100±	

These two sections give a very complete representation of the Clinton of this region, the western outcrops in Logan Valley differing only in minor details such as the apparent absence of the basal sandstone beds, the change of the Keefer sandstone member to a siliceous, ferruginous limestone, and the presence of the Frankstown ore at about the horizon of the 2-inch layer of "keel" in No. 10 of the tunnel section.

Levant or "block" ore beds and red sandstone.—Near the base of the formation is a persistent red sandstone with which is locally associated the Levant or "block" ore bed or pocket as at Marklesburg. At an outcrop about 1,000 feet north of the old Frankstown mine 2½ miles northeast of Hollidaysburg it is a reddish thick-bedded, solid sandstone 10 feet thick. Much red sandstone débris from this bed is scattered on the lower slope of the south end of Brush Mountain. These red layers are reported to persist along the east side of Tussey Mountain to Maryland. They are similar in lithologic character to the red sandstone in the "Cacapon" formation of Virginia and are undoubtedly the thinned northern expression of that type of sandstone. At Marklesburg the associated block ore was a fine oolitic ore 1 to 6 feet thick and clearly a pocket. So far as it was of workable thickness it has been mined out.

Sandstone bed.—Just above the Levant ore and red sandstone lies 15 to 40 feet of hard, fine-grained greenish or grayish sandstone (Nos. 9 and 10 of the preceding sections). This bed crops out over a small area on the crest of the Penn-Walker anticline about 2 miles northwest of Grafton. It seems to be the Castanea sandstone of Swartz.

Frankstown and other ore beds.—In the vicinity of Hollidaysburg, probably about 250 feet above the bottom of the Clinton, is the Frankstown ore bed, 8 to 22 inches thick, in the midst of shale. The ore bed could not be examined, because it does not show in outcrop, and mining ceased many years ago. Fragments of ore picked up on the old dumps consist largely of small lenses, which were in part and probably almost wholly formed by the replacement by ferric oxide of the shells of a small brachiopod, *Coelospira hemispherica*, or are internal moulds of the shells.

Thin, lean ore beds that lie 200 to 300 feet above the Frankstown bed have been known in the region as the upper and double ore beds. They are exposed in some of the streets of Hollidaysburg.

In a section exposed at Lakemont the top 100 feet of the formation contains a number of thin limestone bands and thin ore bands that were not seen east of Tussey Mountain. Just above the Keefer sandstone representative in this section lies 12 to 18 inches of ore that represents the Roberts ore bed of Maryland west of Tussey Mountain.

The Marklesburg bed, a typical Clinton fossiliferous hematite 1 to 2 feet thick, lies just under the Keefer sandstone member, No. 12 of the Marklesburg section. It is known only east of Tussey Mountain.

Keefer sandstone member.—The Keefer sandstone member was named for its exposures on Keefer Mountain, in the southwest corner of Franklin County, Pa., especially at Warren Point, the south end of the mountain. It is the "ore sandstone" of White,[5] so called because it overlies the Marklesburg ore bed. It is generally a highly siliceous, hard, coarse-grained sandstone 8 to 10 feet thick, yielding an abundance of large boulders. Locally it is highly ferruginous, weathers rather soft and spongy, and is fossiliferous and probably calcareous. It persists along the east base of Tussey Mountain, where its outcrop is marked by a hogback or series of low knolls, and is especially well displayed around the detached area of the Clinton formation northeast of Marklesburg and in the small area 2½ miles northwest of McConnellstown. West of Dunning and Lock Mountains the Keefer is represented by a persistent bed of highly ferruginous and sandy limestone 5 feet thick and 60 feet below the top of the Clinton. Where not exposed it reveals its presence by a noticeable brown band in the soil.

Beds above the Keefer member.—Immediately overlying the siliceous limestone bed representing the Keefer member in the section at Lakemont, between Hollidaysburg and Altoona, and with varying details doubtless elsewhere west of Dunning and Lock Mountains, is 61 feet of shale containing thin limestone bands and thin layers of lean ore extending up to the McKenzie formation. East of Tussey Mountain the corresponding interval between the Keefer sandstone member and the McKenzie seems to be about the same, but the rocks included are nearly all green, rusty-weathering, thinly fissile clay shale. Some small thin fragments only, suggesting rotten argillaceous limestone, were noted and White reports thin limestone in this part of the section half a mile east of Barree. These beds are correlated with the Rochester shale.

Thickness.—The thickness of the Clinton as measured at Marklesburg, plus 61 feet for the thickness above the Keefer sandstone member as measured at Lakemont in the Hollidaysburg quadrangle, is 776 feet.

Age and correlation.—Ulrich and Bassler[6] have published an elaborate discussion of the stratigraphic relations and correlation of the Clinton. They divide the formation into lower, middle, and upper Clinton; each division has three zones, and each zone is marked by a characteristic assemblage of fossils. In these quadrangles the lower division of Ulrich and Bassler extends somewhat above the Frankstown ore bed; the upper division extends downward about 50 feet below the Keefer sandstone member; and the middle division lies between the other two. The formation is fossiliferous, some parts of it abundantly. The species that are most abundant and that are generally distributed throughout the formation are ostracodes, bivalved crustaceans about a millimeter long, like the common water fleas, of which *Cypris* is an example. Of these more than 54 species occur in these quadrangles. In the bottom of the Clinton, at the horizon of the "block ore," occur, in addition to several species of characteristic ostracodes, the common Clinton fossils *Coelospira hemispherica*, *Rafinesquina* cf. *R. corrugata*, and a *Pterinea?* closely allied to a Medina species. In the Frankstown ore and 6 to 10 feet above it are, besides 14 species of ostracodes, *Coelospira hemispherica*, *Parmorthis* aff. *P. elegantula*, and *Calymene* aff. *C. blumenbachi*. No collections were obtained from the middle division of the Clinton in these quadrangles, which here seems to lack the more familiar Clinton forms. The upper division of the Clinton is, on the contrary, profusely fossiliferous, and from it 59 species were collected, of which 36 are ostracodes. The other 23 species are more especially characteristic of the Rochester shale of the Niagara Gorge, some of them—for example, *Dalmanites limulurus*—being restricted thereto, as it is also to the part of the Clinton of this region above the Keefer sandstone. That part is therefore correlated with the Rochester shale, which is shown by paleontologic evidence to be represented by the upper 50 to 60 feet of the typical Clinton of eastern New York. This shale of Rochester age constitutes the *Drepanellina clarki* zone of Ulrich.[7] The part of the upper division of the Clinton below the Keefer sandstone member is also proved by the evidence of fossils to be represented in the upper division of the Clinton of New York and in the Alger formation of Foerste in eastern Kentucky and southern Ohio, there being at least nine species of ostracodes common to the beds named. The middle and lower parts of the Clinton in this region correspond to the part of the typical Clinton of eastern New York below the main oolitic ore bed and to the lower two-thirds of that part of the Red Mountain formation of Alabama above the bottom of the "Big seam" of ore. The upper division of the Pennsylvania Clinton is represented in Alabama by the upper 50 feet, more or less, of the Red Mountain formation, which carries *Dalmanites limulurus* and other Rochester shale fossils.

CAYUGA GROUP

To the Cayuga group of this area are assigned, in ascending order, the McKenzie formation, Bloomsburg redbeds, Wills Creek shale, and Tonoloway limestone.

MCKENZIE FORMATION

Name and definition.—The McKenzie formation was named for its exposures near McKenzie station, on the Baltimore &

[5] White, I. C., The geology of Huntingdon County: Pennsylvania Second Geol. Survey Rept. T3, p. 133, 1885.

[6] Ulrich, E. O., and Bassler, R. S., American Silurian formations: Maryland Geol. Survey, Silurian, pp. 255–260, 1923.

[7] Idem, pp. 349–353, 1923.

Ohio Railroad west of Cumberland, Md. It includes the limestone and the shale containing limestone layers that lie between the top of the Clinton as herein defined and the bottom of the persistent overlying Bloomsburg redbeds. In the Hollidaysburg region, as displayed in the fine section exposed at Lakemont, the formation begins at the base with a bed of "bouldery" limestone and extends upward to the base of a bed of red shale (Bloomsburg) which is well displayed around the foot of Brush Mountain. East of Tussey Mountain the formation begins below with the lowest well-developed limestone beds above the Keefer sandstone member of the Clinton (about 60 feet above it) and extends to the bottom of the red shale and red sandstone that crop out on Redstone Ridge. The McKenzie appears to correspond to the "upper Clinton shale" and "Barree limestones" of White,[8] except that White's upper Clinton includes the 60 feet or so of Clinton above the Keefer sandstone member.

Distribution.—The formation has the same general surface distribution as the Clinton at the base of Brush Mountain, the west base of Dunning and Lock Mountains, and the east base of Tussey Mountain. The best exposures are at Lakemont and south of Gaysport. At other places, where not concealed by wash from the mountain sides, the presence of the formation is revealed by a limy soil and by fragments of shale and fossiliferous limestone.

Character.—The McKenzie formation is composed of greenish clay shale with many interbedded thin layers of limestone and has near the middle one or more persistent layers of red shale. Locally limestone predominates below and may even almost wholly make up the lower 50 feet, as in the section at Lakemont. The limestone is mainly dark gray, fine grained, or nongranular, and many layers are crowded with fossils. At the south end of the offset part of Lock Mountain, the McKenzie is composed of gray and yellowish-green shale with thin limestone layers crowded with fossils. Apparently above the middle are two layers of red shale, the lower 15 and the upper 6 feet thick, separated by 6 feet of gray shale. Just above the upper shale is a layer of lean fossil ore 1 to 2 inches thick.

On the east side of Tussey Mountain the section is very much like that at the south end of Lock Mountain. The formation is composed of shale with thin layers of argillaceous granular limestone and has near the middle a persistent band of red shale that is probably at the same stratigraphic horizon as the red shale at the south end of Lock Mountain. The following section, given by White, shows the thickness and composition of the McKenzie.

Section of Stoler tunnel No. 2, 2 miles southwest of Cove[9]

	Feet
Bloomsburg redbeds:	
Concealed by surface débris	43
Red rock	25
McKenzie formation:	
Shale, bluish green	77
Shale, red	70
Shale, olive	60
Clay, blackish, originally limy	47
Shale, olive and yellowish	48
Clay, blackish (decomposed limy beds)	82
	384
Clinton formation:	
Shale, olive and bluish gray	63
Ore; fossils.	

Thickness.—The thickness of the McKenzie is about 200 feet in the Lakemont section and about 400 feet at the south end of the offset Lock Mountain and east of Tussey Mountain.

Age and correlation.—The McKenzie is fossiliferous. Ostracodes are very abundant and many species are represented, but of other fossils only 10 species have been identified. Myriads of ostracodes lived in the water of the McKenzie sea, and the thin valves of their shells make up almost the whole of some layers of rock, a cubic inch of which contains not fewer than 50,000 valves, representing 25,000 individuals. The species are described and figured by Ulrich and Bassler.[10]

The fossils afford no decisive evidence regarding the correlation of the McKenzie. The ostracodes are nearly all peculiar to the formation. The other fossils are also either peculiar—for example, *Reticularia bicostata*—or range through both older and younger formations. In Maryland there is a larger nonostracode fauna, a considerable percentage of which occurs elsewhere in rocks of Rochester or Lockport age. These forms would support correlation of the McKenzie with the Rochester or Lockport. However, the Lockport dolomite, the youngest of the Niagaran formations, thins out toward the east in central New York, and no beds of similar character occur in Pennsylvania, where the McKenzie lies between beds of Rochester age and the Bloomsburg redbeds. The Bloomsburg is overlain by the Wills Creek shale, which is abundantly proved by its fossils to be of Salina (early Cayugan) age. The Salina beds are composed in part of red shale, which is absent in the Niagaran formations, so that the red shale of the McKenzie is believed to indicate that it is of Cayuga (Salina) rather than Niagara age. The large assemblage of ostracodes, unknown in earlier formations, points also to an age later than Niagaran. The McKenzie is therefore correlated with the basal part of the Salina formation of western New York.

[8] White, I. C., op. cit., p. 132.
[9] White, I. C., op. cit., p. 161.
[10] Ulrich, E. O., and Bassler, R. S., op. cit., pp. 500–704, pls. 36–65, 1923.

BLOOMSBURG REDBEDS

The Bloomsburg redbeds formation was named for its exposures at Bloomsburg, Columbia County, Pa. It includes the red shale and red sandstone immediately overlying the McKenzie formation. The red shale and sandstone are prominently displayed along Redstone Ridge and other narrow wooded ridges east of Tussey Mountain. There are especially good exposures 1 mile northeast of Russellville, 1 to 1½ miles north and northeast of Marklesburg, and on the river road in the gorge at the south end of Canoe Mountain, in the northeast corner of the Hollidaysburg quadrangle. It shows well in the road at the east base of the reservoir hill just east of Hollidaysburg, in the road about 1 mile southwest of Gaysport, and on the low ridge east of Altoona and 1 mile south of the north boundary of the quadrangle.

East of Tussey Mountain the Bloomsburg is composed of fine-grained red sandstone, nonfissile lumpy red shale or mudrock, and green shale, and west of Dunning and Lock Mountains it is composed of red shale and impure limestone without sandstone. A section exposed 1 mile northeast of Russellville has 15 layers 1 to 20 feet thick of the different kinds of rock, among which there are two layers of red sandstone making 22 feet and six layers of red shale making 46 feet. The whole thickness exposed is 107 feet. A section exposed at the offset end of Lock Mountain is composed of limestone and red and gray shale, 10 beds in all, 2 to 25 feet thick, of which five are red shale aggregating 41 feet; the full thickness exposed is 87 feet. A notable difference between the formation east of Tussey Mountain and that at the south end of Lock Mountain is the absence of sandstone in the last and the small amount of limestone in the first. Farther west, in the vicinity of Lakemont and Hollidaysburg, the Bloomsburg redbeds is reduced to one or two beds of red shale, apparently separated by gray shale with limestone layers, and probably does not exceed 50 feet in thickness.

A very notable feature of the sandstone and limestone in the Bloomsburg is the vertical cleavage, by which the beds are divided into many small prisms. This cleavage is especially prominent in the sandstone layers along Redstone Ridge, where it is so perfect in places that it has a very misleading resemblance to vertical bedding.

The hard sandstone beds of the Bloomsburg redbeds east of Tussey Mountain make ridges and knobs, along which the rock crops out in many places in ledges marked only by trees and underbrush. Redstone Ridge is an example.

The thickness of the Bloomsburg is 50 to 150 feet.

Age and correlation.—On lithologic grounds and stratigraphic sequence the Bloomsburg redbeds is correlated with the Vernon shale member of the Salina formation.

WILLS CREEK SHALE

Name and definition.—The Wills Creek shale was so named because it crops out along or near Wills Creek at Cumberland, Md. In reports of the Second Geological Survey of Pennsylvania it was called Salina shale. It overlies the Bloomsburg redbeds and underlies the Tonoloway limestone.

Distribution.—The Wills Creek shale crops out around the base of Brush Mountain, well up on the west side of Lock and Dunning Mountains, and along the east side of Tussey Mountain. Except on Lock and Dunning Mountains its outcrop is in a valley or on low ground, as it is easily eroded. The best exposures are along the highway southwest of Gaysport and on roads leading to farmhouses east of the highway. Fairly good exposures may be seen at the east base of Brush Mountain, 3 miles west of Canoe Creek. The belt of outcrop east of Tussey Mountain shows many small exposures and much surficial débris.

Character.—The Wills Creek formation is composed almost wholly of thin, fissile gray shale that is probably calcareous where unweathered. The part of the formation overlying the Bloomsburg redbeds contains thin limestone layers near the base and some at other horizons. In the basal shale small cavities filled with gypsum crystals occur here and there. The formation merges at the top into shaly limestone that is included in the next overlying formation.

Thickness.—The thickness of the formation, computed from the approximate average dip and the width of outcrop, appears to be about 400 feet.

Age and correlation.—*Leperditia* cf. *L. altoides* and a small rhynchonellid are the only fossils found in the Wills Creek of Pennsylvania, but as reported by Swartz,[11] in Maryland the formation has yielded a few more fossils, including such well-known species as *Camarotoechia litchfieldensis, Fardenia interstriatus, "Spirifer" vanuxemi, Calymene camerata,* and *Leperditia alta.* There is a new species of eurypterid, *Dolichopterus cumberlandicus,* and a few fragments have been referred to *Hughmilleria* cf. *H. shawangunk.* About 17 species of ostracodes have been found, most of which are new species or varieties. As the fossils specifically identified are now known to be of rather uncertain stratigraphic value they afford no satisfactory ground for correlation beyond indicating the Cayugan age of the Wills Creek. The presence of salt crystals in the Wills Creek shale and its position above the Bloomsburg redbeds suggest a correlation with the salt-bearing Camillus shale member of the Salina formation of New York.

[11] Swartz, C. K., Maryland Geol. Survey, Silurian, p. 43, 1923.

TONOLOWAY LIMESTONE

Name and definition.—The Tonoloway limestone was named for its exposures in the lower slopes of Tonoloway Ridge, in Washington County, Md. It includes more than the lower half of the Lewistown limestone of previous reports. It underlies the Keyser limestone member of the Helderberg limestone and overlies the Wills Creek shale.

Distribution.—The outcrop of the Tonoloway limestone, together with the overlying Helderberg, makes a ridge paralleling the base of Brush Mountain northeast of Hollidaysburg. The Tonoloway also crops out along the west slope of Lock and Dunning Mountains, near the base. East of Tussey Mountain it crops out along the west side of Warriors Ridge to the north line of the Huntingdon quadrangle. The best exposures of the Tonoloway are in the railroad cut just east of Hollidaysburg and in McKee Gap. The basal beds are exposed at points in the road along the east base of Brush Mountain, and partial exposures along Warriors Ridge east of Tussey Mountain afford a fairly satisfactory knowledge of the limestone.

Character.—The Tonoloway is prevailingly a thin-bedded to laminated dark fine-grained or nongranular limestone. Layers 1 to 2 feet thick occur but compose only a small part of the whole. Its general character is exhibited in the lower part of the section on Bald Hill, east of Hollidaysburg, given below.

Section of limestones at Bald Hill, 1 mile east of Hollidaysburg

	Feet
Devonian	
Oriskany group:	
Ridgeley sandstone	
24. Sandstone, exposed	30±
23. Limestone, thick bedded, siliceous	20
	50
Shriver limestone:	
22. Limestone, very evenly thin bedded, highly siliceous, generally light gray, some dark layers; weathers to fine-grained yellowish sandstone (pl. 22)	130
21. Limestone, shaly, dark and dark bluish	75
20. Limestone, shaly, black, fissile, fossiliferous; contains *Anoplotheca*	10
	215
Hiatus (Becraft limestone member of the Helderberg absent).	
Helderberg limestone:	
New Scotland limestone member:	
19. Limestone, thick bedded, gray; contains *Eospirifer macropleurus*	10
Coeymans limestone member:	
18. Limestone, thick bedded, gray; contains *Gypidula coeymanensis*	12
Keyser limestone member:	
17. Limestone, laminated; contains *Leperditia gigantea* and *L. elongata*	38
16. Limestone, rather thick bedded, but beds really laminated	46
15. Limestone, rather massive, coarse grained	12
14. Limestone, appears like No. 15 but is really nodular; weathers to nodules and small pieces; contains *Favosites helderbergiae* and other fossils	12
13. Limestone, massive, nongranular; contains calcite veins and eyes	7
12. Limestone, thick bedded, but tends to weather in laminae; tubular stromatoporids in bottom. Nos. 12 and 13 are the "calico rock," the quarry rock of the Hollidaysburg district	10
	147
Silurian	
Tonoloway limestone:	
11. Limestone, gray, thick bedded at top, laminated below; *Leperditia alta* abundant at top	70
10. Limestone, thin bedded; has shale partings	5
9. Shale	2
8. Limestone, thick bedded	8
7. Shale	1
6. Limestone, thick bedded, blue	5
5. Shale, with red streak	1
4. Limestone, thin bedded	5
3. Limestone	3
2. Limestone, shaly	20
Not exposed	220
1. Limestone, shaly, probably near bottom of Tonoloway	90
	430
Total thickness of the section	824

As shown in this section, the Tonoloway is thick bedded at top, but the thick layers are laminated, and the formation as a whole is distinctly thin bedded. The limestone is dark to nearly black and fine grained; it appears to be rather impure and is perhaps somewhat magnesian. Thin layers of black chert occur in the top 10 feet of the section. A mile south of Hollidaysburg layers of coarsely crystalline pinkish limestone and of a brown limestone with pebbles of the underlying shale occur in the base of the Tonoloway. East of Tussey Mountain the Tonoloway has about the same character as at Hollidaysburg. North of McConnellstown crystals of galena have been found in calcite veins along the west side of Warriors Ridge, and considerable money has been expended in prospecting for lead ore without success.

Thickness.—The thickness of the Tonoloway exposed in the Bald Hill section east of Hollidaysburg is 430 feet, and the formation probably is thicker, as no beds are exposed in the Bald Hill section like those at the bottom where it is exposed 1 mile south of Hollidaysburg. East of Tussey Mountain the thickness appears to be 600 feet.

Age and correlation.—There seems to be no doubt of the identity of the Tonoloway of this region with that of Maryland. In Maryland 28 species of fossils have been obtained from it, but in this region only a few species of *Leperditia* were obtained, mainly in the upper 50 feet, where they are plentiful in some layers.

Ulrich says, in comparing the Maryland and New York faunas:

> Comparison of these fossils with those of the New York section leaves little doubt concerning the late Cayuga age of the formation. Most of the diagnostic species above listed occur in the Schoharie Valley sections in New York between the base of the Cobleskill and the top of the "Tentaculite" or typical Manlius limestone. A considerable part of these species, it is true, passes upward in the Maryland sections into the Helderberg limestone. * * * The Manlius and Cobleskill therefore seem to be in general correlatable with the Tonoloway, although the fauna indicates that Tonoloway sedimentation in Maryland in part preceded that of the Manlius and Cobleskill in New York.

There are, however, some features of the faunas of the Cobleskill and Manlius that throw doubt on the validity of this correlation.

DEVONIAN SYSTEM

The Devonian system in these quadrangles includes the following formations, beginning with the lowest and oldest: Helderberg limestone, 150 to 200 feet; Oriskany group, composed of the Shriver limestone below, 200 to 300 feet, and the Ridgeley sandstone above, 50 to 100 feet; Onondaga formation, 50 feet; Marcellus shale, 200 to 300 feet; Hamilton formation, 800 to 1,200 feet; Portage group, comprising the Harrell shale below and the Brallier shale above, 1,600 to 2,050 feet; Chemung formation, 2,400 to 3,400 feet; and Hampshire formation, 2,000 to 2,500. In the Hollidaysburg quadrangle the total thickness of the Devonian is 7,465 feet, and in the southeast corner of the Huntingdon quadrangle, where the rocks are nearly vertical, the total thickness determined from the width of outcrop is more than 8,000 feet.

HELDERBERG LIMESTONE

Name and definition.—The Helderberg limestone was named for its exposures in the Helderberg Mountains, in New York. In these quadrangles the boundary between the Helderberg and the underlying Tonoloway limestone is with some doubt placed at the bottom of a bed of limestone known to the quarrymen of the region as the "calico rock," or in some sections a few feet lower. The Helderberg is bounded above by the basal black shale of the Shriver limestone (No. 20 of the section at Bald Hill).

The Helderberg in this region and in Maryland is divided into the Keyser limestone member at the base, the Coeymans limestone member in the middle, and the New Scotland limestone member at the top.

Distribution.—The Helderberg crops out near the crest of the ridge parallel to Brush Mountain from Altoona by way of Newry and Frankstown to the northeast corner of the Hollidaysburg quadrangle, thence southward the outcrop follows the west flank of Lock and Dunning Mountains to the south edge of the quadrangle. The Tower Rocks, just southeast of Hollidaysburg, are in the Helderberg as are also the limestone quarries from Altoona to Canoe Creek. East of Tussey Mountain the Helderberg crops out along the west slope of Warriors Ridge, where a number of quarries mark its basal part. Its full thickness is exposed at the Bald Hill cut, 1 mile east of Hollidaysburg, and in a quarry near Allegheny Furnace, half a mile south of Altoona.

Character.—The Helderberg limestone is variable in character. Its general features are exhibited in the following sections and in the section at Bald Hill given on page 7.

These sections with others are shown in graphic form in Figure 3.

1. *Section of quarry at Allegheny Furnace, half a mile south of Altoona*

	Feet
Helderberg limestone:	
New Scotland and Coeymans (?) limestone members:	
9. Limestone, thick bedded, cherty	10
Keyser limestone member:	
8. Limestone, mostly thin bedded, dark shaly layer at bottom	30
7. Limestone, thick bedded, gray	10
6. Limestone, very dark, nodular; nodules probably *Stromatopora* heads	8
5. Limestone, thin bedded	12
4. Limestone, thick bedded, crystalline	55
3. Limestone, nodular bed	8
2. Limestone, thick bedded ("calico rock")	12
	140
Tonoloway (?) limestone:	
1. Limestone, thick bedded	15

3. *Section of lower part of Helderberg limestone in Smith's quarry, on ridge half a mile west of Frankstown*

	Feet
Helderberg limestone (Keyser limestone member):	
7. Limestone, medium thick bedded, crystalline	10
6. Limestone, argillaceous, nodular; contains cobbly layer (quarrymen's "bogus rock")	3
5. Limestone, massive, gray, flecked with white and yellow calcite eyes and veins; upper 10 feet full of *Stromatopora* heads ("calico rock")	25
4. Limestone, thick bedded, light gray (silver-gray rock, generally included in "calico rock"?)	2–4
3. Limestone, many cylindrical fossils (quarrymen's "hobnail rock," generally included in "calico rock")	1
Tonoloway limestone:	
2. Limestone, thick bedded, layers laminated (quarrymen's "ledge rock")	5
1. Limestone, light gray, shaly; not utilized	1

6. *Section half a mile southwest of Grafton*

	Feet
Helderberg limestone (Keyser limestone member):	
10. Limestone, flaggy, *Stromatopora* abundant at top	12
9. Not exposed	5
8. Limestone, argillaceous, granular; contains *Diplostenopora siluriana*, *Fenestrellina altidorsata*, *Monotrypa corrugata*, *Orthopora regularis ?*, *Camarotoechia litchfieldensis*, *Dalmanella clarki*, and *Camarotoechia deckerensis*	5
7. Limestone, with lenses of argillaceous limestone and gray shale, much like bed No. 5; *Atrypa "reticularis," Stromatopora*, and cup corals are present	8
6. Limestone, thick bedded, granular; contains *Batostomella interporosa*, *Fenestrellina cumberlandiae ?*, *Thamniscus regularis*, and *Camarotoechia gigantea*	5
5. Shale with limestone nodules	4
4. Limestone, coarse, granular, thick bedded; crinoidal layer of other sections but no crinoidal remains here; brachiopods near bottom	6
3. Limestone, flaggy and cherty, dark to black, chert in thin layers and large thin lenses	7
2. Limestone, dove-colored and dark bluish, amorphous, thick bedded ("calico rock")	12
1. Limestone; top seen	15±

9. *Section in old quarry half a mile northwest of Cove*

	Ft.	in.
Helderberg limestone:		
14. Limestone, irregularly bedded, partly exposed (mostly Keyser member but probably includes Coeymans and New Scotland at top)	150±	
13. Limestone, impure, nodular bed (No. 14 of Bald Hill section)		2
12. Limestone, thick bedded, crowded with crinoid joints		6
11. Limestone, cherty, largely made up of chert layers 1 inch thick with wavy surface as if composed of coalesced nodules		8
10. Limestone, shaly; Bryozoa and other fossils present		1
From beds 10 to 14 inclusive, but only from the very bottom of bed 14, the following fossils were collected: *Cyathophyllum clarki*, *C. radiculum*, *Favosites pyriformis*, *Atrypa biconvexa*, *A. "reticularis," Camarotoechia* cf. *C. altiplicata*, *Leptaena "rhomboidalis," Merista typa*, *Neucleospira elegans*, *Rhipidomella* cf. *R. preoblata*, *Rhynchospira globosa*, *Gypidula coeymanensis* var. *prognostica*, and *Delthyris octacostata*.		
9. Limestone, thick bedded, a mass of crinoid stem plates; *Gypidula coeymanensis* var. *prognostica*, or *Merista typa*, present in very bottom	10	
8. Limestone, dark, nongranular; part thick and part thin bedded; weathers rough and cavernous; veined with calcite; one layer crowded with a species of *Striatopora ?*	10	
	187±	

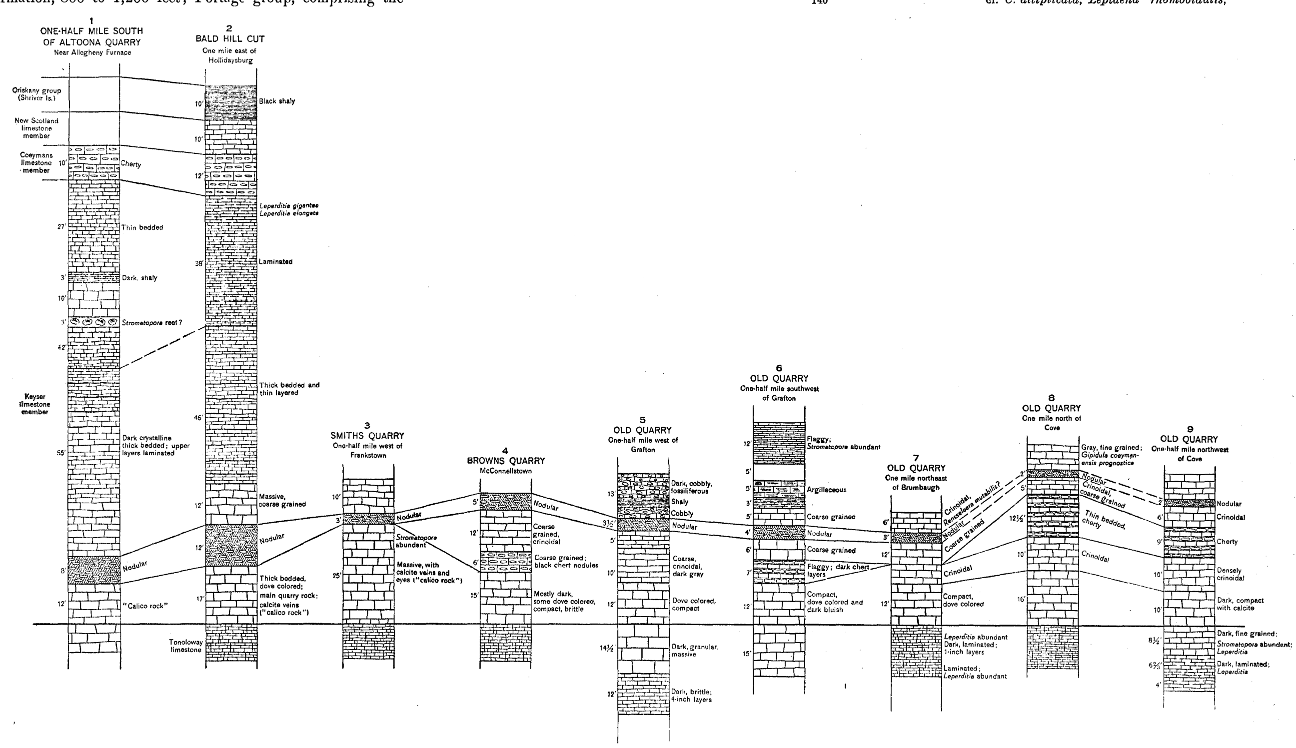


FIGURE 3.—Detailed columnar sections of the Helderberg limestone in the vicinity of Hollidaysburg and along Warriors Ridge.

Tonoloway (?) limestone:	Ft.	in.
7. Limestone, very dark, fine grained, medium thick bedded; crowded with *Stromatopora* below; a few fragments of *Leperditia* and other fossils seen, including a large high-spired gastropod	8	6
6. Limestone, fine grained, with wavy and sandy laminae	1	
5. Limestone, dark, nongranular	1	
4. Limestone, dark, laminated	4	8
3. Limestone, thick bedded, dark, nongranular	4	3
2. Limestone, laminated but compact	1	6
1. Limestone, shaly, dark, sun cracked, *Leperditia* present. (Top of several hundred feet of such beds.)		

Thickness.—The thickness of the Helderberg in the vicinity of Hollidaysburg is about 150 feet and east of Tussey Mountain about 200 feet.

Keyser limestone member.[12]—The Keyser member was named for exposures at Keyser, W. Va. At the bottom of the Keyser is the quarrymen's "calico rock," which is thick-bedded to massive, mostly dove-colored but variegated with white, pink, or yellow calcite veins and eyes, to which its common designation is due. East of Tussey Mountain the "calico rock" is succeeded by coarse crinoidal limestone and cherty limestone 12 to 19 feet thick (fig. 3, section 6-8) in which the chert and limestone occur in alternating layers 1 inch or so thick. In the vicinity of Hollidaysburg there are no beds of this character, and the "calico rock" is succeeded by a highly fossiliferous limestone 3 to 12 feet thick. When not weathered this bed appears like solid limestone with wavy laminae inclosing small lenticular bodies or nodules, and these nodular layers are characteristic of the Keyser member. On weathering the bed disintegrates to a crumbly dirty-white or gray mass surrounding the nodules, some of which at least are small heads of the coral *Favosites helderbergiae*.

In the Bald Hill cut and in the quarry near Allegheny Furnace the part of the Keyser above the nodular layer is fully exposed and is made up of coarsely crystalline, thick-bedded gray to dark limestone 12 to 20 feet thick at the bottom and 75 to 90 feet of thick-bedded but more or less laminated limestone at the top. (See pl. 21.) In the top of this part in the Bald Hill section is a thin layer containing numbers of the notably large species of *Leperditia*, *L. elongata* and *L. gigantea*. The Keyser is 100 feet thick in the Hollidaysburg region and somewhat thicker east of Tussey Mountain.

Coeymans and New Scotland limestone members.—The divisions of the Helderberg limestone long known by the paleontologic terms "Lower *Pentamerus*" limestone and "*Delthyris* shaly" limestone have been renamed the Coeymans limestone and the New Scotland limestone respectively. Both names are derived from villages in Albany County, N. Y.

In the Bald Hill cut (section 2) and in the quarry near Allegheny Furnace (section 1) these members consist of rather thick-bedded gray medium-grained limestone with dense gray chert in thin layers. Chunks of this chert scattered on the surface elsewhere indicate the presence of the parent layers beneath. Limestone one-third of a mile west of Grafton, with fine large specimens of *Eospirifer macropleurus*, a typical New Scotland fossil, proves the presence of the New Scotland east of Tussey Mountain.

In the Bald Hill section 10 feet of noncherty limestone is assigned to the New Scotland and 12 feet of cherty limestone to the Coeymans. Elsewhere the two were not separated. Their combined thickness is 20 to 25 feet.

Age and correlation.—Except for the basal "calico rock," which has not been recognized elsewhere, the Keyser of this region can easily be identified lithologically with the Keyser limestone member of the Helderberg at Keyser, W. Va., and at localities in Maryland.

A species of *Striatopora* is abundant in the "calico rock" half a mile northwest of Cove, and a cylindrical fossil, probably a tubular *Stromatopora*, occurs in the bottom of the "calico rock" in the Hollidaysburg region, where in some places individuals are so common as to suggest the names "hobnail rock" to the quarrymen. Fossils are fairly plentiful in the nodular and other beds immediately above the "calico rock," but in the still higher beds they are so firmly embedded in the matrix that they can not easily be removed in a condition to identify. Within 30 feet above the "calico rock" 37 forms were collected.

In Maryland and West Virginia the Keyser is subdivided into the *Chonetes jerseyensis* zone below, which includes about three-fifths of the entire thickness, and the *Favosites helderbergiae* var. *praecedens* zone above. Most of the fossils identified in these quadrangles occur in the *Chonetes jerseyensis* zone of Maryland, from which it appears that the lower 40 feet of the Keyser of the Hollidaysburg-Huntingdon region is in the *Chonetes jerseyensis* zone.

The Keyser limestone can be definitely correlated with the Decker limestone of New Jersey.

As many of the Keyser species existed in Silurian time, some geologists hesitate to accept the Devonian age of the Keyser, preferring to regard it as Silurian. A considerable percentage of the Keyser fauna, including many species that occur in Maryland and New Jersey, are new or belong to genera that reach their maximum development in the Devonian, and on the principle that the age of a bed is that of its youngest species the Keyser has been referred to the Devonian by Ulrich and Schuchert, and that assignment has been generally accepted.

Fossils from the upper 25 feet of the Helderberg include *Gypidula coeymanensis*, *Eospirifer macropleurus*, *Spirifer perlamellosa*, and *Stropheodonta beckii*. *Gypidula coeymanensis* is the guide fossil of the Coeymans limestone, and *Eospirifer macropleurus* and *Delthyris perlamellosa* are equally characteristic of the New Scotland member.

[12] A number of geologists, as C. K. and F. M. Swartz, are now inclined to class the Keyser as Silurian instead of Devonian.

HIATUS BETWEEN HELDERBERG LIMESTONE AND ORISKANY GROUP

No indication of the presence of the Becraft limestone has been found in these quadrangles, and it is surely absent in places at least, so that there is a slight hiatus between the Helderberg and the Oriskany.

ORISKANY GROUP

Name and definition.—Oriskany sandstone is a long-established name, from Oriskany Falls, Oneida County, N. Y. In this region the Oriskany is overlain by the Onondaga formation and underlain by the Helderberg limestone and has two distinct lithologic divisions corresponding to those in Maryland, the lower of which has been named the Shriver chert and the upper the Ridgeley sandstone. Those names are adopted here, but the divisions are given the rank of formations and the Oriskany is given the rank of a group. In this area the Shriver is more appropriately designated the Shriver limestone.

SHRIVER LIMESTONE

Name and definition.—The Shriver limestone was named for Shriver Ridge, on the outcrop of the formation near Cumberland, Md. I. C. White applied the name Stormville shale to the Shriver limestone because he correlated the Shriver with his Stormville shale of eastern Pennsylvania. According to Weller, however, White used the name Stormville for sandstones of Helderberg age also, and he also applied the name to a limestone in eastern Pennsylvania. Because of these different uses the name Stormville has been superseded in the Hollidaysburg-Huntingdon region by the exactly defined name Shriver.

Distribution.—The Shriver limestone is persistent throughout the quadrangles, its surface distribution being in a narrow belt parallel to that of the Helderberg limestone. The only complete exposure of the formation is in the east side of the Bald Hill cut, 1 mile east of Hollidaysburg. The bottom 80 feet is exposed in a quarry in the south environs of Altoona.

Character.—The Shriver limestone is composed almost wholly of thin-bedded to laminated highly siliceous limestone. (See pl. 16.) At the bottom of the section 1 mile east of Hollidaysburg (p. 7) is a bed of black shaly limestone, and other layers may weather to a shaly condition. On weathering the thin layers of the main body of the Shriver are leached of their calcareous matter and break down into small sandy pieces about the size of the hand and half an inch thick, which fill the soil or thickly strew the surface (pls. 17, 18) and make the location of the outcrop of the Shriver easy. The sandy pieces are exceedingly fine grained, and some pieces have a cherty aspect on fresh fracture.

Thickness.—The Shriver is 200 feet thick in the railroad cut at Bald Hill and appears to be 200 to 300 feet thick east of Tussey Mountain.

Age and correlation.—Fossils are scarce in the Shriver but 32 species have been collected which serve to establish its lower Oriskany age. Among the more significant are *Technocrinus* cf. *T. andrewsi*, *Chonetes hudsonicus*, *Pholidops* cf. *P. tumida*, and *Thlipsura* (*Craterellina*) *robusta*. The last species is known from the Shriver only.

RIDGELEY SANDSTONE

Name and definition.—The Ridgeley sandstone was named for Ridgeley, W. Va., opposite Cumberland, Md.

Distribution.—Though the Ridgeley is thin it is persistent, and evidence of its presence is seen wherever its outcrop is not concealed by débris from the ridges. Its outcrop can be easily followed from Altoona, encircling Scotch Valley, to McKee Gap; thence the outcrop is concealed southward along the west base of Dunning Mountain to Boiling Spring Run, whence the sandstone can be followed to the south line of the quadrangle, beyond which it is finely displayed on the hills in Kimmell Township. The conglomeratic layers of the Ridgeley are especially well displayed in the quarry at Allegheny Furnace (see section below) and on the ridge half a mile nearly due north of Flowing Spring. East of Tussey Mountain the sandstone crops out along the east slope of Warriors Ridge, which is approximately a dip slope on the Ridgeley. Due west of Huntingdon this outcrop on the dip slope is more than a mile wide, owing to the low southeast dip of 5°-10°. The sandstone is best displayed in a cut on the railroad just west of Huntingdon.

Character.—The Ridgeley is in part a pure quartz sandstone, in many places conglomeratic, some layers or lenses being full of quartz pebbles an eighth to a quarter of an inch in diameter. In part the Ridgeley in the fresh condition is so limy that the rock has the appearance of limestone. Near the bottom in the railroad cut just east of Frankstown lie thick beds made up of interlocking wedges, in some of which calcareous material and in others sandy material predominates. On complete leaching the limy rock crumbles to loose sand, which is used for mortar and other purposes. On Robinson Run east of Hollidaysburg there is at the top a highly ferruginous red rock 1 foot thick not seen elsewhere.

The general character of the Ridgeley is well displayed in a quarry at Allegheny Furnace, in which the whole or nearly the whole thickness is exposed.

Section of Ridgeley sandstone at Allegheny Furnace

	Feet
1. Sandstone	10
2. Sandstone, thick bedded, calcareous; contains near the top lenses of quartz conglomerate 1 foot thick, also layers of shell conglomerate densely packed with shell fragments	32
3. Sandstone	3
	45

East of Tussey Mountain, along the crest and east slope of Warriors Ridge, the Ridgeley is a coarse, thick-bedded, loosely cemented quartz sandstone, some layers of which easily crumble to sand in the hand. It has been quarried for sand at a few points.

Thickness.—If part of the Ridgeley at Allegheny Furnace is not exposed the total thickness may be 55 to 60 feet, but generally in the Hollidaysburg quadrangle the thickness seems not to exceed 50 feet. At Huntingdon and southwestward, along Warriors Ridge, the thickness is probably a little more than 100 feet.

Age and correlation.—The Ridgeley is abundantly fossiliferous. The 38 forms collected constitute a characteristic upper Oriskany fauna, which is conclusive evidence for correlating the Ridgeley sandstone with the typical Oriskany sandstone of New York. A few of the more diagnostic species are *Edriocrinus sacculus*, *Costellirostra peculiaris*, *Meristella lata*, *Rensselaeria elongata*, *Costispirifer arenosus*, *Diaphorostoma ventricosum*, and *Platyceras gebhardi*.

ONONDAGA FORMATION

Name and definition.—The Onondaga formation was named for its exposures in Onondaga County, N. Y. In New York the name Onondaga as now applied includes the long well-known "Corniferous limestone." In this region the Onondaga includes dark shale with limestone beds, in all 50 feet thick, extending from the Ridgeley sandstone below to the highly fissile Marcellus black shale above.

The Onondaga beds were recognized by White[13] as a distinct lithologic subdivision but were classed as lower Marcellus. They were also recognized by Platt,[14] who distinctly referred them to the Onondaga ("Corniferous") horizon.

Distribution.—The Onondaga is persistent in the region. It shows near the highway just east of the limestone cut at Bald Hill, about 1 mile east of Hollidaysburg; in the road about 1 mile nearly west of Canoe Creek post office; near the road in the extreme southwest corner of the Hollidaysburg quadrangle; in the southeast corner of the Hollidaysburg quadrangle near the junction of the roads just west of Cove station; in the western outskirts of Huntingdon near the reformatory and along the valley southwest of the reformatory, where an abundance of fine débris marks its position.

Character.—In these quadrangles the Onondaga formation is mostly shale. The following section represents well its general composition:

Section in highway near head of Robinson Run, Hollidaysburg quadrangle

	Feet
Marcellus shale:	
Shale, black.	
Concealed	20
Shale, black	1
Shale, greenish gray	5
Onondaga formation:	
Limestone; contains fossils	1
Shale, greenish, weathering gray	2
Limestone	½
Shale, greenish calcareous bands	12
Limestone, dark; contains fossils	1
Shale, gray with streaks of black	20
Shale, black, fissile, fossiliferous	5
Shale, greenish gray	10
Shale, bluish, calcareous; weathers drab, fossiliferous	5
Not exposed	10
	66½
Ridgeley sandstone:	
Red rock, highly ferruginous	1
Sandstone	20±

Everywhere the Onondaga has limestone at the top and shale in the lower part. The limestone is dark gray and argillaceous and looks earthy after weathering. The shale is

[13] White, I. C., op. cit., p. 114.

[14] Platt, Franklin, Geology of Blair County: Pennsylvania Second Geol. Survey Rept. T, p. 34, 1881.

dark green or bluish, and some bands are calcareous. Both shale and limestone are sparingly fossiliferous.

Thickness.—The thickness of the Onondaga is 50 to 70 feet.

Age and correlation.—The position of the beds here described, between the Oriskany below and the characteristic fissile black shale of the Marcellus above, which is the same as the position of the Onondaga limestone in the type locality in New York State, points almost conclusively to the equivalence of the beds with the Onondaga.

Forty-five species of fossils have been collected from the Onondaga in these quadrangles, but as most of them, exclusive of the trilobites, occur in the Oriskany or Hamilton also, their evidence as to the age of the formation is not satisfactory. Nine species of trilobites from this region or from the same formation elsewhere in this or adjoining States are, according to Kindle, not known except in the Onondaga and assure the Onondaga age of the formation here described. The trilobites are *Acidaspis callicera*, *Conolichas hispidus*, *Otarion* cf. *O. stephanophora*, *Coronura aspectans*, *Lichas* (*Arges*) *contusus*, *Odontocephalus aegeria*, *O. selenurus*, *Phacops cristata*, and *P. cristata* var. *pipa*.

MARCELLUS SHALE

Name and definition.—The Marcellus shale was named for exposures at Marcellus, N. Y. It overlies the Onondaga formation and underlies the Hamilton.

Distribution.—The Marcellus shale is well exposed at the head of Robinson Run, in the railroad cuts and shale pits near South Altoona, in the bed of Frankstown Branch of the Juniata 2 miles north of Claysburg, at several points in the valley southwest of Loop, and in the road crossing the valley three-quarters of a mile north of Loop. There are good exposures also near Huntingdon and along the Huntingdon & Broad Top Mountain Railroad, especially for 2 or 3 miles northeast of Cove. As the Marcellus and the immediately overlying Hamilton shales are soft and easily erodible, valleys have been formed along their outcrops. Such valleys are followed by Frankstown Branch from Frankstown to the south edge of the Hollidaysburg quadrangle and by the Huntingdon & Broad Top Mountain Railroad south of McConnellstown.

Character.—The Marcellus is a widespread formation in New York and Pennsylvania and preserves the same lithologic characteristics throughout except that in its type section in New York its upper half or so is a gray shale. With this exception it is a black fissile shale, the black color being due to carbonaceous matter. In the vicinity of Huntingdon there are many large calcareous concretions in the Marcellus and a few limestone layers that possibly should be included in the Onondaga.

Thickness.—The thickness of the Marcellus is 150 to 200 feet, being perhaps a little greater east of Tussey Mountain than west of Dunning and Lock Mountains.

Age.—The lithologic character and the stratigraphic position of this body of black shale, which apparently correspond closely with those of the typical New York Marcellus, leave no doubt as to its identity with that formation, and this identity has been recognized by all geologists who have worked in the region. Fossils are very scarce in the Marcellus of this region, but some were collected. Of these forms *Leiorhynchus limitare*, which makes its appearance in the Marcellus, is but rarely reported from higher beds and may be regarded as an index fossil for the Marcellus.

HAMILTON FORMATION

Name and definition.—The Hamilton formation was named for its exposures in the vicinity of Hamilton, Madison County, N. Y. In these quadrangles it is underlain by the Marcellus shale and overlain by the Portage group, two intervening formations of the New York section—the Tully limestone, except possibly a foot or two, and the Genesee shale—apparently being absent in this region.

Distribution.—The Hamilton crops out in a belt of uneven width from Altoona around the south point of the Brush Mountain anticline, around Scotch Valley, and southward along Frankstown Branch to the southwest corner of the Hollidaysburg quadrangle. The outcrop east of Tussey Mountain is confined to a long, narrow belt just east of Warriors Ridge and parallel to it. The dip is steep in the south end of this belt, and the outcrop is consequently narrow, but the dip decreases gradually northward to 10° at Huntingdon, so that there the outcrop is 1 mile wide, and the city is built upon the formation.

Besides the localities at which the sections given below were measured, the greater part of the Hamilton is exposed at the south end of the knob just east of East Freedom, at several points around Scotch Valley, and in Huntingdon and vicinity.

Character.—The Hamilton is composed principally of shale. West of Dunning and Lock Mountains very little sandstone is present, but east of Tussey Mountain there are two persistent sandstone beds which divide the shale mass into three nearly equal parts. Its general character west of Dunning and Lock Mountains is shown in the following section:

Section of Hamilton formation at the brick works at South Altoona

	Feet
Burket black shale member of the Harrell shale of the Portage group:	
15. Shale, black, fissile	10
14. Shale, brown	4
13. Shale, black; contains fossils	5
12. Shale, brown (paper shale); contains fossils	5
	24
Hamilton formation:	
11. Shale, green, calcareous, highly fossiliferous	2
10. Limestone, highly fossiliferous	1
9. Shale, mostly green, some very dark, very fossiliferous at bottom	10
8. Limestone, nodular, not persistent, very fossiliferous	1
7. Shale, green, hackly	8
6. Limestone, like No. 10	1
5. Shale, dark olive-green, hackly, with sandstone in layers 1 foot thick or less	180
4. Shale, dark olive-green; few thin sandstone layers	200
3. Concealed	280
2. Shale, olive-green, soft	90
Marcellus shale:	
1. Shale, black, fissile.	
	773

The rocks become more sandy and less fissile within 100 to 150 feet above the bottom, and partial sections at other points, probably falling in the position of the concealed space (No. 3 of the section above), show considerable fine-grained sandstone, in evenly bedded layers generally not more than 1 foot thick and cut by joints into smooth, even-faced, sharp-edged rhombohedral blocks that are very distinctive. The upper olive-green hackly shale, No. 5 (pl. 19), is also very distinctive, and the presence of this part of the Hamilton may commonly be detected by its débris scattered on the surface. Both the limestone and the hackly shale, Nos. 6 to 11 of the above section, are very fossiliferous, but fossils are scarce in the rest of the formation in Logan Valley.

The general character of the Hamilton east of Tussey Mountain is illustrated by the following section:

Section of Hamilton formation in northeast corner of Everett quadrangle, 2½ miles southwest of Cove station

	Feet
Hamilton formation:	
9. Shale, olive-green, stiff, nonfissile, hackly, lumpy or crumbly (mudrock), highly fossiliferous; top not exposed	60±
8. Shale, dark, fissile, with thin sandstone layers	160
7. Not exposed, shale débris, yellow-green, probably shale like No. 8	165
6. Sandstone, gray to greenish, flaggy, fine grained	60±
5. Not exposed	200
4. Shale, dark, fissile	100
3. Sandstone, fine grained, dark bluish when fresh; weathers rusty, flaggy	75±
2. Shale, rusty-weathering above, gray-weathering below, dark, soft, fissile	350
	1,170±
Marcellus shale:	
1. Shale, very black, fissile.	

The two sandstone beds shown in this section are prominent members of the Hamilton in Raystown Valley and form conspicuous ridges. The ridge between the Huntingdon & Broad Top Mountain Railroad and Warriors Ridge, extending from Huntingdon to McConnellstown, was made by the lower sandstone. These beds were called by White the lower and upper Hamilton sandstones, and the three shale divisions were called by him the lower, middle, and upper Hamilton shales. Except for these sandstones the Hamilton in this part of the area is lithologically the same as in Logan Valley. The thin limestone layers in the top may be seen in the road east of Cove station. Under the limestone is the same lumpy, crumbly, fossiliferous olive-green shale or mudrock as that at the top of the Hamilton in Logan Valley.

Thickness.—In Logan Valley and west of Dunning Mountain the thickness of the Hamilton is about 800 feet; east of Tussey Mountain it is about 1,200 feet.

Age and correlation.—The Hamilton age of the rocks described here is satisfactorily demonstrated by their stratigraphic relations, their lithologic character, and their abundant fossils, and they have been accepted as Hamilton by all geologists who have seen them. The collections of fossils comprise 9 corals, 3 crinoids, 14 bryozoans, 41 brachiopods, 39 pelecypods, 13 gastropods, 2 cephalopods, 3 pteropods, and 7 ostracodes. Of these 121 species, 113 occur in the upper 25 feet of the Hamilton and mainly in beds 6 to 11 of the section at South Altoona.

Nearly all the species in these extensive collections occur in the Hamilton of western New York, and most of them are known only from the Hamilton.

Certain species of fossils such as *Chonetes aurora*, *Echinocoelia ambocoelioides?*, and *Emanvella subumbona* demand special comment because they prove the horizon of the Tully limestone. They occur in a limestone about 1 foot thick included in the Hamilton as the top layer, immediately in contact with the overlying Burket black shale member of the Harrell shale, of the Portage group. All three were found 1 mile southwest of Claysburg, in the Hollidaysburg quadrangle, and the first and last with *Leiorhynchus sinuatus* 1 mile southeast of Cove station, in the southwest corner of the Huntingdon quadrangle. In New York and parts of Pennsylvania *Chonetes aurora* occurs with *Hypothyridina venustula*, which is the chief guide fossil of the Tully limestone. The Tully has generally been classified as the basal bed of the Upper Devonian, but evidence for its high Middle Devonian age has been published.

PORTAGE GROUP

Name and definition.—The name Portage has long been in use for the shales and sandstones typically exposed in the gorge of the Genesee River in western New York, between Portageville and Mount Morris. In these quadrangles the Portage rocks are overlain by the Chemung formation and underlain by the Hamilton, two intervening formations, the Genesee shale and Tully limestone, except for a foot or two of limestone, mentioned above, apparently not being represented here. In this region the Portage group is divided into the Harrell shale below and the Brallier shale above.

HARRELL SHALE

Name and definition.—The Harrell shale was thus named because it is well displayed at Harrell station, about 6 miles northeast of Hollidaysburg. It is the lowest formation of the Portage group of this area and is underlain by the Hamilton formation and overlain by the Brallier shale.

Distribution.—The Harrell shale crops out along the west side of Logan Valley and around the Scotch Valley basin. The gray shale facies is best exhibited on the Pennsylvania Railroad in the western outskirts of Altoona, in the shale pits at the Eldorado brick works, and at Harrell. East of Tussey Mountain it crops out along the west side of Middle Ridge and of Piney Ridge north of Aitch. The best exposure is at the west base of Middle Ridge, in the road 1 mile southwest of Aitch, where the section given below was obtained. A small thickness of black shale is exposed in the road just above the park immediately east of Standing Stone Creek at Huntingdon.

Character.—The Harrell shale at Altoona and west of Dunning and Lock Mountains includes at the base a persistent stratum of apparently unbroken black fissile shale (Burket black shale member). This is overlain by very soft brownish-gray or olive-green, highly fissile shale that cleaves into paper-thin laminae of considerable size and uniform thickness. The black shale is the harder and cleaves into small thin chips; the gray shale is much softer, and although it shows lamination cleavage in outcropping faces where it has been cleanly exposed in cuttings it readily decomposes to clay. These two divisions are sharply separated in the western area in Logan Valley, but east of Tussey Mountain the Harrell is composed of alternating comparatively thin beds of black shale and soft brown shale, which are lithologically identical respectively with the black and gray shales of Logan Valley just described but differ in their distribution through the section. The character of the Harrell in this region is shown in the following section:

Section of lower part of Harrell shale 1 mile southwest of Aitch

	Feet
Harrell shale:	
Shale, fissile, dark but not black	60
Shale, black	20
Shale, gray	25
Shale, soft, dark and black alternating in comparatively thin layers	40
	145
Hamilton formation:	
Shale, green, hackly.	

Owing to this distribution in comparatively thin alternating layers the Harrell cannot be subdivided east of Tussey Mountain, as it is west of Lock and Dunning Mountains, yet there is no doubt of the exact equivalence of the Harrell in both areas.

Thickness.—The thickness of the Harrell in both the Hollidaysburg and Huntingdon quadrangles is 200 to 250 feet.

Burket black shale member.—The Burket black shale member of the Harrell shale was named for Burket, 1 mile southwest of Altoona, where this shale is well displayed. Throughout the Hollidaysburg quadrangle this member is an unbroken mass of very black and highly fissile shale 80 feet thick. It crops out in a continuous band from Altoona southwest to Queen just west of the southwest corner of the Hollidaysburg quadrangle and around a large area in the center of Scotch Valley. It is well exposed in Altoona at and near the intersection of Fourteenth Street and Thirteenth Avenue, under the schoolhouse at Burket, on the road 2 miles southwest of Claysburg, and at Harrell station, in Scotch Valley. There are excellent exposures along the Pennsylvania Railroad for 2 or 3 miles northeast of Altoona.

Age and correlation.—The Harrell shale contains a few very small species of fossils, which are rather generally distributed through the formation. Some of the species are fairly abundant—for example, *Paracardium doris* and *Pterochaenia fragilis*. *Styliolina fissurella* is very abundant, as usual in the Devonian black shales of the northeastern United States. The Burket black shale member also contains most of the species that were collected from the other parts of the Harrell shale, and most of the species are present east of Tussey Mountain at the very base of the Harrell, where the black facies is much less strongly developed. The most important fossils for correlation are *Chonetes lepida*, *Buchiola retrostriata*, *Ontaria accincta*, *Paracardium doris*, *Manticoceras patersoni*, and *Probeloceras lutheri*. In a railroad cut 3 miles northeast of Altoona a fine specimen of a goniatite, apparently a new species of *Sandbergeroceras*, was obtained from this shale. Although a number of these fossils, as *Styliolina* and *Pterochaenia*, occur in the Genesee shale and older beds, the assemblage as a whole is characteristic of the lower Portage beds in the vicinity of Naples, Ontario County, N. Y., and taken in connection with the absence of any distinctively Genesee fossils justifies the assignment of the Harrell shale to the Portage group. It probably represents in the main the Cashaqua and Middlesex shale members of the Portage formation of New York and the fossiliferous beds at Naples. The soft gray shale is almost identical lithologically with the Cashaqua. The Burket member is probably equivalent to the so-called Genesee shale of the Maryland Geological Survey report on the Devonian of Maryland, 1913.

BRALLIER SHALE

Name and definition.—The Brallier shale was named for its exposures at Brallier, 5 miles northeast of Everett, Pa. It is the upper formation of the Portage group of this region and lies above the Harrell shale and below the Chemung formation. The bottom of the Brallier shale is sharply marked, but at the top the Brallier merges into the succeeding Chemung, although the two formations are easily distinguishable not far below or above the boundary, which is fixed by the writer at the horizon at which the lowest Chemung fossils are found.

Distribution.—The formation crops out in a belt 1 to 1½ miles wide on the lower slope of the foothills of the Allegheny Front, extending from Altoona to the southwest corner of the Hollidaysburg quadrangle, in a circular area in the center of the Scotch Valley syncline, and east of Tussey Mountain along a broad belt half a mile to 1 mile wide, marked by Middle Ridge and the northern part of Piney Ridge. Good exposures are to be seen on the Pennsylvania Railroad just west of Altoona and just east of Huntingdon.

Character.—The Brallier is predominantly a pale greenish-gray micaceous, sandy, and slaty shale, generally cleaving easily into thin laminae, but there are thin layers of coarser texture and less perfect cleavage. In railroad cuts half a mile east of Huntingdon very evenly bedded layers 1 to 2 feet thick appear, in their unweathered condition, to be fine-grained compact sandstone (pl. 20), but on weathering these beds reveal their thin lamination cleavage and ultimately break down to small, thin plates. The rock is really a stiff sandy shale. A striking feature of some of this shale is a strong dimpling of the bedding planes. In the upper 200 feet are layers of fine-grained greenish sandstone, becoming light gray or dirty white on weathering, fragments of which in places strew the surface. There are a few layers of evenly bedded sandstone and some thin, irregular layers of hard bluish fine-grained sandstone, generally from 1 to 6 inches and rarely 1 foot thick, which are more common from 100 to 200 feet above the base of the formation. Probably the formation does not contain more than 5 percent of layers of sufficient coherence to yield fragments 6 inches thick on weathering. In one of the railroad cuts about a mile southwest of Altoona there are a few thin layers of pale-red shale, probably somewhat above the middle of the formation. A layer of red rock about a foot thick is exposed in the cut on the old incline just west of Foot of Ten.

Thickness.—The thickness of the Brallier is about 1,800 feet.

Age and correlation.—The Brallier is very sparsely fossiliferous. The most common fossil is *Pteridichnites biseriatus* Swartz, a slender, stemlike form about one-eighth of an inch wide, commonly slightly curved, plainly or obscurely segmented, with a narrow longitudinal depression along the middle. These suggest worm trails. They are rather common in a green highly siliceous shale or laminated fine-grained sandstone that, except in a few places, is without other organic remains, and hence they are useful in identifying the formation. A few of the small fossils of the Naples fauna range up through the Brallier, as *Buchiola retrostriata*, *Ontaria suborbicularis*, *O. accincta?*, *Palaeoneilo petila*, and *Pterochaenia*. A species of *Manticoceras*, *Probeloceras lutheri*, and rare specimens of *Phragmostoma natator* and of *Pleurotomaria genundewa* occur also. In contrast to the general rule a thin sandstone cropping out in the road about a quarter of a mile northwest of Upper Reese is crowded with larger fossils, such as *Cladochnus humilis* (rare), *Productella speciosa*, two other species of *Productella*, *Chonetes* cf. *C. scitulus*, *Camarotoechia* cf. *C. congregata*, *C.* cf. *C. sappho*, "*Spirifer*" cf. *S. mucronatus* var. *posterus* and *Ambocoelia umbonata*.

In correlating the Brallier it should be noted that the survivors of the Naples fauna named are listed by Clarke[15] from all the members above the Rhinestreet shale member in the Portage Gorge section of New York. Even the occurrence of the plant fragments is noted. Likewise these upper members of the Portage, and especially the Gardeau shale, the thickest member of the post-Rhinestreet mass, are singularly like the Brallier shale in lithologic character. The Brallier certainly includes the equivalent of the Gardeau and probably is to be correlated with all of the Portage above the Rhinestreet. The total thickness of the Portage formation in the Portage section, with which the Brallier is correlated, Hatch shale to Wiscoy shale, inclusive, is 978 feet. If the correlation is correct, the thickness nearly doubles in passing under the Allegheny Plateau, for the Brallier is 1,800 feet thick where it emerges on the foothills of the Allegheny Front. Southwestward along the Appalachian Valley the Brallier can be traced into the Woodmont shale member of the Jennings formation in Maryland and into the Kimberling shale of southwestern Virginia, which reaches a thickness of about 3,000 feet in Bland County. The small fossils of the Naples fauna are present in the Woodmont as in the Brallier, and they occur as far southwest as Roanoke and Craig Counties, Va., but have not been found in Bland County and farther southwest, where, however, the lithologic character of the Brallier is well preserved and a few of the problematic worm trails are found and plant shreds are rather common.

The fossils of the thin sandstone near Upper Reese mentioned above probably indicate a brief invasion of the Ithaca fauna of the Portage which barely reached this area. Possibly the red beds mentioned above represent an extension of the Oneonta sandstone, also of the Portage, into this region.

CHEMUNG FORMATION

The Chemung formation was named for its exposures along the Chemung River, N. Y. In these quadrangles it is underlain by the Brallier shale and overlain by the Hampshire formation. The Chemung and Brallier are not separable by an easily recognizable lithologic difference at the contact, but the separation is made at the lowest horizon at which locally fossils of the Chemung appear in the beds. Such fossils are *Caroniferella tioga*, *Leiorhynchus mesacostale*, *Productella speciosa*, *Cyrtospirifer disjunctus*, *Leptodesma rogersi*, and *L. longispinum*. The use of this criterion has given consistent results in tracing the boundary. Not far above or below the boundary thus located the respective formations are recognizable by their lithologic characteristics.

Distribution.—There are three belts of outcrop—one on the foothills of the Allegheny Front, one in Raystown Valley, and a third east of Sideling Hill, in the southeast corner of the Huntingdon quadrangle.

Character.—The Chemung is composed mostly of shale, but it includes considerable sandstone, generally in relatively thin layers interspersed through the shale, and a little conglomerate. (See pl. 21.) In general its lower part differs from the underlying Brallier shale in that its shale is prevailingly soft and of more clayey composition, or more of the nature of mudrock, and in that a greater number of thin sandstone layers are present. Its character is illustrated by the following detailed sections:

1. *Section of Chemung formation on main line of Pennsylvania Railroad beginning about 1½ miles east of Kittanning Point*

	Ft.	in.
Hampshire formation (shale and sandstone, almost all red).		
Chemung formation:		
68. Shale and sandstone, yellow-green; mudrock with thin sandstone layers; *Cyrtospirifer disjunctus*	35	
67. Not exposed (see description below)	600	
66. Shale, chocolate-colored, with thin layers of sandstone	80	
65. Sandstone, few small pebbles	2	
64. Shale, greenish gray, clay	35	
63. Shale, with thin sandstone layers	15	
62. Sandstone, solid layer	2	6
61. Shale and thin sandstone	6	
60. Sandstone, thick bedded	7	
59. Shale, blue, clay	2	
58. Conglomerate; pebbles half an inch in maximum diameter	1	6
57. Sandstone, thick bedded	10	
56. Shale, green, clay	30	
55. Shale and thin sandstone, gray	30	
54. Shale, chocolate-colored	5	
53. Shale and thin sandstone, gray	35	
52. Shale and thin sandstone, with chocolate-colored layers	30	
51. Shale, yellow-green	10	
50. Not exposed (see description below)	400	
49. Sandstone, thick bedded, medium coarse grained, gray, with "*Spirifer*" *mesistrialis* (Saxton conglomerate member)	10	
48. Shale, soft clay	10	
47. Sandstone	10	
46. Shale, blue clay, soft	10	
45. Sandstone	5	
44. Conglomerate		6±
43. Sandstone	15	
42. Limestone, impure; fossils		6
41. Shale, with sandstone layers, 2 to 3 inches thick	5	
40. Shale, clay	15	
39. Sandstone, cross-bedded; has fucoids in bottom	10	
38. Shale, clay	10	
37. Sandstone	10	
36. Shale, clay	25	
35. Shale, soft, dark and yellowish green, with sandstone layers	230	
34. Not exposed	265	
33. Shale, gray and yellowish, with thin sandstone layers	165	
32. Shale	10	
31. Not exposed	200	
30. Shale and sandstone	15	
29. Not exposed	100	
28. Sandstone	20	
27. Shale	4	
26. Shale, with thin sandstone	5	
25. Sandstone	13	
24. Shale	29	
23. Shale, with thin sandstone layers	4	6
22. Shale	28	6
21. Sandstone		6
20. Shale, with thin sandstone layers	4	6
19. Sandstone, with shale partings	1	4
18. Shale	1	7
17. Sandstone	1	6
16. Shale	19	
15. Sandstone		9
14. Shale	4	6
13. Sandstone		6
12. Shale	25	
11. Shale, with sandstone bands	4	6
10. Shale	52	7
9. Sandstone		3
8. Shale		6
7. Sandstone		8
6. Shale	19	
5. Shale and thin sandstone	36	
4. Not exposed	200±	
3. Shale, with thin sandstone bands	20	
2. Sandstone, with *Leiorhynchus mesacostale* and *Productella speciosa?*; bottom of Chemung		2
	2,953	10
Brallier shale:		
1. Shale, greenish	20	

No. 68 and part of No. 67 are exposed on the New Portage branch of the Pennsylvania Railroad in Blair Gap Run, half a mile east of the quadrangle boundary, as follows:

2. *Section in Blair Gap Run*

	Feet
Hampshire formation (shale and sandstone, nearly all red).	
Chemung formation:	
Mudrock, yellow-green, lumpy and sandy; contains *Cyrtospirifer disjunctus* and *Camarotoechia* sp.	50
Shale, yellow-green, with a few thin layers of fine-grained green argillaceous sandstone, and a bed of chocolate-colored shale and sandstone 3 feet thick, 70 feet below the top; fossils scarce; fish fragments in the chocolate-colored sandstone; *Cyrtospirifer disjunctus* and *Camarotoechia* sp. noted at one horizon	200
Not exposed to bottom of No. 67	385

On the Portage branch of the Pennsylvania Railroad the rocks in interval No. 50 are partly exposed as follows:

3. *Section on Portage branch of Pennsylvania Railroad*

	Feet
Shale and sandstone	180
Not exposed	90
Sandstone, thick bedded, fine grained; contains *Spirifer mesistrialis* (Saxton conglomerate member)	10

Observations at other points warrant the statement that the gaps in section No. 1 are filled by rocks of the same character as those exposed and that the section adequately represents the general character of the Chemung formation along the eastern slope of the Allegheny Front. The following sections exhibit its character in the Raystown Valley:

4. *Section of upper part of Chemung formation at Hawn Bridge*

	Ft.	in.
Hampshire formation (nearly all red for 2,000 feet).		
Chemung formation:		
26. Not exposed; débris on surface indicates green shale with thin layers of green sandstone as in other sections	100	
25. Not exposed; red soil, with a few thin exposures of red or chocolate-colored shale and brown sandstone, fossils in lower part	380	
24. Not exposed; green shale and sandstone débris	70	
23. Partly exposed; green shale showing at intervals	35	
22. Not exposed; gray soil, green shale and sandstone débris	80	
21. Not exposed	60	
20. Sandstone, laminated, cross-bedded, some layers conglomeratic	20	
19. Partly exposed, shale and sandstone, chocolate-colored and green	80	
18. Shale, with thin sandstone layers, mostly chocolate-colored	70	
17. Sandstone, thick bedded, chocolate-colored; containing "*Spirifer*" *mesistrialis*	8	6
16. Sandstone, gray, cross-bedded, conglomeratic; contains bryozoans	2	6
15. Shale, with thin sandstone layers, chocolate-colored; contains bryozoans	10	
14. Shale, with thin sandstone layers, chocolate-colored	50	
13. Sandstone, chocolate-colored, hard, fine grained, two layers of 3 feet each	6	
12. Shale, chocolate-colored	10	
11. Sandstone, greenish, hard, fine grained, upper 3 feet solid, lower 3 feet in three layers, pebbles in pockets	6	
(Nos. 11 to 17 inclusive may be the Saxton conglomerate in two benches.)		
10. Shale and thin sandstone, chocolate-colored	250	
9. Sandstone, greenish, fine grained, thick layers, tending to be laminated	15	
8. Shale and thin sandstone, chocolate-colored	100	
7. Shale, greenish	25	
6. Sandstone, hard, fine grained, 1-foot layers	5	
5. Shale, mostly green	75	
4. Shale and sandstone, chocolate-colored	20	
3. Not exposed; section south of Hawn Bridge shows green shale and thin sandstone	230	
2. Shale and thin sandstone flags, about one-half each of chocolate-colored and green (see pl. 21)	140	

[15] Clarke, J. M., and Luther, D. D., Geologic map and descriptions of the Portage and Nunda quadrangles: New York State Mus. Bull. 118, pp. 57, 60, 61, 66, 1908.

	Ft.	in.
1. Shale and a few 4-inch sandstone layers; thin impure shell limestone at base; shale mottled with purple	140	
	1,938	

The bottom of this section is near the horizon of the Allegrippis sandstone member, which does not show here and probably is locally absent, for it shows well within half a mile both north and south of Hawn Bridge.

The above section is partly duplicated and partly supplemented by the following section along Raystown Branch and the Huntingdon & Broad Top Mountain Railroad northwest of Saxton, 2 miles south of the southeast corner of the Hollidaysburg quadrangle.

The distance between No. 17 and the base of the Hampshire in this section is 845 feet. No. 49 of the Pennsylvania Railroad section is 1,336 feet below the Hampshire in that area. If Nos. 17 and 49 are the same it appears that the base of the Hampshire is 491 feet lower in the section at Hawn Bridge than in the section on the Allegheny Front. This is in accord with the general observation that the red sediments transgress downward toward the east.

5. *Section of lower and middle parts of Chemung formation northwest of Saxton*

	Ft.	in.
45. Shale, green	40	
Saxton conglomerate member:		
44. Conglomerate	7	
43. Shale, green	8	
42. Sandstone	1	
41. Shale, chocolate-colored	8	
40. Sandstone, chocolate-colored	6	
39. Shale, mostly green, chocolate-colored layer 2 feet thick	16	
38. Sandstone, thick bedded and conglomeratic	7	
37. Shale, green	5	
36. Sandstone, thick bedded, fine grained, chocolate-colored	15	
35. Shale, green	2	
34. Sandstone	5	
33. Shale, green	30	
32. Sandstone, gray, flaggy	3	
31. Sandstone, thick bedded, hard, fine grained	8	
30. Shale, green	20	
29. Not exposed; green and chocolate-colored shale débris	350	
28. Shale, green, thin, argillaceous, micaceous, with green sandstone layers	20	
27. Sandstone, fine grained, shale partings, chocolate-colored	65	
26. Not exposed	250	
25. Shale, green mudrock mottled with chocolate color; fossiliferous layer 75 feet below top	100	
24. Not exposed; thin sandstone débris	100	
23. Sandstone and fine-grained flags and shale, green	55	
22. Limestone, crinoidal		1½
21. Shale, mostly chocolate-colored, green shale and thin green sandstone at top, thick bedded, fine grained	65	
Allegrippis sandstone member:		
20. Sandstone, 2-foot shale parting in middle, ripple marked below shale	15	
19. Shale, green, ripple marked	15	
18. Sandstone, like No. 20	5	
17. Shale, gray, soft	40	
16. Sandstone, as above	2	6
15. Shale, like No. 17 with blocky sandstone layers 8 inches or less thick	100	
14. Sandstone, fine-grained, in layers 1 to 6 inches thick, mostly chocolate colored; a little green shale and sandstone	160	
13. Shale, green, stiff; thin sandstone layers	30	
12. Shale, chocolate-colored		6
11. Shale and thin sandstone layers	105	
10. Not exposed	45	
9. Shale, green clay; even sandstone layers 6 inches or less thick	150	
8. Not exposed	60	
7. Shale, green	40	
6. Sandstone and shale; sandstone irregularly bedded	48	
5. Sandstone, flaggy, irregularly bedded; Piney Ridge sandstone member (?)	40	
4. Shale, yellow, green, soft	50	
3. Not exposed	50	
2. Mudrock, stiff	5	
1. Shale and thin sandstone, near bottom of Chemung	85	
	2,232	1½

If this section goes to the bottom of the Chemung, as it appears, and if the sandstone of No. 5 is the Piney Ridge sandstone member, there is probably a fault between it and the Allegrippis sandstone, for farther north the interval between the two is 1,400 feet, whereas in this section it is only 800 feet.

6. *Section along Pennsylvania Railroad from Huntingdon to Ardenheim*

[Top is about half a mile west of Ardenheim]

	Feet
Chemung formation:	
15. Sandstone, thick bedded	10
14. Shale	15
13. Sandstone, thick bedded	5
12. Shale, yellow-green clay	15
11. Sandstone, thick bedded	10
10. Shale, yellow-green	65
9. Not exposed	50
8. Shale, yellow-green	80
7. Shale yellow green with many sandstone layers 1 to 6 inches thick	120
6. Sandstone, with shale partings (Piney Ridge?)	50
5. Shale	100
4. Sandstone, with shale partings	30
3. Shale, soft clay, fossils (*Leptodesma*) near top	160
Brallier shale:	
2. Not exposed	160
1. Shale, stiff, green, siliceous and micaceous; some freshly exposed portions resemble sandstone (pl. 20) but weather to shaly chips; typical	650

In this section the lower 810 feet is Brallier shale, and the fossils of No. 3 mark the Portage-Chemung boundary. Here, as at other points in the area, they occur in rather soft greenish clay shale 130 feet below the Piney Ridge sandstone member.

Some features of the preceding sections require comment. One of these is the reddish shale and sandstone in the upper half. This color has been described as red without recognition of the fact that, almost without exception, the "red" color below the top of the Chemung is brown or chocolate-colored and is noticeably different from the brighter hues prevailing in the Hampshire formation. It does not yield a red soil.

The green shale is mostly of clay composition, greenish to bluish gray or slate-colored when fresh but weathering yellow-green. A little of this shale showing in the Pennsylvania Railroad section on Burgoon Run is of rather bright greenish-gray (copperas) color.

The sandstone, which except in a few places is present as thin layers in the shale, composing a small proportion of the whole, is almost all hard, fine grained, and either greenish gray or in the upper part chocolate-brown. (See pl. 21.) There are some thicker masses of sandstone, most of which is included in the sandstone or conglomeratic members described below. A very little impure limestone is formed by the accumulation of many shells in a few layers. The yellow-green lumpy mudrock and thin, irregularly surfaced fine-grained yellow or dark-greenish sandstone at the top of the formation, as shown in section No. 2, are highly characteristic and are invariably present just below the red shales of the Hampshire throughout these quadrangles, in the Ebensburg quadrangle, on the west, and as far northeast as Lock Haven, Clinton County. They also carry everywhere, except possibly east of Sideling Hill, a peculiar assemblage of fossils, consisting of *Cyrtospirifer disjunctus* and a large coarse-ribbed *Camarotoechia*, and in the western outcrop a peculiar staple-shaped form described by H. S. Williams as *Arenicolites*. The formation is moderately fossiliferous throughout and differs greatly in that respect from the Chemung of western New York. Such features as ripple marks, sun cracks, and rain prints are not common.

Thickness.—The thickness of the formation is about 2,400 feet in its western area and 3,350 feet in the Raystown Valley. The measured section at Hawn Bridge shows 1,900 feet down to the horizon of the Allegrippis sandstone, which is about 1,600 feet above the bottom of the Chemung, making a total of 3,500 feet. A measurement based on the average dip and the width of outcrop on Shy Beaver Creek is 3,300 feet. East of Sideling Hill the thickness is about 2,800 to 3,000 feet.

Piney Ridge sandstone member.—The Piney Ridge sandstone was named for Piney Ridge, in the southern part of the Huntingdon quadrangle, along which it crops out. It is a persistent bed about 50 feet thick and is 30 to 200 feet above the base of the Chemung. It is greenish gray and iron specked and weathers with a white to light-gray surface. In the section northwest of Saxton (No. 5), it is made up of a number of rather thick sandstone layers, separated by soft greenish clay shale. In places fossils, of which there are several species, are fairly abundant.

Allegrippis sandstone member.—The Allegrippis sandstone was named for Allegrippis Ridge, which it forms and along which it crops out across the Huntington quadrangle. It is about 1,400 feet above the Piney Ridge sandstone. It is generally a greenish-gray sandstone, weathering white, but locally is a coarse conglomerate and commonly has layers or pockets of conglomeratic sandstone. As shown in section 5 there are three beds of sandstone, separated by shale, in a thickness of 77 feet. Only for a short distance on Allegrippis Ridge near the south boundary of the Huntingdon quadrangle was coarse conglomerate observed.

Saxton conglomerate member.—The Saxton conglomerate member was named for Saxton, 2 miles south of the Huntingdon quadrangle, where it is well exposed. It is the Lackawaxen conglomerate of I. C. White, who correlated it with a conglomerate so named by him from Lackawaxen Township, Pike County, Pa. As a conglomerate supposed to be the Lackawaxen had been reported from only one intermediate point, there seemed sufficient doubt about the correlation to warrant the adoption of a new name.

The Saxton conglomerate is made up of conglomeratic sandstone and shale of greenish, greenish-gray, and chocolate-brown hues as shown in the preceding sections of the Chemung and in the following section measured on Raystown Branch a few hundred feet south of the south line of the Huntingdon quadrangle:

Section of the Saxton conglomerate member southeast of Cove station on Raystown Branch

	Ft.	in.
Chemung formation:		
Saxton conglomerate member:		
32. Sandstone, chocolate-colored, cross-bedded at bottom, with pebbles 1 foot above bottom	3	
31. Conglomerate, ferruginous, quartz pebbles three-quarters of an inch in diameter	1	8
30. Shale, green, rather fissile	13	
29. Sandstone, fine grained, ferruginous in top 6 feet, bluish in bottom foot	7	
28. Shale, green, stiff, fissile	10	
27. Conglomerate, greenish gray, two or three thin layers of purplish gray, whole mass pebbly, some layers crowded with pebbles half an inch in diameter, some pebbles 1½ inches long and half an inch thick. Most of the pebbles are very small, and in some layers these are scattered	21	
26. Shale, green, soft, and thin sandstone	2	
25. Sandstone, bluish, hard; iron stained on weathering, contains fossils		8
24. Sandstone, irregularly bedded, 2-inch layers, fine grained, greenish, in part more or less crumbly, about half sandstone and half sandy shale; fossils	6	
23. Sandstone, like No. 27 but no pebbles	7	
22. Sandstone, thin irregular flags, chocolate-colored	5	
21. Shale, green, crumbly, ferruginous; fossils 2½ feet below the top	11	
20. Sandstone, green, fine grained, flaggy	3	6
19. Shale, green, finely fissile	4	
18. Shale, chocolate-colored	2	
17. Shale and thin sandstone, mainly chocolate-colored	3	6
16. Conglomerate, irregular lens; pebbles as much as 1 inch in diameter	1	8
	102	
Beds below Saxton member:		
15. Shale, green	3	
14. Shale and sandstone; shale merges below into sandstone, chocolate-colored	8	
13. Shale, chocolate-colored	4	
12. Sandstone, green, fine grained; fossils at top, plant stems, *Fenestrelina?*, *Camarotoechia*		6
11. Shale, chocolate-colored		8
10. Shale or mudrock, irregular, lumpy, green, sandy, fine pebbles; fish scales?	3	
9. Shale, lumpy, chocolate-colored	15	
8. Shale, green; 1 foot of sandstone in middle	5	
7. Shale and stiff layers (sandstone?), chocolate-colored	20	
6. Shale, chocolate-colored and green interbedded; fossils in middle	10	
5. Shale with 4-inch sandstone layers, chocolate-colored	2	
4. Not exposed; probably chocolate-colored shale	20	
3. Sandstone, chocolate-colored, fine grained	7	
2. Sandstone, greenish and chocolate-colored, fine grained	15	
1. Not exposed; chocolate-colored shale débris	50±	
	163	2

White refers to the Saxton (his Lackawaxen) only the 21 feet of No. 27, which may or may not persist as the most prominent bed in the member, so it seems best to include the full thickness of 102 feet in the member. The siliceous beds are hard fine-grained gray, greenish-gray, and chocolate-colored sandstone, some containing scattered small pebbles and locally crowded with quartz pebbles that make 50 per cent or more of the mass. The pebbles may be of clear glassy quartz, milky quartz, or rose quartz, and the largest are 1½ inches in longest diameter. They are rather flat but not so flat as those of the conglomerates of western New York. White found fish fragments in the conglomerate or associated layers, and the fact that the Lackawaxen conglomerate of Pike County likewise has such remains is one reason for the correlation made by White.

The Saxton conglomerate member is all exposed in the river bluff 1,000 feet east of the northwest end of the railroad bridge over Raystown Branch at Saxton (section 5) and is excellently displayed in the river bed, where it makes a fall, on the Cove-Saxton road a quarter of a mile south of the Huntingdon quadrangle and in the river bank just south of the quadrangle on the Saxton-Entriken Bridge road. It yields the great quantity of large boulders at the foot of the bluff on the road 1 mile southwest of Entriken Bridge. It is well exposed on the road midway between Grafton and Fink Bridge where White reports pebbles 3 inches in longest diameter. It is also clearly exposed in the bluff north of Hawn Bridge but is neither heavy nor very conglomeratic at that point nor farther north.

The conglomerate mapped in the western area of Chemung in the Hollidaysburg quadrangle is believed to be the Saxton, partly because the western conglomerate is about the same distance below the top of the Chemung as the Saxton and partly because of the presence of "*Spirifer*" *mesistrialis* in the bed in both areas. It is best exhibited in that area in a cut on the Pennsylvania Railroad as shown in section 1 and may be traced by its débris southwestward along the line of high knobs nearly to the southwest corner of the Hollidaysburg quadrangle.

Other conglomerates.—There are at least three other local conglomerates present in the Chemung formation of this area. One is about 20 feet thick and about 400 feet below the Allegrippis sandstone half a mile west of Hawn Bridge. A conglomerate about 1 foot thick in the Shy Beaver Creek section probably lies at this horizon. In the Hawn Bridge section (No. 4), bed 20 is a 25-foot bed of conglomeratic sandstone about 100 feet above the Saxton conglomerate member. A mile west of Fink Bridge a second conglomeratic sandstone about 500 feet above the Saxton conglomerate is indicated by débris. In the western area of the Chemung is a conglomeratic sandstone showing on the Pennsylvania Railroad (section 1)

540 feet above the Saxton that probably represents this upper conglomerate horizon.

Age and correlation.—The Chemung is fossiliferous throughout. The 111 species collected include those most characteristic of the Chemung of the type locality in western New York, and the Chemung age of the fauna is unquestionable. Some of the species are cited in the detailed stratigraphic sections.

Chemung-Hampshire boundary.—White[16] drew the boundary between the Chemung and Catskill (Hampshire of this report) at the bottom of the lowest chocolate-colored ("red") layers, which he placed 150 feet above the Allegrippis sandstone. He had approached the region from eastern Pennsylvania, where the redbeds facies extends much lower stratigraphically than it does in the central and northwestern parts of the State. Stevenson,[17] however, approaching the region from the west, placed the Chemung-Catskill boundary at the base of the continuous redbeds, thus including in the Chemung all the distinctly marine fossiliferous beds. The writer adopts this boundary, which gives a constant and consistent division plane valid for Pennsylvania west of the Broadtop Mountain syncline. East of Sideling Hill, however, the redbeds of Catskill type extend lower and probably include the equivalent of 500 to 700 feet of rocks that are embraced in the Chemung west of the Broadtop Mountain syncline, for apparently Chemung fossils do not extend more than 300 feet above the Saxton conglomerate member in that part of the area, whereas they are abundant for 1,300 feet above on the Allegheny Front. It appears that the Chemung-Hampshire boundary will have to be located at lower and lower horizons eastward from the Broadtop Mountain syncline.

HAMPSHIRE FORMATION

Name and definition.—The Hampshire formation was named by Darton[18] from Hampshire County, W. Va. It was applied to the youngest Devonian formation in the central Appalachian region of Virginia and West Virginia. The beds here called Hampshire were at one time referred to the Catskill formation, but recent investigations have shown that the rocks in the Catskill Mountains are older than beds that have been referred to the Catskill in Pennsylvania, West Virginia, and Virginia. (See fig. 5.) The use of the name Hampshire conforms with present usage of the Virginia Geological Survey.[19] In this region the Hampshire formation overlies the Chemung and is overlain by the Pocono formation.

Distribution.—The Hampshire crops out in a broad belt along the west side of the Hollidaysburg quadrangle, and a great part of the formation is exposed in the railroad cuts east of Kittanning Point. Another belt 1 to 2 miles wide crosses the Huntingdon quadrangle along Raystown Branch, whose meanders cut across the redbeds a number of times and lay them bare. A third belt crosses the southeast corner of the Huntingdon quadrangle along Smith Valley, which lies entirely upon the Hampshire outcrop.

Character.—The most obvious and distinctive feature of the Hampshire is its red color. According to Ridgway's classification of colors, however, the Hampshire "red" ranges through vinaceous drab, brownish drab, deep brownish drab, and dark grayish brown, which result from mixture in different proportions of red and orange. In the area on the Allegheny Front probably 80 percent and in the Raystown Valley probably 95 percent of the Hampshire rocks have one of these hues. The Hampshire, however, includes gray or greenish beds, rarely exceeding 20 feet in thickness, of the same texture as the redbeds. Streaks of greenish-gray rock 1 to 4 inches thick and irregular mixtures or mottling of greenish gray in the "red" layers are common and make very striking contrasts with the prevailing "red."

It is estimated that the Hampshire is three-fourths shale and one-fourth sandstone. The shale is a coarse, lumpy mudrock. It is without fissility, breaks or crumbles into irregular lumps, and passes by admixture of sand into a coarse, lumpy sandstone. The sandstone is generally fine grained and hard and in layers 1 to 2 feet thick, but part of it is in layers only 1 to 2 inches thick. Some layers are thinly fissile and some highly micaceous. Few of the sandstone strata exceed 50 feet in thickness, and most of them are between 5 and 20 feet thick. Sun cracks and ripple marks are common, and there is some cross-bedding.

Thickness.—The thickness of the Hampshire is 2,000 feet west of the Broadtop trough and about 2,500 feet east of Sideling Hill.

Age and correlation.—As stated above, the lower 500 to 700 feet of the Hampshire east of Sideling Hill is believed to be contemporaneous with the upper 500 to 700 feet of the Chemung west of the Broadtop Mountain syncline and therefore to be of Chemung age. No fossils were found east of Tussey Mountain, nor are any known from the red parts of the formation anywhere, but in the Hollidaysburg area marine fossils occur in

[16] White, I. C., op. cit., p. 101.

[17] Stevenson, J. J., The geology of Bedford and Fulton Counties: Pennsylvania Second Geol. Survey Rept. T2, p. 76, 1885.

[18] Darton, N. H., Notes on the stratigraphy of a portion of central Appalachian Virginia: Am. Geol., vol. 10, pp. 13, 17, 18, 1892.

[19] Butts, Charles, Geology of the Appalachian Valley in Virginia: Va. Geol. Survey. Bull. 52, pp. 333-335, 1940.

gray and greenish beds 500 feet above the bottom and 500 feet below the top, among which are *Cyrtospirifer disjunctus*, *Delthyris mesacostalis*, *Schuchertella chemungensis*, *Grammysia elliptica*, *Sphenotus clavulus*, and *Pteronites rostratus*. *Oehlertella pleurites* was found near the bottom of the formation.

The Hampshire west of the Broadtop Mountain syncline is known through tracing and well borings to include the equivalent of strata in western New York and northwestern Pennsylvania that are characterized by beds of red shale. These western strata have usually been classed as Devonian and are still so classed by good authorities. There are, however, considerations, not necessary to discuss here, favoring the conclusion that they are really Carboniferous, and they are so classed by the New York State Geological Survey.[20]

CARBONIFEROUS SYSTEM

The rocks of unquestioned Carboniferous age in this region are divided into the Mississippian series below and the Pennsylvanian series, or coal measures, above. The Mississippian series is subdivided into the Pocono, Loyalhanna, and Mauch Chunk formations, and the Pennsylvanian series into the Pottsville, Allegheny, Conemaugh, and Monongahela formations, but the last two are not present in the Hollidaysburg and Huntingdon quadrangles.

MISSISSIPPIAN SERIES

POCONO FORMATION

Name and definition.—The Pocono formation was named from its development in the Pocono Mountains of northeastern Pennsylvania. In the Hollidaysburg-Huntingdon area the Pocono includes all the rocks, predominantly gray, between the red Hampshire below and the equally red Mauch Chunk above. It is sharply distinguished from both and easily recognized. The bottom contact is exposed on the Pennsylvania Railroad on the Allegheny Front. (See pl. 22.)

The basal 50 feet of the Pocono is marked over a large area in central Pennsylvania by one or more layers of a ferruginous and calcareous conglomerate, which in places carries many small heads of a calcareous alga, the largest 2 inches in diameter. Such layers were observed in the Riddlesburg Gap of the Juniata River, 3 miles south of the southwest corner of the Huntingdon quadrangle; on the railroad 2 miles south of the Horseshoe Curve, on the Allegheny Front; on the Snowshoe branch of the Pennsylvania Railroad half a mile northeast of Clarks station, in the Bellefonte quadrangle, Centre County; and 2 miles northwest of Lock Haven, Clinton County, in the east bluff of the river. At every one of these localities the layers of algae appear within 50 feet above the continuous redbeds of the Hampshire and are a reliable marker for the base of the Pocono.

Distribution.—The Pocono crops out on the steep upper face and caps the spurs and summits of the Allegheny Front in the northwest corner of the Hollidaysburg quadrangle, where it is almost all exposed along the Pennsylvania Railroad in the gorge of Sugar Run. In the Huntingdon quadrangle the Pocono crops out along the upper part of the west face of Terrace Mountain and over a wide area on its gentle east slope known as The Barrens. The formation also crops out along Sideling Hill, the core of which is formed by the vertical beds of the lower part of the Burgoon sandstone member.

Character.—On the Allegheny Front and on Terrace Mountain the Pocono includes two very distinct lithologic subdivisions that make up the main mass of the formation. The upper main subdivision is the Burgoon sandstone member. The lower main subdivision, constituting about two-thirds of the Pocono, is, on the Allegheny Front and probably on Terrace Mountain also, composed predominantly of gray sandy shale that includes beds of gray and red sandstone, red shale, and some layers of clay. In Terrace Mountain a bed of conglomerate with quartz pebbles, the largest half an inch in diameter, occurs locally at least in this division near the bottom. This bed is exposed in the gorge of Great Trough Creek through Terrace Mountain and has considerable extent in that region. On the Allegheny Front, as exposed on the Pennsylvania Railroad, a bed of sandstone 180 feet thick, including a layer of red shale 50 feet above the bottom, lies at the bottom of the Pocono and immediately upon the thick red shale that forms the top of the Hampshire. On Sideling Hill the exposures are poor and the two main subdivisions are not as obvious as elsewhere, but the upper part is a sandstone of the Burgoon type, and shale is exposed in the lower part at one place. The two subdivisions are therefore indicated, but their limits and thickress have not been determined.

The thickness of the lower subdivision is about 700 feet on the Allegheny Front and 900 to 1,000 feet on Terrace Mountain.

Patton shale member.—The Patton shale was named for Patton station, in Jefferson County. On the railroad along the Allegheny Front it is a bed of red shale about 40 feet thick immediately underlying the Burgoon sandstone member. In the region west of the Allegheny Front the Patton shale is a prominent horizon marker.

[20] Hartnagel, C. A., New York State Mus. Handbook 19, 1912.

Burgoon sandstone member.—The Burgoon sandstone was named for Burgoon Run, in the northwest corner of the Hollidaysburg quadrangle. It consists of nearly continuous thick-bedded, rather coarse micaceous and feldspathic sandstone, yellowish green to bluish gray and weathering gray. On the Allegheny Front it contains locally at one horizon or another small quartz pebbles but is nowhere conspicuously conglomeratic. On the Allegheny Front it is 300 feet thick and on Terrace Mountain at least 375 feet and may be as much as 500 feet.

Coal in the Pocono.—On the Allegheny Front an 8-inch coal bed in the Burgoon sandstone, about 100 feet above the bottom, is exposed on the Pennsylvania Railroad. I. C. White reports thin streaks of coal apparently near the same horizon, exposed in the gorge of Great Trough Creek. Ashburner reports 19 thin layers of coal in the Pocono of Sideling Hill, exposed in the tunnel of the East Broad Top Railroad 5 miles south of the Huntingdon quadrangle. No coal of commercial value is known in this formation.

Thickness.—On the Allegheny Front the total thickness of the Pocono is 990 feet; on Terrace Mountain and Sideling Hill it is 1,400 feet. Ashburner[21] made the thickness of the Pocono in Sideling Hill 2,133 feet, but this seems to be erroneous, for the thickness cannot exceed the width of outcrop, which is only 1,400 feet.

Age and correlation.—The lower part of the Pocono is somewhat fossiliferous, yielding both plant and animal fossils, including the undescribed calcareous algae mentioned above.

David White refers the beds below the Burgoon sandstone carrying lepidodendrons to the Mississippian but with a reservation on beds containing *Lepidodendron chemungense?*. Those beds, however, are Mississippian if the others are.

The lower division of the Pocono carries invertebrates in the Broadtop Mountain and Terrace Mountain area in a bed of shale 50 feet thick 600 feet below the top. Girty[22] has studied these fossils and finds that they are all new species bearing more resemblance to those of a Cuyahoga horizon in Ohio than any others.

Independently of evidence from fossils the Burgoon sandstone is satisfactorily correlated through field tracing and oil-well borings with the Logan formation of Ohio and the lower shaly part of the Pocono with the Cuyahoga formation of Ohio. It is now known that the Logan and Cuyahoga are the equivalent of the New Providence shale of Indiana and Kentucky, and that the New Providence is the approximate equivalent of the Fern Glen and lower Burlington beds of Illinois, Iowa, and Missouri, whence it follows that the Pocono is correlative with the Fern Glen and lower Burlington beds of the Mississippi Valley.

HIATUS BETWEEN THE POCONO FORMATION AND LOYALHANNA LIMESTONE

On the Allegheny Front there is an unconformity at the top of the Burgoon sandstone resulting from the absence of beds equivalent to the Warsaw, Spergen, St. Louis, and Keokuk limestones. In the Broadtop Mountain region this unconformity is increased by the absence of the Loyalhanna limestone in addition. On the Allegheny Front the Loyalhanna succeeds the Burgoon, and in the Broadtop Mountain region the Mauch Chunk shale, which overlies the Loyalhanna, succeeds the Burgoon.

LOYALHANNA LIMESTONE

Name and definition.—The Loyalhanna limestone is the same as the "Siliceous" limestone of the reports of the Second Geological Survey of Pennsylvania. It was named for its exposures in the gorge of Loyalhanna Creek, above Latrobe, in Westmoreland County. It has been customary to include the Loyalhanna in the Pocono as a member, but for reasons stated below it is now given the rank of a formation. It occupies the stratigraphic interval above the Burgoon sandstone member of the Pocono and below the Mauch Chunk formation.

Distribution.—The Loyalhanna limestone has only a small extent of outcrop on the summit of the Allegheny Front in the northwest corner of the Hollidaysburg quadrangle. It extends westward throughout Westmoreland County into Fayette County and probably underlies all the southwestern counties of Pennsylvania.

Character.—The Loyalhanna is a siliceous and slightly oolitic limestone of differing composition in different layers. Some seem to be predominantly composed of quartz grains cemented by calcium carbonate, and others are predominantly limestone with scattered quartz grains. It is notably cross-bedded, the cross-bedding being plainly revealed by diagonal furrows on the weathered surfaces, some of which are also deeply pitted owing to leaching of the more calcareous parts. (See pl. 23.)

Thickness.—The Loyalhanna limestone is about 40 feet thick in this region.

Age and correlation.—The Loyalhanna is lithologically much like the Ste. Genevieve limestone of northeastern Kentucky,

[21] Ashburner, C. A., Aughwick Valley and East Broad Top district: Pennsylvania Second Geol. Survey Rept. F, pp. 206—208, 1878.

[22] Girty, G. H., Pocono fauna of the Broadtop coal field, Pennsylvania: U. S. Geol. Survey Prof. Paper 150, p. 111, 1928.

which there is a siliceous cross-bedded oolite. In that region the Ste. Genevieve immediately overlies the Logan formation and is succeeded above by the Gasper oolite. Now, as already shown, the Logan formation is the same as the Burgoon sandstone immediately beneath the Loyalhanna limestone, and the Gasper oolite, overlying the Ste. Genevieve in eastern Kentucky and the main constituent of the Maxville limestone of Ohio, is correlated by its fossils with the Greenbrier limestone member of the Mauch Chunk shale, 50 feet above the Loyalhanna limestone on Chestnut Ridge east of Connellsville and elsewhere in southwestern Pennsylvania and western Maryland. On the basis of sequence and character, therefore, the Loyalhanna is probably the eastern representative of the Ste. Genevieve.

MAUCH CHUNK FORMATION

Name and definition.—The name Mauch Chunk is taken from Mauch Chunk, in the anthracite region of eastern Pennsylvania, where the formation is typically developed. It overlies the Pocono formation and underlies the Pottsville, and in the Huntingdon quadrangle it includes at or near the bottom the Trough Creek limestone member.

Distribution.—The Mauch Chunk is present in the northwest corner of the Hollidaysburg quadrangle and on the slopes of Broadtop Mountain in the Huntingdon quadrangle. The formation is well exposed at many points in the Trough Creek Valley, and Round Mountain is composed of it except a thin cap of Pottsville sandstone.

Character.—On the Allegheny Front, immediately above the Loyalhanna limestone, lies 5 to 6 feet of interbedded red shale and sandstone, and above this is 80 feet of mostly thick-bedded gray to greenish sandstone, in the lower part of which occurs a bed of conglomerate 2 to 3 feet thick. The character of these beds is shown in Plate 24. The sandstone is succeeded by shale, mostly red but with thin green layers. The red shale is soft, and some of it appears to be earthy. It is not fissile but crumbly and lumpy, and most of it weathers into small cubical fragments.

In the Trough Creek Valley the Mauch Chunk is almost wholly a solid body of red shale similar to that on the Allegheny Front. At or near the bottom in the Huntingdon quadrangle lies the Trough Creek limestone member, and at the top is a few feet of greenish flaggy sandstone and shale. Red sandstone débris at the south base of Round Mountain near Newburg and yellow-green sandstone débris 200 feet higher show the presence of thin sandstone layers in the shale. Thin limestone is reported near the middle of the red shale on Round Mountain and near Newburg. No body of greenish and gray thick-bedded sandstone is present in the Trough Creek Valley as on the Allegheny Front. As in the Hampshire, the "red" color is brownish or light brownish drab, according to Ridgway's color classification.

The Mauch Chunk decomposes to a loose rich soil of good depth and free from stones, and its area in the Trough Creek Valley is one of the best farming districts in these quadrangles. In the forests its outcrop is marked by peculiarities of vegetation, such as large straight trees and freedom from undergrowth of brush and saplings, which grow thickly upon the adjoining Pottsville and Burgoon arear. Instead of underbrush there is an abundance of herbaceous plants in a rather open forest, and in such a spot a stroke of the pick rarely fails to disclose the characteristic red soil. This feature was utilized in tracing the outcrop along the wooded Allegheny Front.

Thickness.—The thickness of the Mauch Chunk on the Allegheny Front is 180 feet, in Trough Creek Valley about 1,000 feet.

Trough Creek limestone member.—The Trough Creek limestone member, named by White[23] lies near the bottom of the Mauch Chunk and is separated from the Burgoon sandstone member of the Pocono by a few feet of red and green shale and some thin layers of soft yellow-green sandstone. It is a rather coarsely crystalline "red" and gray limestone, as shown in the following sections.

1. *Section in the bend of Great Trough Creek a short distance northwest of Tod*

	Ft.	in.
Mauch Chunk formation:		
5. Shale, red, crumbly, with calcareous layers and nodules	25	
Trough Creek member (quarried):		
4. Limestone, thin layered, with red bands		8
3. Limestone, gray	3	
2. Shale, like No. 1, but no calcareous layers seen; only partly exposed	6	
Pocono formation:		
1. Sandstone, even top, cross-bedded (Burgoon member).		

White says that a limestone 2 feet thick is exposed just above the Pocono in this section.

2. *Section at the mouth of Lick Run, three-fourths of a mile east of Newburg*[24]

	Ft.	in.
Mauch Chunk formation:		
7. Shale, red.		
Trough Creek member:		
6. Limestone, red, brecciated, fossils (*Straparollus*)	5	
5. Shale, red, and limy beds	12	
4. Limestone, gray	3	6
3. Shale, red, and limy beds	10	
2. Limestone, gray	2	6
Pocono formation:		
1. Sandstone, gray, massive (Burgoon member)	20	

[23] White, I. C., The geology of Huntingdon County: Pennsylvania 2d Geol. Survey Rept. T3, p. 283, 1885.

[24] White, I. C., idem, p. 283.

The Trough Creek limestone has been quarried and utilized to a considerable extent for agricultural lime, which is said to be of excellent quality.

Age and correlation.—Except specimens of *Straparollus* reported by White (see section No. 2 above) and of *Dielasmia?* and *Allorisma?* reported by Ashburner from a quarry at Tod and a few reported by Reger apparently from the same place, no fossils have been found in the Mauch Chunk of this region. In Westmoreland County, however, on Chestnut Ridge, the Mauch Chunk includes near the bottom the Greenbrier limestone member, which by its fossils is correlated with the Maxville limestone of Ohio. The Maxville is in the main equivalent to the Gasper oolite of Kentucky and Tennessee, which is of lower Chester age. Possibly the Trough Creek limestone is a northwestward extension of the Greenbrier and therefore of lower Chester age, from which it follows that the usual correlation of the Mauch Chunk with the Chester group, if the Ste. Genevieve limestone is omitted, is amply justified.

HIATUS AT BASE OF POTTSVILLE FORMATION

In the anthracite field of eastern Pennsylvania the Mauch Chunk is 2,200 feet thick; in the Broadtop region, 1,100 feet; on the Allegheny Front 180 feet; in the Allegheny Valley it is absent. This thinning and disappearance of the Mauch Chunk westward is regarded as probably due to its erosion after deposition. It was upon the eroded surface of the Mauch Chunk that the Pottsville of this region was deposited, so that an unconformity exists between them. This relation between the Pottsville and the Mississippian continues along the western part of the Appalachian province from New York to Alabama.

The hiatus between the Mauch Chunk and the Pottsville is far greater than would appear from this simple statement. The Pottsville that follows the Mauch Chunk in this region is late Pottsville, and along the Appalachian troughs, as in the Pocahontas coal field, in West Virginia, and the Coosa and Cahaba troughs, in Alabama, as much as 10,000 feet or even more of still earlier Pottsville beds was laid down in the interval represented by the Mauch Chunk-Pottsville unconformity.

PENNSYLVANIAN SERIES

POTTSVILLE FORMATION

Name and definition.—The Pottsville was named for its development at Pottsville, Pa. It overlies the Mauch Chunk formation and underlies the Allegheny formation and is here composed of the Connoquenessing sandstone member, the Mercer shale member, and the Homewood sandstone member, the three members recognized in the western part of the State.

Distribution.—The Pottsville occupies a small area on the margin of the plateau in the northwest corner of the Hollidaysburg quadrangle. There is a rather extensive area on the northern margin of Broadtop Mountain, two small areas capping Bunns and Round Mountains, and a triangular area on Rocky Ridge extending from the quadrangle boundary north to the summit of Shirley Knob. Only on Rocky Ridge is the full thickness of the formation present in the Broadtop area.

Character.—The Connoquenessing member of the Pottsville is a rather coarse gray sandstone, 80 to 100 feet thick, containing small lenses or layers of gray sandy shale. Above it on the Pennsylvania Railroad just southeast of Bennington Station lies 6 feet of shale, overlain by 9 feet of fire clay, at the top of which, partly included in the overlying Homewood sandstone, are small pockets of coal 2 inches thick. In the shale were found specimens of small plants, which are regarded by David White as characteristic of the Mercer shale, lying between the Connoquenessing and Homewood sandstones of other areas, and these beds are therefore identified as the Mercer shale member of the Pottsville. In the southwest corner of the Patton quadrangle, about 2 miles north of Bennington, the Mercer coal is a workable bed, but it is not known to be workable in the Hollidaysburg quadrangle. The Homewood sandstone, at the top of the Pottsville, is coarse, thick bedded, and 15 feet thick. It shows well in the first cut east of Bennington but dips below track level 400 feet east of the station. Neither the Connoquenessing nor the Homewood sandstone is conglomeratic in this section.

In the Broadtop Mountain region the Pottsville is likewise made up of two coarse siliceous sandstone members probably separated by shale, although no exposure of the shale is to be seen in that region. The sandstones are fairly well exposed on Rocky Ridge and in the gorge of Great Trough Creek, in the southeast corner of the Huntingdon quadrangle, but not in such a condition that the thickness of either could be accurately determined.

Thickness.—The thickness of the Pottsville on the Allegheny Front is 130 feet, and the best estimate of its thickness in Rocky Ridge is 300 feet. This estimate agrees very closely with the thickness of 280 feet determined by Ashburner.[25] His section is as follows:

Section of Pottsville formation on Wrays Hill and Rocky Ridge

	Feet
Sandstone [Homewood?]	160
Shale [Mercer]	40
Sandstone [Connoquenessing]	10
Sandstone	70
	280

Probably the lower 80 feet of sandstone is all Connoquenessing.

Age and correlation.—It has been shown by White[26] that the Pottsville of this region corresponds to only the topmost beds of the Pottsville along the east side of the Appalachian region. White divides the Pottsville into lower, middle, and upper divisions, and the Pottsville of this region includes only the upper three members of the upper Pottsville. Further discussion of this subject is given under "Historical geology."

ALLEGHENY FORMATION

Name and definition.—The Allegheny formation was named for the Allegheny Valley, where it is typically developed. It was formerly known as the "Lower Productive Coal Measures." It overlies the Pottsville formation and is the youngest Paleozoic formation present in these quadrangles.

Distribution.—Only a very small area of the Allegheny formation is present in the Hollidaysburg quadrangle, on the spur between Burgoon and Sugar Runs. In the southeast corner of the Huntingdon quadrangle there is a small area of the Allegheny on Rocky Ridge.

Character.—The Allegheny formation consists of shale, sandstone, and limestone, with a number of coal beds. The coal beds mined in Cambria and Clearfield Counties, west and northwest of the Hollidaysburg quadrangle, and those of Rocky Ridge and Broadtop Mountain are in the Allegheny formation. Rocky Ridge contains three thick coal beds—the Fulton bed, 6 feet thick, close above the top of the Pottsville; the Barnett bed, 3 feet 6 inches thick, 45 feet above the Fulton; and the Kelly bed, 4 feet 8 inches thick, 100 feet above the Barnett and very near the top of the part of the Allegheny formation present in that locality. The intervening beds are shale and sandstone, as in the Allegheny elsewhere.

Thickness.—On the Allegheny Front probably not more than the basal 50 feet of the Allegheny is present, and the thickness remaining on Rocky Ridge probably does not much exceed 200 feet.

Age and correlation.—As implied in the name, the Allegheny formation of this region is the equivalent of the Allegheny formation west of the Allegheny Front. To judge from their stratigraphic relations the Fulton coal is Clarion, the Barnett is Lower Kittanning, and the Kelly is Upper Freeport.

LATE PALEOZOIC, MESOZOIC, AND TERTIARY ROCKS

Except the Recent deposits described below, no rocks younger than those of the Allegheny formation still remain in the Hollidaysburg and Huntingdon quadrangles. An immensely long period of time, represented in other parts of the earth by tens of thousands of feet of rocks, is thus not represented here.

QUATERNARY SYSTEM

Alluvium.—Under the head of alluvium are included the silt, sand, and gravel deposited on the flood plains of existing streams as they have overflowed their banks in Recent time. Such deposits are probably nowhere in this region more than 25 feet thick.

STRUCTURE

The Hollidaysburg and Huntingdon quadrangles are situated on the northwest side of the Valley and Ridge province and participate in the main features of geologic structure characterizing that province from southeastern New York to northeastern Alabama.

By structure is meant the present attitude of the strata, which were deposited approximately horizontal but subsequently were tilted or folded and broken in places and displaced along the breaks (faulted). Instead of lying horizontal the strata are now generally inclined at different angles or even overturned in places. This structure is represented by dip and strike symbols on the geologic maps and by structure sections, which exhibit the beds as they would appear on the side of a deep trench cutting directly across the outcropping edges of the strata.

The larger features of the structure are the two great folds that cross the region with a trend about N. 30° E. These are the Nittany arch on the northwest and the Broadtop trough on the southeast.

The Nittany arch is a great upbending of the strata, 35 miles wide, from the bottom of the Broadtop trough, in the southeast corner of the Huntingdon quadrangle, on the southeast to the bottom of the Wilmore syncline, 5 miles west of the northwest corner of the Hollidaysburg quadrangle, on the northwest.

[25] Ashburner, C. A., op. cit., p. 192.

[26] White, David, Geol. Soc. America Bull., vol. 15, pp. 267-282, 1904.

Figure 4 shows a section across the Nittany arch and Broadtop syncline, made up by combining structure section F–F′ of the Huntingdon quadrangle and section C–C′ of the Hollidaysburg quadrangle and restoring the strata that have been eroded from the crest of the arch. The Allegheny formation, the highest in the quadrangles, would on the restored arch be about 5 miles above the present surface of the land on the crest of the arch, the highest point of which lies about 1 mile northwest of Drab. There is probably no anticline or arch of greater magnitude in the Valley and Ridge province.

The Broadtop trough is a great syncline or down bend in the strata. Its breadth, measured from the crest of the Nittany arch northwest of Drab to the crest of Jacks Mountain, about 1 mile east of the southeast corner of the Huntingdon quadrangle, is about 20 miles. In the bottom of the trough, in the southeast corner of the Huntingdon quadrangle, the Warrior limestone, which crops out on the crest of the Nittany arch 1 mile northwest of Drab, is about 5 miles below the summit of Rocky Ridge.

As the strata in these folds were originally horizontal they now occupy a less width in the earth's crust than they did before the folding. The total crustal shortening between Jacks Mountain and the Allegheny Front is 5 miles—that is, points on the Tuscarora quartzite or any other bed would be 5 miles farther apart than now if the strata were restored to horizontality.

These great folds are not simple symmetrical features, but are somewhat steeper on their northwestern than on their southeastern limbs and have subordinate folds or wrinkles on their flanks or crests. The Broadtop trough has a wide, nearly flat bottom, and if the section shown in Figure 4 had been located farther south, as on the line of section E–E′ of the Hollidaysburg quadrangle, or had been located 10 miles northeast of the quadrangle, it would show a broad, nearly flat crest on the Nittany arch.

A notable feature of the structure is the Scotch Valley syncline. This fold may be regarded as a deep depression in the northwest limb of the Nittany arch, to which its narrowness in the northern two-thirds of the quadrangles is due.

The minor anticlines and synclines, shown by their axes, include the Sinking Valley, Roaring Springs, and Woodbury anticlines and the Scotch Valley, McCue, and Trough Creek synclines.

The crest of the Nittany arch is also broken by the Halter Creek, east and west Henrietta, and Williamsburg faults, along which, except the east Henrietta fault, the strata have been thrust upward and westward into contact with younger rocks on the west, as shown in the structure sections. The stratigraphic displacement on the Halter Creek fault at the south edge of the Hollidaysburg quadrangle is 5,000 feet, the Warrior limestone being thrust up into contact with the Reedsville shale. The displacement on the west Henrietta fault, due east of Martinsburg, is also about 5,000 feet. Elsewhere the displacement is less.

The faults throughout most of their extent are strike faults, but in places they cut across the strike, notably the east and west Henrietta faults and the Williamsburg fault in the northwest corner of the Huntingdon quadrangle.

The relations brought about by the Henrietta faults are unusual. The rocks on the east of the west fault are upthrust, and those on the east of the east fault are relatively downthrown. If the wedge of older strata between the faults were withdrawn and the resulting gap closed, the corresponding formations on opposite sides of the gap would nearly match end to end. The present relations are such as would be brought about by the formation and opening of a fracture due to tensional strain in the arching of the strata, the branching of the fracture at depth, and the pushing upward of the wedge between the branches by the enormous compressive forces involved in the folding acting upon the broad base of the wedge. The present conditions may have been brought about in some such way.

The rocks of the region are but slightly affected by minor structural features. Slaty cleavage has been produced in the Reedsville shale in places where it has been squeezed most as in the angle between Short and Loop Mountains. Some of the Tuscarora quartzite has undergone cementation to compact quartzite where the silicification could have been effected by water that could easily penetrate the vertical beds cropping out on the summits of the high ridges. There is no apparent evidence of load metamorphism in the lowest beds exposed on the summit of the Nittany arch, where they were once subjected to a load of overlying rocks 5 miles thick and probably had a temperature of not less than 300° F.

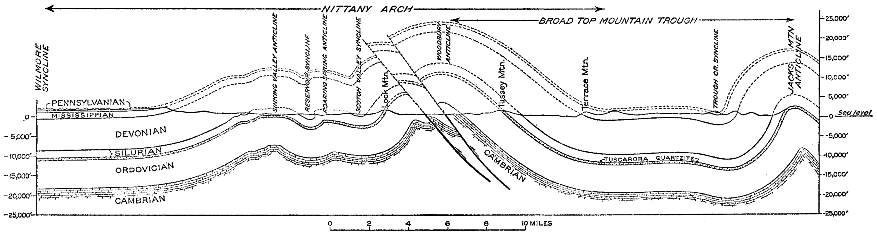


FIGURE 4.—Generalized cross section, northwest to southeast, across Hollidaysburg and Huntingdon quadrangles, showing restored positions of the eroded strata.
Horizontal shortening 5 miles.

GEOLOGIC HISTORY

PROTEROZOIC ERA

In the Proterozoic era were deposited stratified rocks older than the earliest rocks that contain an abundance of recognizable fossils. At the end of the era these rocks formed a land mass in the central United States and another one extending along the Atlantic coast from Newfoundland to Florida. Between the two land masses a comparatively narrow trough known as the Appalachian Strait extended from the Gulf of St. Lawrence through central Pennsylvania to the Gulf of Mexico. Proterozoic rocks formed the bottom of this strait and made the foundation upon which the overlying Paleozoic rocks in this region were deposited.

PALEOZOIC ERA

The Paleozoic era is the era of ancient life. All the great classes of invertebrate animals were already differentiated at its beginning, and the lower classes of vertebrates, the fishes and amphibia, appeared before its end.

CAMBRIAN PERIOD

In the early part of the Cambrian period coarse sediment was discharged from the bordering lands into the Appalachian Strait and formed strata of sandstone, conglomerate, and shale in places supposed to be more than 10,000 feet thick. These rocks, now cropping out in South Mountain, Pa., and along the Blue Ridge of Virginia, are believed to extend westward in places at least and to underlie the Hollidaysburg and Huntingdon quadrangles at considerable depth.

The deposition of limestone followed, and the Tomstown dolomite of Pennsylvania, which is supposed to underlie the Waynesboro formation in these quadrangles, and the equivalent Shady dolomite of the southern Appalachian region were laid down. The deposition of this limestone indicates a change of geographic or climatic conditions, possibly a wearing down or sinking of the land, from which the slow-running streams would carry little or no sediment to the strait, or possibly a desert condition with no drainage. Again the conditions changed, and red and green mud, sand, and fine gravel were deposited, making the rocks of the Waynesboro formation. The red mud could have originated through the deep decay of the rocks of the land during Tomstown time, when there was little erosion, red sediment being commonly regarded as a result of desert conditions. Quartz pebbles in these conglomerates may have come from the Piedmont region, a hundred miles away. Scarcity of life in the region is indicated by the fewness of the fossils in the Waynesboro rocks. The second change to limestone deposition in the Pleasant Hill and Warrior epochs may plausibly be associated with a period of widespread submergence of the area now the interior of the United States, during which shore lines were far removed from this region. The Pleasant Hill sea was invaded by trilobites and brachiopods near the end of this epoch. Precipitation of calcium carbonate from the water, possibly through the agency of bacteria or algae, continued through the Warrior epoch. Most of the Warrior deposit, however, is now a dolomite or magnesian limestone, probably the product of a concentration of magnesium salts in the sea water caused by rapid evaporation.

Some of the geographic conditions at this time are indicated by the sandy layers of the Warrior. The Hollidaysburg-Huntingdon region must have been near the shore of the Warrior sea, where streams carrying the sand and coarser quartz grains debouched.

Trilobites and oboloid brachiopods lived in the sea from time to time, as shown by their fossil remains found at several horizons. *Cryptozoon undulatum*, a species of marine alga, a low plant form, was one of the principal inhabitants of the Warrior sea. (See pls. 7, 8, and 9.)

In Gatesburg time at least some parts of the land yielded great quantities of quartz sand. A somewhat arid climate may have prevailed, resulting in concentrated saline water that favored the deposition of a great thickness of coarse dolomite. There may have been intermittent floods, as in modern desert regions, that carried the quartz sand to the sea to form the recurrent beds of sandstone. For a brief time limestone-forming conditions prevailed locally, and the Ore Hill limestone member was laid down. Conditions were favorable to life in the Ore Hill sea, in which lived trilobites and a few other forms.

ORDOVICIAN PERIOD

During most of the Ordovician period, limestone and dolomite were deposited in this region. Near the end of the period clastic sediment that now forms the Reedsville shale and the Juniata formation were deposited.

At the beginning of Mines time the sea was briefly invaded in places by many gastropods. The general geographic and climatic conditions of Gatesburg time continued, possibly with a still wider sea and less drainage, with resulting cessation of transportation of sand but with increase of disseminated silica to form the chert of the Mines. Mines conditions continued through Larke time except that the deposits seemed to be almost without silica of any kind.

In the Nittany epoch calcareous sediment, later becoming dolomite, was deposited; during the succeeding Axemann epoch limestone intermixed with dolomite layers was laid down; and in the Bellefonte epoch calcareous sediment that merges into dolomite was again deposited. Throughout these three epochs of Beekmantown time gastropods were the predominating forms of animal life, with fewer cephalopods, brachiopods, and trilobites, and plant life in very low form was represented by Cryptozoa, which are supposed to be lime-secreting algae.

Beekmantown time was followed by an unrecorded interval corresponding to the early part of the Chazy epoch, the rocks of which, several hundred feet thick, are believed to be absent in this region. The absent formations are the St. Peter sandstone of the Mississippi Valley and most if not all of the Murfreesboro limestone, 500 feet thick, of Tennessee. The whole Appalachian Valley probably was dry land of very low relief during most of the unrecorded time. Later the sea, gradually transgressing from the southwest, again submerged central Pennsylvania in Middle Ordovician time, and in this sea the Carlim limestone was deposited. Transgression of the sea from the southwest is inferred from the fact that the Murfreesboro limestone is believed to be present in southwestern Virginia, where it was laid down in the transgressing water before the submergence reached central Pennsylvania. The Lemont argillaceous limestone, the top member of the Carlim, grows thicker toward the northeast, and possibly its materials came from that direction. Shallow water is indicated by ripple marks and mud cracks on some of the limestone layers. Bryozoa, brachiopods, pelecypods, gastropods, ostracodes, and trilobites were the principal inhabitants of the Carlim sea and were most abundant in Lemont time.

For a very long time after the Carlim epoch the central Pennsylvania region was dry land, or, at most, only slightly submerged, whereas the sea covered other parts of the Appalachian Valley province, as in eastern Tennessee, where 6,000 to 8,000 feet of strata (Blount group of Ulrich), including the Holston marble, Athens shale, Tellico sandstone, and Sevier shale, are believed to have been deposited between Chazy and Black River time. This unrecorded interval was thus a very long one.

In Lowville time the transgression of the Ordovician sea reached its culmination, and the central part of the United States at least was very largely submerged, for in the Eastern States rocks of Lowville age are probably the most widespread of all in the Ordovician system. Life was fairly abundant, especially in Rodman time, and bryozoans, brachiopods, gastropods, and corals were the most common forms.

Although the deposition of limestone persisted in this region during Trenton time, it is known that terrigenous rather than calcareous sediment was being deposited in eastern Pennsylvania, where the lower part of the Martinsburg shale is of Trenton age. Some of the carbonaceous matter, to which the dark color of much of the Martinsburg shale is due, and perhaps a little of the finest clay sediment were conveyed to this region, giving the Trenton limestone its shale partings, impurities, and dark color. The same general forms of life inhabited the Trenton sea as were in the seas of the preceding epoch, although of different species.

The deposition of the succeeding Reedsville shale marked the beginning of a great change in geographic conditions in the Appalachian Gulf. Uplift of the sea floor, warping, shallowing of the water, and finally a dominance of clastic sediments more pronounced than had occurred in the region since early Cambrian time are the distinguishing features of the Martinsburg, Reedsville, and succeeding epochs up to the Tonoloway. Not only in central Pennsylvania but also over a very large region in the eastern United States the deposition of fine mud was the rule during the Reedsville epoch. The strait had probably become a broad, comparatively shallow gulf agitated by great waves and swept by tidal and possibly strong oceanic currents. Conditions were generally favorable to life in this epoch, and at different times the sea bottom must have been covered with shell-bearing animals, for many thin layers of impure limestone composed of these shells are intercalated in the shale.

In the epoch succeeding the Reedsville there were probably lands of moderate relief on the northwest in Canada and on the southeast in the Blue Ridge province, but for a time at least they underwent relative elevation; the shores moved seaward and exposed to subaerial erosion the old submerged coastal shelf, where lay a large body of sandy residue left after the finer material of the Martinsburg shale was washed out and laid down farther seaward. This sandy shelf, now become a coastal plain, and the higher land farther from the shore supplied the sandy material of the later formations of the Ordovician.

Thus the deposits of the succeeding Oswego epoch were predominantly fine quartz sand. The absence of the Oswego southeast of this region, nearer the Appalachian Mountains, and its presence in central New York indicate an old land northwest of the Appalachian Strait as the source of the sandy sediment.

During the succeeding Juniata epoch the deposition of sandy and muddy sediments continued. Considerable variation in the kinds of sediment discharged into the water or in the transporting power of the currents by which the sediment was distributed is attested by the alternating beds of shale and sandstone. It is supposed that the red sediments predominating in the Juniata were derived from an area on the east upon which had accumulated a deep residual soil. This iron-stained soil was transported toward the western sea of the time, occupying a large area in Ohio, Indiana, Kentucky, and Canada, and was deposited as a great delta similar to that now forming along the lower course of the Yellow River in China.

SILURIAN PERIOD

The Tuscarora epoch was one of widespread deposition of pure quartz sand in the Appalachian region. The formation implies much erosion of tributary land and much sorting of material, which left a mantle of comparatively coarse sand on the low land of a wide coastal plain.

The absence of fossils in the Oswego, Juniata, and Tuscarora formations is regarded as very strong evidence that they were all terrestrial, perhaps shore deposits, exposed to the air all or part of the time and laid down before air-breathing animals had appeared upon the earth. Similar deposits of later times contain the tracks and fossil remains of air-breathing animals.

During the Clinton epoch the region was again submerged in the sea, which at times swarmed with ostracodes and other invertebrates. The feature, however, that peculiarly distinguishes the Clinton formation is the occurrence of beds of fossil and oolitic iron ore. These beds are present along the Appalachian Valley from New York to Alabama and point to a remarkable uniformity of conditions. That the iron was deposited contemporaneously in the beds in which it occurs is the most generally accepted theory. Extensive more or less sheltered lagoons in which animals flourished may be conceived. The shells and other skeletal parts of the animals, usually in a comminuted state, such as the coquina found in Florida at the present time, accumulated in these lagoons, and as calcium carbonate precipitates iron from solution the iron, possibly brought into the lagoons in solution as iron carbonate or iron sulphate, was precipitated and mixed with the animal débris, the calcium carbonate of which it finally replaced to form the ore.

Between the Clinton and McKenzie epochs is an unrecorded interval during which the Lockport dolomite, absent in Pennsylvania, was deposited in New York and Canada.

Pure limestone marks the beginning of the McKenzie epoch. Later argillaceous sediments predominated. Animal life flourished and ostracodes and brachiopods were very abundant.

Following McKenzie time the few beds of the red sandstone and shale of the Bloomsburg redbeds were deposited.

In Wills Creek time fine sediment, at rare intervals calcareous, seems to have been laid down everywhere. In marked contrast with the McKenzie sea the Wills Creek sea in this region was very nearly destitute of inhabitants. The salt and gypsum deposits of the equivalent Salina formation of New York indicate a more or less isolated body of water and an arid climate with excess of evaporation. Such conditions, though perhaps less extreme, may have existed in central Pennsylvania during the epoch.

During the Tonoloway epoch the deposition of nearly pure calcareous sediment, for the first time since the Trenton epoch, was resumed in this region. Land was probably far distant.

DEVONIAN PERIOD

By the beginning of the Devonian period the Appalachian Gulf had contracted to a rather small basin occupied by the sea of earlier Helderberg time, supposedly connected with Atlantic waters. This sea expanded to the southwest and possibly to the northeast and after Onondaga time received a vast amount of sediment from the highlands on the east and northeast, which spread out delta-like from the head of the sea or gulf in the region of the Catskill Mountains in southeastern New York and extended southwestward into southwestern Virginia and over most of West Virginia and eastern Ohio. The Hollidaysburg-Huntingdon area was continuously submerged and received deposits of clay and sand during the whole of the period following the Helderberg epoch.

The narrow Helderberg sea of the central Appalachian region extended from New York through central Pennsylvania to southwestern Virginia and was probably surrounded by very low lands on which slight erosion was going on. Deposition of limestone prevailed, and conditions were favorable to life. Many of the inhabitants of the Helderberg sea were survivors from the Silurian, and some new types were introduced.

The Oriskany epoch marked the beginning of a revival of the transporting power of streams. Fine sand was mixed with calcareous sediment to form the thinner siliceous limestone of the Shriver, and later with growing transporting power still coarser sand and small quartz pebbles were delivered by the streams to the highly calcareous seas to form the calcareous Ridgeley sandstone. The Appalachian Gulf in the Oriskany epoch extended from Canada to southwestern Virginia, and perhaps the Appalachian Valley area was occupied by shallow lagoons as far south as Alabama and Georgia, where isolated Oriskany deposits occur. During Shriver time conditions were less favorable to life than in Helderberg, but in Ridgeley time they again became favorable, and the sea bottom was thickly populated by shell-bearing invertebrates, especially brachiopods and gastropods.

In central Pennsylvania during Onondaga time fine argillaceous and calcareous sedimentation prevailed. On the north and west in New York and Ohio only limestone was laid down. The shale and limestone of this area were near-shore deposits, and the limestone on the north and northwest was deposited farther from shore in clear water. Animal life was not abundant in the Hollidaysburg-Huntingdon region, but in some parts of the Onondaga sea it was profuse.

The rocks of the Marcellus, Hamilton, Genesee, Portage, and Chemung formations were laid down in a more or less landlocked bay or gulf, the head of which was in southeastern New York. The clay, silt, and sand of which they are composed were apparently derived from land on the northeast and southeast, whose western shore probably extended from New York southward some distance west of the present line of the Blue Ridge. The character of these formations indicates accumulation in shallow water, which involves a long period of slow and constant subsidence of the floor of the Appalachian Gulf in order that 7,000 or 8,000 feet of shallow-water deposits might accumulate therein.

The Marcellus sea was sparsely populated except by small pteropods (*Styliolina*), which were abundant. So was the Hamilton sea in central Pennsylvania, except near the end of its existence, when bryozoans and brachiopods flourished and many other forms were common. The inhabitants of the Portage sea were peculiar diminutive pelecypods and gastropods that seem to have lived in small numbers throughout the time and some larger and still less abundant cephalopods. The Chemung fauna was more abundant and the forms of life were larger, brachiopods and pelecypods predominating in number of species and individuals.

Before the beginning of Chemung deposition—in fact, soon after Hamilton time—the redbed facies of sedimentation began in southeastern New York with the deposition of the Oneonta sandstone. From this time onward the deposition of red rocks continued, being contemporaneous at first with the marine Portage, later with the Chemung, and at the end probably with early Mississippian deposits. Thus it happens that the redbed facies diminishes in thickness from the bottom upward as it extends westward, until it is represented in western Pennsylvania and New York by only a few hundred feet of rocks characterized by beds of red shale. As a whole, however, the redbed facies is best explained as a dry delta deposit extending from the Catskill Mountains to Maryland and West Virginia, the upper one-third or so of which is represented in western New York and northwestern Pennsylvania by prevailingly marine fossiliferous sediment in which are local red layers. In the Hollidaysburg and Huntingdon quadrangles the delta type of sediment predominates, but at times the western margin of the delta was submerged from the west and tongues of marine fossiliferous sediment were laid down.

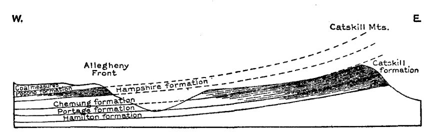


FIGURE 5.—Sketch section from the Catskill Mountains of New York to the Allegheny Front in Pennsylvania, showing the relations of the Hampshire and Catskill formations. The shading indicates red shale and red sandstone which diminish westward and rise into higher formations.

It is thought that the red sediment was derived from the highly oxidized residuum of deeply decayed crystalline rocks of a very old land surface such as exists today in parts of the Southern States. This land may have been in the Adirondacks or New England region. The gray shale and sandstone strata occurring at several horizons in the Hampshire and bearing a marine fauna as described above may have had a northwestern source or may have been derived from the same source as the red sediment and been bleached by the decaying organic matter of the marine water.

In the latter half of Devonian time two notable events in the history of the earth came to pass—land plants and primitive fish became fairly common, remains of which are present in the Hampshire of Pennsylvania.

CARBONIFEROUS PERIOD

In the Hollidaysburg-Huntingdon region sedimentation apparently went on continuously from the Devonian period into the Carboniferous. As the oldest Pocono seems to be of Burlington and Fern Glen age, this would imply that the Kinderhook is represented in the upper part of the Hampshire.

The distinguishing feature of the Carboniferous period, especially its later half, was the abundant vegetal growth, which supplied the material for coal. It was a time of warm climate and extensive marshes near sea level, in which plants of different kinds grew luxuriantly and on falling were covered by water and so preserved from decay in the same manner as vegetal débris is preserved in the peatbogs of the present day.

In this region the same oscillations between marine and nonmarine conditions as in the Hampshire persisted in at least the first half of Pocono time. Nonmarine conditions were fully established in the later part of the epoch, when the Burgoon sandstone member was laid down.

As the Loyalhanna limestone probably represents the Ste. Genevieve limestone, no representatives of Keokuk, Warsaw, Spergen, and St. Louis formations are present in this region, so there is an unrecorded interval of considerable length between the Burgoon and Loyalhanna epochs. The Loyalhanna limestone shows considerable resemblance to wind-blown deposits of oolite in the Bahama Islands and probably had a similar origin. The carbonate of lime may have been carried by wind from its source on the southwest into the probably very shallow waters of the Appalachian Gulf and widely distributed over the lowlands bordering the Mississippian sea on the east and mixed with quartz beach sand at the same time. The absence of fossils and the extreme cross-bedding indicate a partly terrestrial wind-blown origin.

The deposition of the prevailingly gray Pocono was succeeded by a third extensive deposition of redbeds, composing the Mauch Chunk formation. The conditions in Pennsylvania during Mauch Chunk time were unfavorable for invertebrate and plant life, for the formation contains no coal beds and shows little evidence of the presence of either plants or animals. At the same time, however, in western Pennsylvania and eastern Ohio, marine limestones and shales were being deposited upon a sea bottom thickly inhabited by marine invertebrates, whose fossil remains now crowd the Greenbrier limestone member of the Mauch Chunk of Pennsylvania and the contemporaneous Maxville limestone of Ohio.

After the deposition of the Mauch Chunk an unrecorded interval ensued in this region that was long enough for the deposition of 10,000 feet of rock, including many coal beds in the Pottsville troughs of Alabama. If these beds were present in this part of Pennsylvania, they would lie between the top of the Mauch Chunk and the bottom of the Pottsville bed as described below.

At the beginning of Pottsville deposition there was a sinking trough in eastern Pennsylvania extending southward, bordered by land, probably high around the north end and on the southeast, and by lowland on the northwest. From these lands the rapid streams brought in immense quantities of coarse material. This deposition of coarse material went on until 1,000 feet of strata, containing coal beds, was laid down in the southern anthracite field of Pennsylvania and 10,000 feet, containing many coal beds, in Alabama. While these masses of Pottsville sediments were accumulating the land from central Pennsylvania westward had been worn down nearly to sea level and then in the later part of Pottsville time it was submerged and sedimentation upon it was resumed. This sedimentation produced first the Connoquenessing sandstone—the lowest member of the Pottsville of these quadrangles.

Deposition continued from the Pottsville into the Allegheny epoch, which was marked by rapidly alternating conditions, and as a result shale, sandstone, limestone, and coal beds succeeded one another at short intervals. Practically all the coal in western Pennsylvania occurs in the Allegheny or in higher formations that do not now exist in these quadrangles. Deposition continued in the region at least through Conemaugh and Monongahela time, as indicated by the presence of rocks of those epochs in Broadtop Mountain, south of these quadrangles. No history of these quadrangles during Permian time, the final epoch of the Paleozoic era, has been preserved, but a considerable thickness of Permian rocks (Dunkard group) was deposited in the extreme southwest corner of the State, and probably Permian rocks were deposited in this region also.

MESOZOIC AND CENOZOIC ERAS

The Paleozoic era had been one of sedimentation in the Appalachian Valley and Appalachian Plateaus, during which a great series of rock formations was built up. The Mesozoic and Cenozoic, on the contrary, were eras of deformation and erosion. Very few and fragmentary records of the events of these eras have been preserved in the Appalachian region, although evidence that vast changes occurred is plainly to be seen. To a certain extent the history of the region can be inferred from records that persist in other parts of the country.

APPALACHIAN UPLIFT

The Dunkard epoch brought sedimentation in the north end of the Appalachian trough to a close, and a long series of events of a totally different kind began. So far as known, from the close of Carboniferous deposition until the present time dry land has existed in the north end of the Appalachian Valley, except in the areas occupied by the Triassic basins that existed from place to place from Connecticut to North Carolina. Uplift of the sea bottom was accompanied by strong deformation, by which the originally horizontal sedimentary strata of the Appalachian Valley were folded into high anticlines and deep synclines, and west of the Allegheny Front into the low anticlines and shallow synclines of the bituminous coal fields. This folding must have taken place in Mesozoic time because the youngest Paleozoic strata (Dunkard group) are involved in it. This profound change in the history of the region is known as the Appalachian revolution.

CYCLES OF EROSION

The wearing away of land by processes of erosion is ceaseless. If a region should cease to rise or the upward movement become very slow, the land would in time be worn down to a plain near to sea level. A surface thus reduced is called a peneplain. Should a second uplift occur, erosion would be renewed and as before would proceed faster on soft rocks, forming valleys, than on harder rocks, which would be left standing as ridges between valleys. The tops of these ridges would for a long time approximately coincide with the surface, now uplifted, of the old peneplain. Such cycles of erosion may be several times repeated and leave remnants of the successive peneplaned surfaces at accordant levels as a series of hill or ridge tops, or benches along the valley walls, or spurs extending out from them. With these broad principles of erosion in cycles as a clue some inferences as to post-Paleozoic history of this region can be drawn from the land forms now existing.

Kittatinny peneplain.—It is believed that during Triassic and Jurassic times the surface of the uplifted and folded Appalachian Valley was eroded, possibly more than once, to a peneplain. The first of these, if there was more than one in these periods, is called the Kittatinny peneplain, because remnants of it are well preserved on the flat tops of Kittatinny Mountain in eastern Pennsylvania. The crests of Dunning and Tussey Mountains and other hard sandstone ridges in Blair County and the crest of the Allegheny Front also approximately represent the uplifted surface of this peneplain.

Schooley peneplain.—After the uplift of the Kittatinny peneplain erosion produced a second peneplain, parts of which may be the summits at 1,500 to 1,800 feet above sea level on the eastern foothills of the Allegheny Front and possibly the conspicuous bench about 1,800 feet above sea level on the outcrop of the Oswego sandstone along the east side of Tussey Mountain and the west side of Lock and Dunning Mountains. This peneplain is correlated by some with the Schooley peneplain, developed on Schooley Mountain in northern New Jersey. It is believed that the Schooley peneplain was completed by the beginning of Upper Cretaceous time, for in New Jersey a remnant of what is supposed to be that peneplain extends seaward beneath deposits of Upper Cretaceous age. The Kittatinny peneplain then was completed in an earlier period, perhaps the Jurassic.

Harrisburg peneplain.—After the formation of the Schooley peneplain the region was again uplifted, erosion was renewed, and the broad, rolling area of Morrison Cove, now 1,200 to 1,400 feet above sea level, was developed. This area possibly represents the Harrisburg peneplain, well developed near Harrisburg, where its altitude is about 500 feet.

Post-Harrisburg erosion.—The Harrisburg peneplain is supposed to have been uplifted unequally, and modern stream valleys have been eroded below its surface in the later part of Tertiary time and to their present depths in Quaternary time.

Development of drainage features.—When something is known of the history of the region since the Appalachian revolution as outlined above, it is easy to understand the origin of such gaps through the ridges as McKee Gap, and the gap of Frankstown Branch of the Juniata at Point View. The streams that occupy these gaps took their courses on the nearly level surface of the Kittatinny peneplain, which was topographically above the tops of the ridges of the present day. During subsequent uplifts they maintained their courses and as the country rose eroded their beds to lower levels while the side streams wore down their valleys on the more easily erodible rocks between the harder strata of the ridges. Thus the streams have sawed, so to speak, the gorges through the ridges. Point View knob (pl. 2) was separated from the north end of Lock Mountain in this way.

GLACIAL EPOCH

In the Pleistocene epoch of the Quaternary period the northern and central parts of the United States were covered a number of times by great ice sheets from the Canadian highlands, but these did not reach the Hollidaysburg-Huntingdon region, the southern margin of the ice advance in Pennsylvania being 100 miles or so to the north.

RECENT EPOCH

In the Recent epoch of the Quaternary period the final sculpturing of the region to its present topographic aspect was effected, and the Recent deposits of alluvium were laid down along the lowlands bordering the streams.

PROGRESS OF LIFE

It is probable that the terrestrial plants and animals of Mesozoic and Cenozoic time, whose existence is recorded by their remains in the rocks of those eras along the Atlantic and Gulf coasts and in the Rocky Mountains, flourished in this region also. The cycads and ferns of the Triassic and Jurassic periods doubtless clothed the surface of the land and supplied nutriment to the great reptiles (dinosaurs) and the small mammals that, from tracks and skeletal remains found in Connecticut and North Carolina, are known to have been living in the region as early as Triassic time. Probably the kinds of fish characteristic of the times swam in the rivers and creeks of the region. But no vestige of this life remains, because all deposits in which any of the plants or animals could have been buried and preserved were later swept away in the general erosion of the region.

In the Cretaceous period great forests of deciduous trees must have grown in which must have roamed other forms of gigantic dinosaurs than those of Triassic or Jurassic time. In this period such common kinds of trees as the oak, willow, sassafras, and tulip tree (yellow poplar) first appeared upon the earth. All traces of these Cretaceous plants too, have been obliterated in this region, although their remains, especially leaves, are abundant in the Cretaceous deposits in New Jersey, Maryland, and Virginia, having been borne into the bordering Cretaceous seas by streams and winds. In Tertiary time many strange forms of mammals, known from their remains in the Rocky Mountains, probably inhabited this region also, and in Pleistocene time extinct animals whose remains are now found in the swamps, bogs, and caves of the region were the common denizens of the land. In a cave at Smith's quarry, half a mile west of Frankstown, Pa., were found remains of a tapir, a ground sloth (*Megalonyx*), two species of peccary, a bison, a mastodon, and a carnivore resembling the jaguar.[27] In a cave near Cumberland, Md., there have been found, among many species, a horse and an eland,[28] the latter now known only in Africa.

ECONOMIC GEOLOGY[29]

STONE

LIMESTONE

Limestone is a valuable resource of this region. Large quantities have been used for flux in the blast furnaces of Pittsburgh. Some is burned for lime, some used in the glass industry, and some for fertilizer. Five formations yield commercial rock—the Axemann limestone, Bellefonte dolomite, Carlim limestone, Lowville limestone, and Helderberg limestone (Keyser member).

Bellefonte dolomite.—The Bellefonte dolomite, quarried at the Clover Creek quarry, southeast of Williamsburg, is used for flux. About 50 feet at the top has been utilized. Its high percentage of magnesia unfits the rock for making cement. Some of the rock from the vicinity of Wertz has been used for back walls of furnaces. The composition of the rock is indicated by the following analyses:

Analyses of dolomite from Hollidaysburg-Huntingdon region

[Analyses by Cambria Steel Co.]

	1	2	3	4	5	6	7	8
$CaCO_3$	54.43	53.38	50.58	50.92	48.39	48.29	44–52	54–95.75
$MgCO_3$	38.20	41.84	41.08	41.52	40.86	41.43	35–42	.90–39.
Al_2O_3	1	.68	.72	.92	.88	1.06	.49–3.37	.40–2.25
SiO_2[a]	4.76	2.40	5.78	4.94	8.04	7.22	3.34–12.34	1.26–6.57
Fe_2O_3	.70	.70	.84	.70	.84	.98	------	------
S	------	------	------	------	------	------	.04	------
P	------	------	------	------	------	------	.03–.11	.003–.015
	99.09	99.00	99.00	99.00	99.01	98.98		

[a] Average SiO_2 from 31 analyses, 3.72.

1–6. Bottenfield farm, 2 miles southeast of Williamsburg.

7. Dolomite near Carlim. Extremes of a number of analyses.

8. Dolomite from Fox Hollow, 1 mile north of Carlim. Extremes of 31 analyses.

[27] Holland, W. J., Carnegie Mus. Annals, vol. 4, pp. 223–228, 1906–8.

[28] Gidley, J. W., U. S. Nat. Mus. Proc., vol. 46, pp. 93–102, 1913.

[29] This chapter was written about 1915. Present conditions differ in same particulars.

Axemann limestone.—The Axemann limestone has been quarried on a small scale by farmers and burned for agricultural lime.

Carlim and Lowville limestones.—All the large quarries of the region are opened on the Carlim and Lowville limestones, and the combined thickness of about 360 feet is generally quarried. The argillaceous and siliceous Lemont member in the top of the Carlim, unless quarried for ballast or road metal, is rejected.

The composition of these limestones differs from bed to bed, but the average content of insoluble matter for the entire thickness, excluding the Lemont member, is somewhat less than 5 percent. The following statement was given by the superintendent at the quarry:

Average composition of limestones in Blair No. 5 quarry, about 3 miles north of Carlim

Calcium carbonate ($CaCO_3$)	90.739
Alumina (Al_2O_3)	1.000
Silica (SiO_2)	3.75
Magnesium carbonate ($MgCO_3$)	4.50
Sulphur (S)	.009
Phosphorus (P)	.004
	100.002

The following analyses[30] show the composition of the limestone in a quarry at Franklin Forge (Ganister):

Analyses of Carlim and Lowville limestones at the quarry of St. Clair Limestone Co., at Franklin Forge

	1	2
Calcium carbonate ($CaCO_3$)	91.07	94.00
Magnesium carbonate ($MgCO_3$)	5.04	3.00
Iron and alumina (Fe_2O_3, Al_2O_3)	1.10	------
Silica (SiO_2)	4.20	2.00
Undetermined	------	1.00
	101.41	100.00

Samples that were taken from a quarry near Martinsburg, probably in the Carlim limestone, had the composition shown below:

Composition of Carlim limestone from quarry near Martinsburg

	1	2
Calcium carbonate ($CaCO_3$)	91.08	98.00
Magnesium carbonate ($MgCO_3$)	3.99	------
Iron and alumina (Fe_2O_3, Al_2O_3)	.86	------
Silica (SiO_2)	3.07	------
Other minerals	1.05	------
Undetermined	------	2.00
	100.05	100.00

1. Quarry of Isaac Campbell, Martinsburg.
2. Credited to John Manning, quarry in vicinity of Martinsburg.

Tonoloway limestone.—The top of the Tonoloway limestone east of Tussey Mountain is, locally at least, of good quality, as shown by analyses 3, 4, and 5 below of samples from the old Powell quarries.

Helderberg limestone.—The Helderberg has been largely quarried near Hollidaysburg, on the low curved ridge extending from Altoona past Duncansville and Newry to the vicinity of Canoe Creek, 6 miles northeast of Hollidaysburg. Its composition ranges from 90 to 98 percent of calcium carbonate, 0 to 5 percent of magnesium carbonate, about 5 percent of iron oxide, alumina, and silica, and a negligible quantity of sulphur and phosphorus.

If lime suitable for paper making or ground limestone for glass making is desired, only the "calico rock" at the base of the Keyser member is used. The "calico rock" and most of the rock for 50 feet below it (Tonoloway) has been quarried for flux a mile west of Canoe Creek. In the vicinity of Altoona the crystalline limestone above the "calico rock" is quarried for concrete and road metal, and at the Frankstown quarries it is burned for fertilizer lime.

The composition of the "calico rock" and adjacent beds is shown in the following tables, which were furnished by J. K. McLannahan:

Composition of samples taken from 34 feet of limestone, including the "calico rock" at old Reservoir quarry, about 1 mile southwest of Hollidaysburg

	1	2	3	4	5	6
$CaCO_3$	86.78	96.72	95.09	95.01	92.84	95.22
SiO_2	8.44	1.90	1.55	1.18	1.26	1.86
$MgCO_3$	.31	1.96	1.10	1.96	1.79	1.40
Al_2O_3	.81	.80	1.40	.53	2.91	.72
Fe_2O_3	.09	.12	.18	1.10	.15	.11

Mr. McLannahan states that the "calico rock" at the Reservoir quarry became so siliceous along the strike that the quarry had to be abandoned.

[30] Pennsylvania State Coll. Agr. Exper. Sta. Bull. 127, p. 79, 1913.

Composition of "calico rock" and beds above and below it at quarries near Hollidaysburg and Frankstown

	1	2	3	4	5
$CaCO_3$	88.34	89.10	92.07	96.70	96.06
SiO_2	9.28	3.16	3.40	2.60	2.06
$MgCO_3$	1.96	6.01	3.05	1.90	3.06
$Al_2O_3+Fe_2O_3$	.63	1.96	1.31	1.55	1.02
P				.004	.0046
S				.011	

1. First bed below "calico rock" at old Reservoir quarry.
2. Crystalline rock above "calico rock" at Frankstown quarries.
3. Bed immediately under "calico rock" at Frankstown quarries.
4. "Calico rock" at Frankstown. Cambria Steel Co., analyst.
5. Frankstown quarries, average of one year's shipment. Analysis by Mr. Johnson, of the Harmsworth Steel Co.

East of Tussey Mountain the lower 20 feet of the Helderberg and the upper 14½ feet of the Tonoloway limestone are of good quality as shown in the following table. The relations of these beds are shown in section 5 of the chart on page 8.

Composition of the lower beds of the Helderberg and upper beds of the Tonoloway limestone at the old Powell quarries at Grafton[a]

[Analyses by A. S. McCreath]

	1	2	3	4	5
$CaCO_3$	95.536	98.035	94.642	95.446	93.035
$MgCO_3$	1.589	.908	2.8	1.135	1.816
$Fe_2O_3+Al_2O_3$	.490	.410	.370	.520	.730
SiO_2, etc	1.851	.420	1.730	2.350	3.480
P	.011	.011	.006	.006	.006
	99.476	99.779	99.548	99.475	99.067

[a] Pennsylvania Second Geol. Survey Rept. T, p. 125, 1881.
1. From top of crinoidal layer.
2. From bottom of crinoidal layer.
3, 4, and 5. From 14½ feet of limestone just below "calico rock" and regarded as Tonoloway.

The limestone from the crinoidal bed is said to be preferred by blast-furnace operators to that of any of the other beds of the Helderberg and Tonoloway rock along Warriors Ridge. The "calico rock," however, makes the whitest lime.

Conditions that affect quarrying.—The quarry beds dip at angles ranging from 10° to vertical, but most of them dip more than 25°. Very favorable conditions exist for quarrying the Carlim and Lowville limestones along Clover Creek and Frankstown Branch east and northeast of Williamsburg and along Piney Creek south of Ganister. Here the quarry bottoms are located just above high-water level along the streams, and operations proceed horizontally. Some quarries begin on the end of the beds and proceed along the strike, as the quarry of the St. Clair Limestone Co. at Franklin Forge (Ganister), or operations may begin at the top of the beds and proceed against the dip to the bottom of the Carlim limestone, as in the St. Clair quarry, or deeper, if the Bellefonte dolomite is quarried, as on the west side of Clover Creek. (See pl. 25.) Quarrying may begin below the top of the quarry beds and proceed with the dip to a point where the Rodman limestone comes in at the top of the quarry face and makes further operations in that direction impracticable. This plan has been followed in the quarries on the west side of Piney Creek, where the beds dip 40° W. under Lock Mountain. (See pl. 26.)

When the rock available along the valleys has been quarried out, it will be necessary to open new quarries on the upland level, as near Martinsburg and around the south end of Lock and Loop Mountains, or to mine the rock down the dip below drainage level. The location and altitude of the outcrops of the Carlim and Lowville quarry beds in their undeveloped area are shown on the areal-geology map.

The outcrop of the Helderberg quarry rock is in general coincident with the crest of the ridge along the middle of the strip of Helderberg around the point of Brush Mountain, along the south side of Scotch Valley, and along Warriors Ridge east of Tussey Mountain.

GANISTER

Occurrence and composition.—An active industry of Blair County is the exploitation of the rock known as ganister, from which is made refractory brick for several kinds of furnace linings. The name ganister is derived from the German Ganster, meaning a spark, and is applied because the rock, which is very hard, will give a spark when struck with iron.

The ganister occurs as beds in the Tuscarora quartzite. Possibly the whole of the formation, 400 to 600 feet thick, may have the qualities of ganister. This formation extends through the mountain region of central Pennsylvania and makes the conspicuous ridges of which Tussey and Dunning Mountains are examples. Point View knob (pl. 2) shows well the mode of occurrence.

The ganister of Blair County and vicinity is a nearly pure silica rock, as shown by the table giving the results of analyses of samples from Lock Mountain near Point View. The data were furnished by Mr. J. D. Hartman, of Hollidaysburg.

The specific gravity of ganister ranges from 2.46 to 2.58. The Pennsylvania ganister is a compact light-gray to white quartzite with somewhat vitreous luster. It becomes more or

Analyses of ganister from Lock Mountain

[Isaac Reese & Sons Co., analyst]

	1	2	3	4	5	6	7
SiO_2	97.90	97.98	97.30	98.65	99.10	98.15	98.20
$Fe_2O_3+Al_2O_3$	.90	.95	1.20	.30	.60	1.20	1.35
CaO	.40	.25	.30	.25	None	None	None
MgO	.36	.29	.30	.30	Trace	Trace	Trace
Loss on ignition	.40	.50	.85	.45	.25	.20	.50

less iron stained after exposure to the weather or to water along joint planes. Microscopic examinations show that the rock was originally a quartz sandstone with well-rounded grains 0.1 to 0.3 millimeter in diameter, but additions of silica that are crystallographically continuous with the original grains now fill the interstices and cement the original sandstone to a compact quartzite.

Economic qualities.—There seems to be a difference of opinion as to the qualities of ganister that make it suitable for silica brick, although ordinary sandstone of the same composition is not suitable. Some think that brick from sandstone is less refractory than that from quartzite; others think that brick from sandstone will not stand handling before burning. Quartz from a loosely cemented sandstone should not fuse at a lower temperature than that from a compactly cemented quartzite like the ganister rock, so it appears probable that the suitability of the quartzite for brick is due to the superior strength that it gives. This difference in strength is due to the fact that the constituent grains of ganister, being firmly cemented together, do not separate in crushing, but the whole mass breaks up into angular fragments and slivers that can be pressed together into a cohering mass in molding and so make a brick that will not break easily in handling, whereas loosely cemented sandstone pulverizes more or less completely into its constituent rounded grains, which do not interlock in molding and so have but little coherence.

Ganister should contain but very small quantities of lime or iron, as their presence in larger quantities destroys the refractory quality of the brick. About 1.25 percent of iron oxide is said to be the maximum percentage allowable.

BUILDING STONE

Sandstones from the Juniata and Tuscarora formations and sandy limestone from the Shriver have been used for coarse masonry, and the red and brown sandstone of the Hampshire would probably be a good rock for this purpose. There does not appear to be any rock in the region suitable for superstructure or ornamental work.

ROAD METAL

The limestone, dolomite, and chert of the region furnish abundant road metal, and the Tuscarora quartzite has been used for paving blocks on some of the Altoona streets and appears to be durable.

IRON ORE

The iron ores of the region are now of historical rather than practical interest. Iron mining and smelting has been practically abandoned since 1880, and most of the furnaces had gone out of blast before that date. The iron ores are of two kinds—hematite or fossil ore, also called Clinton ore because it occurs in the Clinton formation, and limonite.

CLINTON OR FOSSIL ORE

Ore occurs at four distinct horizons in the Clinton of this region—the "block" or Levant ore, near the bottom; the Frankstown bed, about 250 feet above the bottom; lean ore bands associated with limestone and shale through a thickness of 15 to 20 feet, 200 feet or so above the Frankstown bed; and the Marklesburg bed, just beneath the Keefer sandstone member.

"Block" or Levant ore.—The "block" ore has been found only in a local pocket a mile or so northwest of Marklesburg, where from an oolitic bed nowhere more than 6 feet thick about 20,000 tons was mined by the Cambria Iron Co. The Old Powell mine, about 1 mile west of Foxton, where 5 to 6 feet of soft rich fossil ore is reported, was probably on this bed.

Frankstown ore.—The Frankstown is the only extensive bed in the Hollidaysburg region. It was formerly worked by the Cambria Iron Co. at the Frankstown slope, 1¼ miles northwest of Frankstown. According to Platt[31], who visited the mine before it closed, the Frankstown bed ranges from 8 to 22 inches in thickness and averages 15 to 16 inches. Its stratigraphic relations are shown in the following section taken from Platt:

Section of beds inclosing Frankstown ore bed near Frankstown

	Ft.	in.
8. Blue slate, fossiliferous, holding three small ore pins	40	
7. Upper bastard ore, sandy, fossiliferous, worthless; blue slate, "bearing-in" slate	2	
6. Frankstown ore bed, averaging	1	3
5. Slate holding two small ore pins		10
4. Chocolate-colored slate	20	
3. Slate?	130	
2. Slate and sandstone	50	
1. Keel iron ore, or hard fossil ore (Levant or "block" ore)	10±	

[31] Platt, Franklin, op. cit., pp. 137–152.

No. 1 is only a ferruginous sandstone here. The Frankstown ore is highly fossiliferous and slightly oolitic, the oolitic grains being flattened and generally of considerable size. It much resembles the Alabama Clinton ore. Its composition is shown in the following table:

Composition of the Frankstown ore

[Analyses by Cambria Iron Co.]

Peroxide of iron	61.27
Silica	6.46
Alumina	1.50
Protoxide of manganese	.95
Carbonate of calcium	19.02
Carbonate of magnesium	3.02
Phosphorus	.30
Sulphur	Trace
Water	.19
Metallic iron	47.15

The high lime content indicates hard, unweathered ore, and the metallic content shows a high grade for such an unweathered Clinton ore.

The part of the outcrop of the Frankstown bed that has been worked is at the south end of Brush Mountain. From this area in both directions the bed thins and becomes worthless. Along Brush Run north of Hollidaysburg the slopes are reported to have extended 400 feet west of the outcrop to a limit where the ore became too thin for profitable mining. The Frankstown mine produced a greater quantity of ore than any other, the output having reached 20,000 tons a year in the seventies. Platt reports the slope as 710 feet long and 218 feet deep in 1879 or 1880. Since then it has not been worked.

Marklesburg ore.—The Marklesburg ore bed, just under the Keefer sandstone, has been extensively mined in a narrow area beginning about 1 mile north of Marklesburg and extending northeastward to a point west of McConnellstown. The bed is a typical fossil ore 1 foot to 1½ feet thick. The following section was furnished by the operator of a small mine 1 mile north of Marklesburg:

Section of the Marklesburg ore near Marklesburg

	Ft.	in.
Sandstone, cap rock (Keefer sandstone member)	9	
Ore	1	6–8
Ocher; mining bench		4
Shale	9	
Shale and soft ore in alternating layers, 3 inches thick, in some mines a layer of soft ore that may be 10 inches thick	3	
Shale (No. 10 of section, p. 6)	600±	

The ore probably carries a small content of calcium carbonate in the unweathered condition, limy (hard) ore having been encountered in places. Most of the ore mined, however, is leached, soft, of spongy texture and spangled throughout with small particles said to be specular hematite.

LIMONITE OR BROWN HEMATITE ORE

A full and satisfactory account of the deposits of limonite or brown hematite was given by Platt.[32] The principal old workings were the Springfield mines, at Oreminea; the Bloomfield mines, at Ore Hill; the Henrietta mine, at Henrietta; the Millerstown red-ore bank; and the Rebecca mines, near Rebecca Furnace.

Springfield mines.—The main pits at Oreminea are on the Gatesburg formation. The ore occurred partly as lumps in a residual mass of clay, sand, and sandstone fragments more than 200 feet deep, inclosed by rock walls on the north, east, and west. On the bottom was a layer 6 feet thick of ore in lumps and blocks embedded in clay. Most of this material was passed through the washer. Some of the ore was of excellent grade. The following analyses show its composition:

Composition of limonite from the old Springfield mines[a]

[Analyses by A. S. McCreath]

	1	2	3	4
Bisulphide of iron			0.004	0.024
Sesquioxide of iron	52.428	73.714	84.428	78.143
Sesquioxide of manganese	1.344	.610	.368	.103
Oxide of cobalt			Trace	Trace
Alumina	2.042	1.979	2.617	2.146
Lime	Trace	Trace	.070	.030
Magnesia	.129	.309	.227	.493
Sulphuric acid	.075	.072	.237	.147
Phosphoric acid	.080	.137	.123	.137
Water	9.375	10.510	8.672	11.886
Insoluble residue	34.700	12.260	3.460	6.845
Metallic iron	36.700	51.600	59.100	54.710
Metallic manganese	.936	.425	.256	.072
Sulphur	.030	.029	.096	.072
Phosphorus	.035	.060	.054	.060

[a] Pennsylvania Second Geol. Survey Rept. T, p. 173, 1881.
1. Mine No. 1, wash ore.
2. Mine No. 2, wash ore.
3. Mine No. 2, bombshell ore.
4. Mine No. 3, wash ore.

The samples analyzed, except No. 3, were taken from the washer and represent the ore as it went to the furnace.

Bloomfield mines.—The Bloomfield mines, on the ridge south of Ore Hill, like the Springfield mines, are on the Gatesburg formation. The ore is in all respects similar to that at Spring-

[32] Platt, Franklin, op. cit., pp. 153–246.

field. The ore-bearing residuum extends over a space 7,200 feet long and 1,000 to 1,500 feet wide, and the known depth is more than 200 feet. The deposit is clearly in a deep rock depression bordered on the north, west, and south and perhaps on the east also by rock walls. The Bloomfield ores average, according to analyses published by Platt,[33] from 32 to 55 percent metallic iron, and are very low in phosphorus. Manganiferous ore, used to some extent for spiegel iron, occurs in places. A specimen analyzed by McCreath had the following composition:

Analysis of manganiferous ore from Bloomfield mines

Iron	22.700
Manganese	37.611
Sulphur	.018
Phosphorus	.043
Alumina	.144
Lime	.470

Millerstown ore bank.—The Millerstown or red-ore bank, on the Bellefonte dolomite about 1 mile north of Henrietta, occupied a generally shallow pit, but according to report shafts were sunk more than 100 feet without striking rock, although around the borders of the workings the rock is only a few feet below the surface. The ore, a dark-brown limonite, is coated with brown clay, from which it was called red ore. A specimen analyzed by McCreath contained 54 percent of metallic iron.

Henrietta mine.—The mine at Henrietta was an open cut 600 feet long, 200 feet wide, and 60 feet deep, mainly in Nittany dolomite near the east Henrietta fault, along which the Nittany is in contact with the Reedsville shale. The deposit probably occupied a solution trough in the dolomite on the west side of the fault. It consisted of clay and ore, without sand, sandstone, or chert. The ore is stained black in the upper part and is called black ore. Some manganiferous ore was present. The average composition of washed ore from the depth of 50 feet is shown in the table below:

Composition of the Henrietta iron ore

[Analysis by A. S. McCreath]

Sesquioxide of iron	60.000
Sesquioxide of manganese	3.517
Alumina	2.321
Lime	.270
Magnesia	.398
Sulphuric acid	.162
Phosphoric acid	.822
Water	11.131
Insoluble residue	20.590
	99.211
Metallic iron	42.00
Metallic manganese	2.449
Sulphur	.065
Phosphorus	.359

Other mines.—Deposits of limonite, apparently small, are associated with the Trough Creek limestone member at the bottom of the Mauch Chunk formation in Trough Creek Valley. Ore of good quality was seen at a point 1 mile southwest of Calvin. There is some manganiferous ore at the base of the east slope of Terrace Mountain, 1 mile north-northwest of Round Mountain, supposed to be the source of the manganiferous ores used at the old Patterson Furnace, near by. The old workings extended over an area of but a few acres, and the depth to the top of the Burgoon sandstone member of the Pocono formation is probably only 2 to 10 feet.

Origin of the deposits.—From their occurrence in deep depressions in the rocks and from the intermixture of sand, clay, and ore it seems probable that the deposits are residual masses that accumulated where found, during a long period of denudation. It appears probable also that the present rock basins holding the deposits are old sinks or caves that have gradually silted up after their outlets were clogged. The sinks may have been in former times foci of drainage for considerable areas, from which the clay, sand, and ore were collected. The materials were rudely assorted, and the iron was more or less disseminated through them. Subsequently the ore was concentrated by segregation within the clay. It is of interest to note that in England are extensive deposits of similar manner of occurrence in what are called "swallow holes."

COAL

A small synclinal area of less than a square mile at the north end of Rocky Ridge, in the southeast corner of the Huntingdon quadrangle, contains three workable coal beds in the Allegheny formation, as shown below.

	Ft.	in.
Not exposed.		
Coal, Dudley (Lower Freeport?)	4	8
Not exposed	100±	
Coal, Barnett (Lower Kittanning)	3	6
Not exposed	45	
Coal, Fulton (Clarion)	6	
Not exposed, about	30	
Sandstone, Pottsville	189	

Sections at other localities in the Broadtop Mountain field, published by Gardner,[34] show that most of the rock that lies between the coal beds is shale. The coal from the Fulton and Barnett beds is lustrous and soft and has a prismatic cleavage.

[33] Platt, Franklin, op. cit., pp. 214–218.

[34] Gardner, James, Pennsylvania Top. and Geol. Survey Comm. Rept. 10, p. 25, 1913.

Coals from these beds farther south in the Broadtop field are shown by analyses to be of semibituminous grade. Apparently the small area of the Allegheny formation in the northwest corner of the Hollidaysburg quadrangle includes very little if any coal.

CLAY AND SHALE

Clays occurring with the deposits of iron ore described above are utilized for making fire brick, converter linings, and saggers for pottery works. Their origin and mode of occurrence have been already described in connection with the ore deposits at Oreminea and Ore Hill. (See pl. 27.) Their composition is shown below.

Composition of clay mined at Oreminea

[Average of 4 analyses. Authority, J. K. McLannahan, Jr.]

Silica	59.275
Alumina	28.875
Ferric oxide	1.425
Lime	.035
Magnesia	Trace
Water (combined)	9.65
	99.260

The deposits of clay are too irregular in thickness and areal extent to permit any reliable estimates of quantity. The main bodies so far as known are at Ore Hill, Oreminea, and the old Rebecca mine. Clay has been shipped from the deposits at Ore Hill and Oreminea to Pittsburgh for making brick and to east Liverpool, Ohio, for making saggers. Shale from South Altoona and Eldorado has been used to make common brick. At south Altoona shale from the Marcellus and the lower part of the Hamilton formation, together with the overlying 10 to 12 feet of creek wash—clay, sand, and gravel—was used. The shale and overburden were mixed in equal parts. At Eldorado 200 feet of soft drab or brown shale of the Harrell above the Burket black shale member as well as the basal 100 feet of green sandy Brallier shale immediately overlying the Harrell shale, was utilized. The product is a strong common brick that is sold in the surrounding country.

SAND

Deposits of sand suitable for mortar and cement are common in the areas underlain by the Gatesburg formation. At an old pit half a mile southwest of Williamsburg the sand is 30 feet thick, and there is much sand on the surface of the ridges at Ore Hill, Oreminea, and Henrietta. Sand occurs throughout the iron ore bearing deposits, and a little has been taken out at Ore Hill and Henrietta. The Ridgeley sandstone of the Oriskany group, being in part calcareous and generally loosely cemented, yields much loose sand on its outcrop, and being soft and friable is also readily reduced to sand by crushing. On Warriors Ridge the Ridgeley is about 100 feet thick and is favorably situated for quarrying. Sand quarries at Brumbaugh and Aitch have been worked on a considerable scale. At Mapleton, a few miles southeast of Huntingdon, the Ridgeley is a valuable source of glass sand. The flood-plain deposits along Frankstown Branch near and north of Reese supply a good molding sand, utilized largely in the car-wheel foundries of the Pennsylvania Railroad at Altoona.

SOIL

The soil of much of the Hollidaysburg and Huntingdon quadrangles is residual—that is, it has been derived from the subjacent rocks by disintegration during the long course of weathering to which they have been subjected. On the limestone areas the soil is the insoluble residue from limestone and dolomite, the calcium and magnesium carbonates having been removed by solution. Some of the soils are colluvial—that is, they are a mixture of soils from different rock formations. Thus, on the slopes of the ridges rock waste from the higher part has been washed downward upon the lower part of the slopes occupied by different rock formations. In places along the west base of Tussey Mountain, for example, the clay soil of the Ordovician limestones and dolomites on the lower slopes is mixed with clay and sand from the Reedsville, Oswego, Juniata, and Tuscarora formations cropping out on the higher parts of the mountain.

According to the classification and nomenclature of the Bureau of Soils,[35] the soils of the quadrangles include five kinds—the Morrison, Hagerstown, De Kalb, Upshur, and Holston. The Holston is a colluvial soil. The Morrison soil covers the ridges underlain by the Gatesburg formation. It is described as consisting of 6 to 12 inches of sandy or clayey loam with reddish or yellowish sandy and clayey subsoil, generally low in humus and water. It is little cultivated but bears a good growth of timber.

The Hagerstown is a limestone soil overlying the limestone and dolomite formations of Morrison Cove, except the areas of the Gatesburg, and overlying the Helderberg and Tonoloway limestones outside of Morrison Cove. The soil is essentially a clayey loam of tawny color, 6 to 10 inches thick, with a stiff clayey subsoil of uneven thickness, in most places 3 to 6 feet, resting upon limestone. In areas underlain by the Nittany and

[35] A reconnaissance soil survey of south-central Pennsylvania, U. S. Dept. Agr. Bur. Soils, 1912.

Bellefonte dolomites much chert in large boulders and smaller fragments is scattered over and mixed through the soil. Although derived from limestone and dolomite this soil is deficient in lime, which has been removed by solution. It holds water well and except the Holston is the most productive soil of the quadrangles; corn, wheat, grass, and clover are the principal crops grown on it.

The De Kalb soil covers the areas of the Tuscarora, Clinton, Wills Creek, Oriskany, Hamilton, Portage, Chemung, and Pocono formations, a total area greater than that occupied by any other soil. Except in the areas of the Tuscarora and the Ridgeley, the soil is predominantly a gray clay loam, including smaller areas of silt loam and sandy loam, with or without slabby fragments of sandstone, which are abundant in places. The soil is 6 to 10 inches thick; the subsoil in most places is a hard, tenacious clay or sandy clay with abundant shale and sandstone fragments. The soil of the Ridgeley and Burgoon sandstone areas is sandy. The east slope of Warriors Ridge and The Barrens of the Trough Creek Valley have soil of this type. Soil of the Tuscarora quartzite ridges is sandy and full of or covered with boulders and in places destitute of vegetation. The De Kalb areas, where arable, produce good crops of cereals and grass and are good grazing lands.

The Upshur soil is the red soil of the red shale and sandstone formations—the Juniata, Hampshire, and Mauch Chunk. Very little of the Juniata area is arable. The Upshur is a clay, silt, or sandy red loam 6 to 12 inches thick and is likely to contain many fragments of red shale. It appears to grade generally into a clay subsoil at the depth of 2 to 3 feet. Where arable it is productive, bearing good crops of cereals, grass, potatoes, and fruit. The Mauch Chunk soil of the Trough Creek Valley is especially productive naturally.

The colluvial soil known as the Holston soil is that upon the flood plains of the streams, mapped and described as alluvium, and consists of the finer material from many original sources deposited from suspension in the stream waters as they have overflowed their banks. It is a brownish sandy loam of considerable depth. Here and there it may contain a little gravel. Owing to its manner of origin it is the most fertile and most easily tilled of the several soils. The market-gardening areas from Altoona to East Freedom are on Holston soil.

WATER RESOURCES

Surface water.—The mean annual precipitation of the region is approximately 40 inches. The large and medium-sized streams maintain a moderate flow even in times of drought. Stream-gaging stations are maintained on Raystown Branch of Juniata River at Saxton, on Great Trough Creek near Marklesburg, and on Standing Stone Creek near Huntingdon.[36] The streams in or heading in Morrison Cove are fed by springs and are to a large extent independent of the weather. These streams, too, maintain the water in Frankstown Branch of the Juniata River. There is an abundant and reliable supply of water for the present industrial needs of the region. Hollidaysburg and Altoona obtain their public water supply from Blair Gap Run and Burgoon Run, perennial streams of excellent soft water, which head upon the forested Allegheny Front. Roaring Spring, Martinsburg, and Williamsburg obtain their water from springs and natural drainage upon the sides of Tussey, Dunning, and Loop Mountains that face Morrison Cove.

Ground water.—Water for household use can be had almost anywhere in the area from shallow dug wells. Drilled wells also are numerous, and most of the new wells put down are of this type. The water-bearing formations that appear to be most productive for drilled wells are the Cambrian and Ordovician limestones and dolomites, the Clinton formation, Cayuga group, Helderberg limestone, Shriver limestone, and Ridgeley sandstone. Two wells at Hollidaysburg and three at Huntingdon have a small natural flow.[37] It is possible that additional flowing wells could be obtained at Huntingdon. Structure favorable for an artesian basin exists in the Broadtop syncline, in Trough Creek Valley, where the Burgoon sandstone member of the Pocono formation crops out in large catchment areas on both sides and dips beneath the impermeable Mauch Chunk shales in the bottom of the valley. In this basin flowing wells might be obtained at depths less than 1,000 feet.

At Williamsburg and Roaring Spring there are large springs; that at Williamsburg issues from beneath the Gatesburg dolomite, and that at Roaring Spring from the Nittany dolomite. The main source of the great volume of water in both is probably the Gatesburg formation, which crops out to the south of

[36] Discharge records have been given yearly in the Geological Survey Water-Supply Papers, "Surface water supply of the United States, part 1, North Atlantic slope basins," as follows: Raystown Branch of Juniata River at Saxton, October 1918 to September 1921 and October 1931 to date; Great Trough Creek near Marklesburg, October 1931 to date; and Standing Stone Creek near Huntingdon, October 1931 to date. Records are given also in reports of the Pennsylvania Department of Forests and Waters for Raystown Branch, August 1911 to date; Great Trough Creek, January 1930 to date; and Standing Stone Creek, October 1929 to date.

[37] For further information see Lohman, S. W., Ground water in south-central Pennsylvania: Pennsylvania Geological Survey, 4th ser., Bull. W 5, 1938. This report contains a description of Blair and Huntingdon Counties and includes tables of wells for each county and a map showing the locations of the wells.

each. These outcrop areas are deeply covered with coarse sand, which acts as a natural reservoir for the water falling upon it, and the formation itself is composed of rather open-textured dolomite and sandstone, through which the water finds an easy passage. The Big Springs at Williamsburg are reported to yield more than 4,000 gallons a minute, and Roaring Spring about 5,500 gallons a minute. These springs supply paper mills at Williamsburg and Roaring Spring. Another spring at Royer, which issues from the Bellefonte dolomite, has an estimated yield of 1,500 gallons a minute. Small springs are extensively used for domestic supplies, particularly in some of the valleys that are bordered by high ridges.

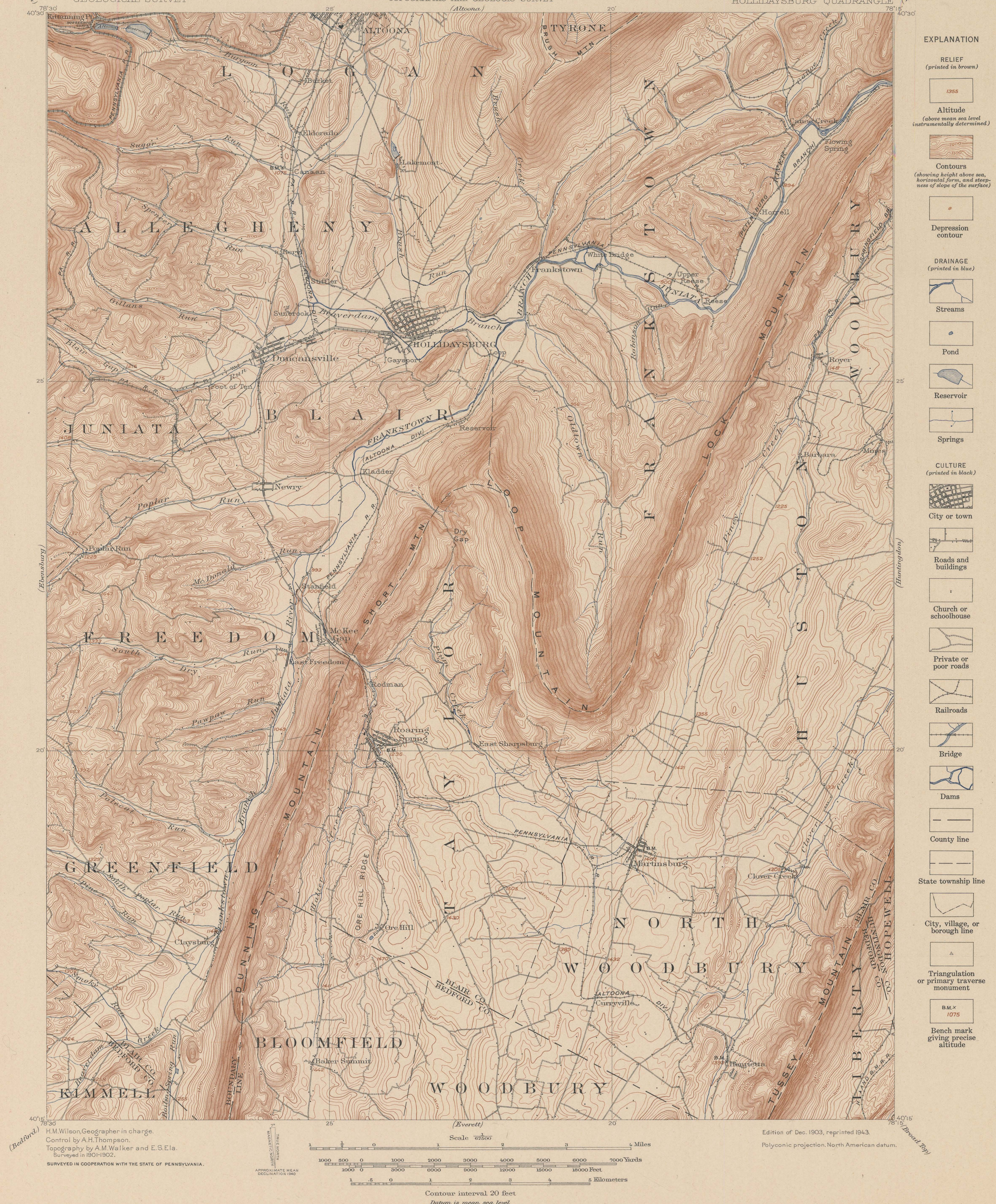
Most of the water from wells and springs is of good quality, but some of the limestone waters, especially from the Cayuga group, are too hard for use in boilers.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TOPOGRAPHY

STATE OF PENNSYLVANIA
REPRESENTED BY THE
DEPARTMENT OF INTERNAL AFFAIRS
TOPOGRAPHIC AND GEOLOGIC SURVEY

PENNSYLVANIA
HOLLIDAYSBURG QUADRANGLE



H.M.Wilson, Geographer in charge.
Control by A.H.Thompson.
Topography by A.M.Walker and E.S.Ela.
Surveyed in 1901-1902.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

APPROXIMATE MEAN DECLINATION 1940

Scale $\frac{1}{62500}$

Contour interval 20 feet
Datum is mean sea level

1945

Edition of Dec. 1903, reprinted 1943.
Polyconic projection. North American datum.

AREAL GEOLOGY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF PENNSYLVANIA
REPRESENTED BY THE
DEPARTMENT OF INTERNAL AFFAIRS
TOPOGRAPHIC AND GEOLOGIC SURVEY

PENNSYLVANIA
HOLLIDAYSBURG QUADRANGLE

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY — Recent

Qal — **Alluvium**
(*silt, sand, and gravel constituting the flood plains of present streams*)

CARBONIFEROUS — Pennsylvanian

lk, Ca — **Allegheny formation**
(*shale and sandstone with beds of coal and clay;* lk, *Lower Kittanning coal bed shown by blue line*)

Cpv — **Pottsville formation**
(*sandstone, conglomerate, shale, and coal; Homewood sandstone member at top; Mercer shale member in middle; Connoquenessing sandstone member, coarse, thick-bedded sandstone and conglomerate, at bottom*)

UNCONFORMITY

CARBONIFEROUS — Mississippian

Cmc — **Mauch Chunk formation**
(*upper part mostly red shale and some green; lower part thick-bedded green sandstone*)

Cl — **Loyalhanna limestone**
(*siliceous limestone weathering to highly pitted and strongly cross-bedded sandstone*)

Cb, Cpo — **Pocono formation**
(*lower part red, gray, and olive-green shale with gray sandstone layers; Burgoon sandstone member,* Cb *at top, underlain by Patton shale member, sparingly fossiliferous*)

DEVONIAN — Upper Devonian

Dha — **Hampshire formation**
(*predominantly red lumpy shale or mud rock and red sandstone; some gray and green shale and sandstone*)

Dsx, Dch — **Chemung formation**
(*chiefly green, gray, and chocolate-colored shale and thin beds of argillaceous fine-grained sandstone; fossiliferous throughout; includes Saxton conglomerate member,* Dsx *; upper part largely chocolate-colored*)

Portage group

Db — **Brallier shale**
(*micaceous, siliceous slaty green shale with some thin beds of fine-grained sandstone; sparsely fossiliferous throughout, mainly pelecypods of Gardeau type*)

Dhr, Dbk — **Harrell shale**
(*soft gray shale in upper part; Burket black shale member,* Dbk *, in lower part; highly fossiliferous, small pelecypods and cephalopods of the Naples fauna*)

DEVONIAN — Middle Devonian

Dh — **Hamilton formation**
(*principally olive-green shale with even-layered blocky-jointed sandstone and thin limestone at top; ridge-making sandstone at two horizons; sparingly fossiliferous; locally a foot or two of limestone at top with Tully fauna*)

Dm — **Marcellus shale**
(*black fissile clay shale, grading upward into olive-green shale*)

Do — **Onondaga formation**
(*gray shale, probably calcareous, and thin argillaceous limestone*)

DEVONIAN — Lower Devonian

Oriskany group

Dr — **Ridgeley sandstone**
(*thick-bedded calcareous sandstone weathering to coarse friable sandstone; locally a fine conglomerate at top with quartz pebbles; highly fossiliferous*)

Ds — **Shriver limestone**
(*thin-bedded siliceous limestone, weathering to fine-grained sandstone; black calcareous shale at bottom; sparingly fossiliferous*)

Dhb — **Helderberg limestone**
(*lower part is thick-bedded gray limestone with thin gray chert at top, chiefly Keyser limestone member; overlying Coeymans and New Scotland limestone members thin and locally absent; contains valuable quarry rock, called "calico rock"; fossiliferous throughout*)

SILURIAN — Cayuga group

Stw — **Tonoloway limestone**
(*thin-bedded finely laminated dark limestone; sparingly fossiliferous, chiefly Leperditia*)

Swc — **Wills Creek shale**
(*chiefly gray calcareous shale and some greenish limestone; fossils scarce*)

Sb — **Bloomsburg redbeds**
(*lumpy red shale and thick-bedded ridge-making red sandstone*)

Smk — **McKenzie formation**
(*blue thin-bedded fossiliferous limestone and soft gray and green shale; thin red shale east of Tussey Mountain and a little red shale west of Lock Mountain*)

SILURIAN — Niagara group

Sk, Sc, Scs — **Clinton formation**
(*mainly green and blue shale, weathering purplish, and thin fine-grained green sandstone in middle; Keefer sandstone member,* Sk *, near top; shale with thin limestone layers above Keefer sandstone member represent Rochester shale; Marklesburg iron-ore bed just beneath Keefer sandstone member; Frankstown iron-ore bed in lower half; hard quartzitic sandstone, red sandstone, and Levant Block iron ore,* Scs *at base; generally fossiliferous*)

St — **Tuscarora quartzite**
(*hard white quartzite and sandstone, largely thick-bedded; quartzite extensively quarried for ganister; contains scolithus worm tubes and Arthrophycus at top*)

EXPLANATION

CONTINUED

ORDOVICIAN — Upper Ordovician

Oj — **Juniata formation**
(*chiefly red and some green fine-grained cross-bedded sandstone and red lumpy mud rock; nonfossiliferous*)

Oo — **Oswego sandstone**
(*gray fine-grained thick-bedded cross-laminated sandstone; contains a few small quartz pebbles in lower part; nonfossiliferous*)

Orv — **Reedsville shale**
(*chiefly olive-green shale, weathering to small slivers, upper part containing argillaceous and ferruginous limestone layers; thick-bedded dark sandstone with abundant brachiopods of the Orthorhyncula zone at top, and a few feet of black shale containing graptolites at base*)

ORDOVICIAN — Middle Ordovician

Ot — **Trenton limestone**
(*thin-bedded black argillaceous limestone weathering to small flat residual pieces; sparsely fossiliferous*)

Black River group

Or — **Rodman limestone**
(*thick- and thin-bedded dark crystalline limestone, weathering granular; fossiliferous*)

Ol — **Lowville limestone**
(*thick-bedded dark, fine, even-grained limestone, with conchoidal fracture; mostly high-grade limestone, the upper quarry rock*)

UNCONFORMITY

ORDOVICIAN — Lower Ordovician

Oc — **Carlim limestone**
(*thick-bedded, mainly fine-grained dark limestone, the lower quarry rock; sparsely fossiliferous; Lemont argillaceous limestone member, generally highly fossiliferous (Maclurea magna zone) at top, and separating the two quarry beds*)

UNCONFORMITY

Beekmantown group

Ob — **Bellefonte dolomite**
(*dark fine-grained dolomite, thick-bedded in lower part, dark shaly layers in upper part; contains heavy chert locally; sparingly fossiliferous*)

Oa — **Axemann limestone**
(*thin-bedded blue limestone with a few dolomite layers; abundantly fossiliferous*)

On — **Nittany dolomite**
(*thick-bedded light-gray fine-grained dolomite with some chert layers which weather to heavy chert at surface; chert commonly fossiliferous; a thin limestone, possibly Stonehenge, present near and southeast of Ore Hill*)

Ola — **Larke dolomite**
(*chiefly thick-bedded dark-blue coarsely crystalline dolomite, generally without chert but locally yields some chert at the surface; lower part is light-gray, fine-grained, and thinly banded by siliceous laminae that weather in relief; sparsely fossiliferous*)

Om — **Mines dolomite**
(*coarse and fine grained blue dolomite, largely oolitic; on weathering gives rise to great quantity of irregular platy scoriaceous chert, much of which is silicified oolite with black grains and contains two species of Cryptozoon*)

CAMBRIAN — Upper Cambrian

€o, €g, €s — **Gatesburg formation**
(*chiefly thick-bedded blue coarsely crystalline dolomite, with many layers of sandstone up to 10 feet thick; Stacy dolomite member,* €s *, free of sandstone, at base; Ore Hill limestone member,* €o *, which contains rare trilobites, in middle*)

€w — **Warrior limestone**
(*thin-bedded blue fine-grained magnesian limestone with shaly partings; some layers contain abundant rounded quartz grains; sparingly fossiliferous, including Cryptozoon and trilobites*)

CAMBRIAN — Middle Cambrian

€ph — **Pleasant Hill limestone**
(*lower part argillaceous thin-bedded limestone weathering to shale; upper part pure thick-bedded dark limestone; contains trilobites, brachiopods, and Hyolithus*)

CAMBRIAN — Lower Cambrian

€wb — **Waynesboro formation**
(*yellowish arkosic sandstone, fine quartz conglomerate, red and green shale, and calcareous sandstone; contains Hyolithus and trilobites*)

Known fault

Probable fault

Concealed fault
(*covered by younger deposits*)

T, *Overthrust side of thrust fault*

35° *Strike and dip of stratified rocks*

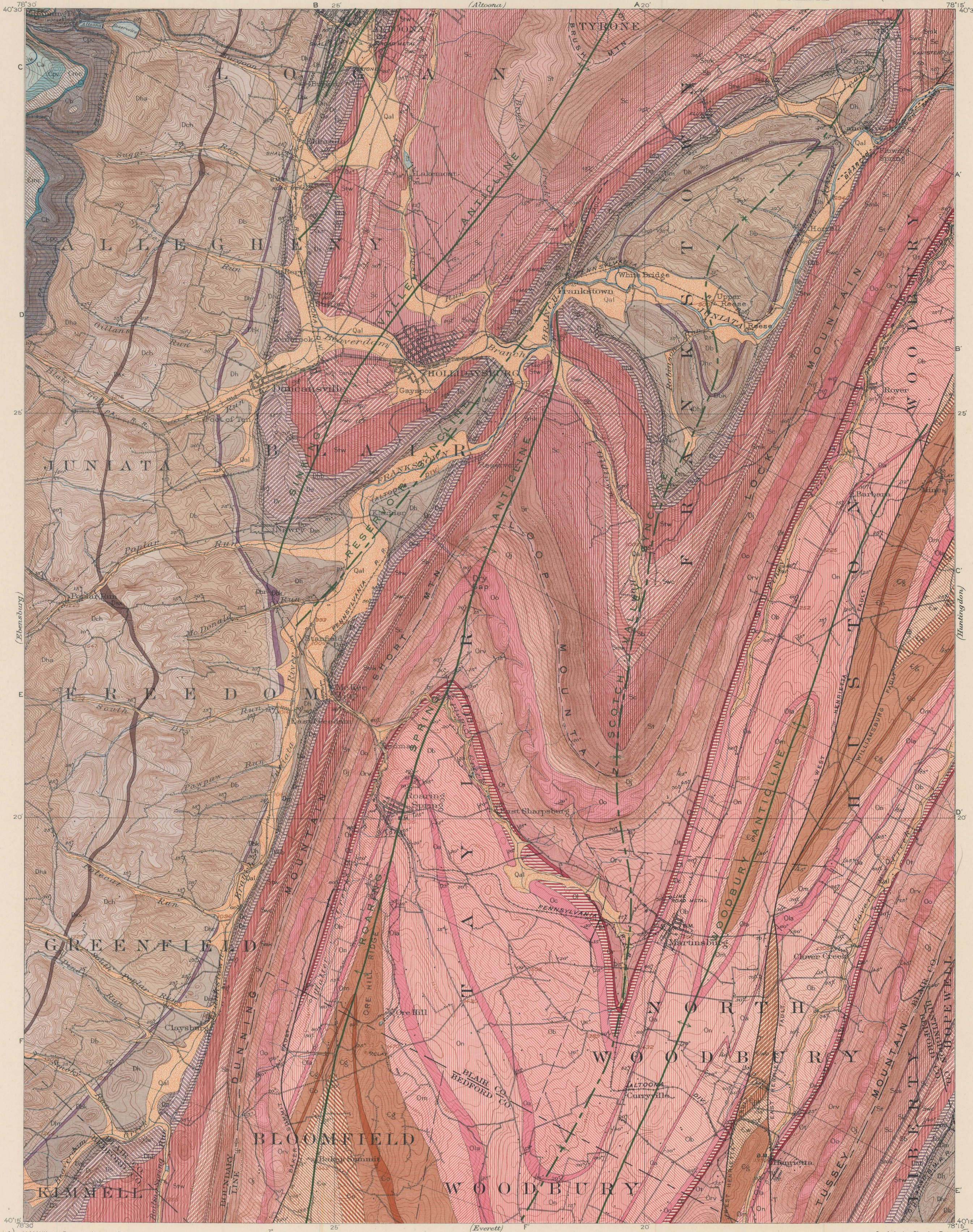
Strike of vertical beds

⊕ *Horizontal beds*

⚒ *Quarry*

Axis of anticline

Axis of syncline



H.M.Wilson, Geographer in charge.
Control by A.H.Thompson.
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Surveyed in 1901-1902.

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TRUE NORTH
MAGNETIC NORTH
7°
APPROXIMATE MEAN DECLINATION 1940

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards

1000 0 3000 6000 9000 12000 15000 18000 Feet

1 .5 0 1 2 3 4 5 Kilometers

Contour interval 20 feet
Datum is mean sea level
Edition of December 1945

Geology by Charles Butts.
Surveyed in 1908.

EXPLANATION

SEDIMENTARY ROCKS

SHEET SYMBOL — SECTION SYMBOL

QUATERNARY

Recent

Qal — **Alluvium**
(*silt, sand, and gravel constituting the flood plains of present streams*)

CARBONIFEROUS

Pennsylvanian

Ca — **Allegheny formation**
(*shale and sandstone with beds of coal and clay*)

Cpv — **Pottsville formation**
(*sandstone, conglomerate, shale, and coal; Homewood sandstone member at top; Mercer shale member in middle; Connoquenessing sandstone member, coarse, thick-bedded sandstone and conglomerate, at bottom*)

UNCONFORMITY

Mississippian

Cmc — **Mauch Chunk formation**
(*upper part mostly red shale and some green; lower part thick-bedded green sandstone*)

Cl — **Loyalhanna limestone**
(*siliceous limestone weathering to highly pitted and strongly cross-bedded sandstone*)

Cb, Cpo — **Pocono formation**
(*lower part red, gray, and olive-green shale with gray sandstone layers; Burgoon sandstone member,* Cb *at top, underlain by Patton shale member, sparingly fossiliferous*)

DEVONIAN

Upper Devonian

Dha — **Hampshire formation**
(*predominantly red lumpy shale or mud rock and red sandstone; some gray and green shale and sandstone*)

Dsx, Dch — **Chemung formation**
(*chiefly green, gray, and chocolate-colored shale and thin beds of argillaceous fine-grained sandstone; fossiliferous throughout; includes Saxton conglomerate member,* Dsx *; upper part largely chocolate-colored*)

Portage group

Db — **Brallier shale**
(*micaceous, siliceous slaty green shale with some thin beds of fine-grained sandstone; sparsely fossiliferous throughout, mainly pelecypods of Gardeau type*)

Dhr, Dbk — **Harrell shale**
(*soft gray shale in upper part; Burket black shale member,* Dbk *, in lower part; highly fossiliferous, small pelecypods and cephalopods of the Naples fauna*)

Middle Devonian

Dh — **Hamilton formation**
(*principally olive-green shale with even-layered blocky-jointed sandstone and thin limestone at top; ridge-making sandstone at two horizons; sparingly fossiliferous; locally a foot or two of limestone at top with Tully fauna*)

Dm — **Marcellus shale**
(*black fissile clay shale, grading upward into olive-green shale*)

Do — **Onondaga formation**
(*gray shale, probably calcareous, and thin argillaceous limestone*)

Lower Devonian

Oriskany group

Dr — **Ridgeley sandstone**
(*thick-bedded calcareous sandstone weathering to coarse friable sandstone; locally a fine conglomerate at top with quartz pebbles; highly fossiliferous*)

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(*lower part is thick-bedded gray limestone with thin gray chert at top, chiefly Keyser limestone member; overlying Coeymans and New Scotland limestone members thin and locally absent; contains valuable quarry rock, called "calico rock"; fossiliferous throughout*)

SILURIAN

Cayuga group

Stw — **Tonoloway limestone**
(*thin-bedded finely laminated dark limestone; sparingly fossiliferous, chiefly Leperditia*)

Swc — **Wills Creek shale**
(*chiefly gray calcareous shale and some greenish limestone; fossils scarce*)

Sb — **Bloomsburg redbeds**
(*lumpy red shale and thick-bedded ridge-making red sandstone*)

Smk — **McKenzie formation**
(*blue thin-bedded fossiliferous limestone and soft gray and green shale; thin red shale east of Tussey Mountain and a little red shale west of Lock Mountain*)

Niagara group

Sk, Sc, Scs — **Clinton formation**
(*mainly green and blue shale, weathering purplish, and thin fine-grained green sandstone in middle; Keefer sandstone member,* Sk *, near top; shale with thin limestone layers above Keefer sandstone member represent Rochester shale; Marklesburg iron-ore bed just beneath Keefer sandstone member; Frankstown iron-ore bed in lower half; hard quartzitic sandstone, red sandstone, and Levant Block iron ore,* Scs *, at base; generally fossiliferous*)

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EXPLANATION

CONTINUED

SHEET SYMBOL — SECTION SYMBOL

ORDOVICIAN

Upper Ordovician

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Oo — **Oswego sandstone**
(*gray fine-grained thick-bedded cross-laminated sandstone; contains a few small quartz pebbles in lower part; nonfossiliferous*)

Orv — **Reedsville shale**
(*chiefly olive-green shale, weathering to small slivers, upper part containing argillaceous and ferruginous limestone layers; thick-bedded dark sandstone with abundant brachiopods of the Orthorhynchula zone at top, and a few feet of black shale containing graptolites at base*)

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UNCONFORMITY

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UNCONFORMITY

Lower Ordovician

Beekmantown group

Ob — **Bellefonte dolomite**
(*dark fine-grained dolomite, thick-bedded in lower part, dark shaly layers in upper part; contains heavy chert locally; sparingly fossiliferous*)

Oa — **Axemann limestone**
(*thin-bedded blue limestone with a few dolomite layers; abundantly fossiliferous*)

On — **Nittany dolomite**
(*thick-bedded light-gray fine-grained dolomite with some chert layers which weather to heavy chert at surface; chert commonly fossiliferous; a thin limestone, possibly Stonehenge, present near and southeast of Ore Hill*)

Ola — **Larke dolomite**
(*chiefly thick-bedded dark-blue coarsely crystalline dolomite, generally without chert but locally gives some chert at the surface; lower part is light-gray, fine-grained, and thinly banded by siliceous laminae that weather in relief; sparsely fossiliferous*)

Om — **Mines dolomite**
(*coarse and fine grained blue dolomite, largely oolitic; on weathering gives rise to great quantity of irregular platy porous chert, much of which is silicified oolite with black grains and contains two species of Cryptozoon*)

CAMBRIAN

Upper Cambrian

Cg — **Gatesburg formation**
(*chiefly thick-bedded blue coarsely crystalline dolomite, with many layers of sandstone up to 10 feet thick; Stacy dolomite member,* Cs *, free of sandstone, at base; Ore Hill limestone member,* Co *, which contains rare trilobites, in middle*)

Cw — **Warrior limestone**
(*thin-bedded blue fine-grained magnesian limestone with shaly partings; some layers contain abundant rounded quartz grains; Cryptozoon and trilobites*)

Middle Cambrian

Cph — **Pleasant Hill limestone**
(*lower part argillaceous thin-bedded limestone weathering to shale; upper part pure thick-bedded dark limestone; contains trilobites, brachiopods, and Hyolithus*)

Lower Cambrian

Cwb — **Waynesboro formation**
(*yellowish arkosic sandstone, fine quartz conglomerate, red and green shale, and calcareous sandstone; contains Hyolithus and trilobites*)

Known fault
Probable fault
Concealed fault
(*covered by younger deposits*)

Overthrust side of thrust fault
Strike and dip of stratified rocks
Strike of vertical beds
Horizontal beds
Quarry

Axis of anticline
Axis of syncline

STRUCTURE SECTIONS

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY

STATE OF PENNSYLVANIA REPRESENTED BY THE DEPARTMENT OF INTERNAL AFFAIRS TOPOGRAPHIC AND GEOLOGIC SURVEY

PENNSYLVANIA HOLLIDAYSBURG QUADRANGLE

H.M. Wilson, Geographer in charge.
Control by A.H. Thompson.
Topography by A.M. Walker and E.S. Ela.
Surveyed in 1901-1902.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

APPROXIMATE MEAN DECLINATION 1940

Geology by Charles Butts.
Surveyed in 1908.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards

1000 0 3000 6000 9000 12000 15000 18000 Feet

1 .5 0 1 2 3 4 5 Kilometers

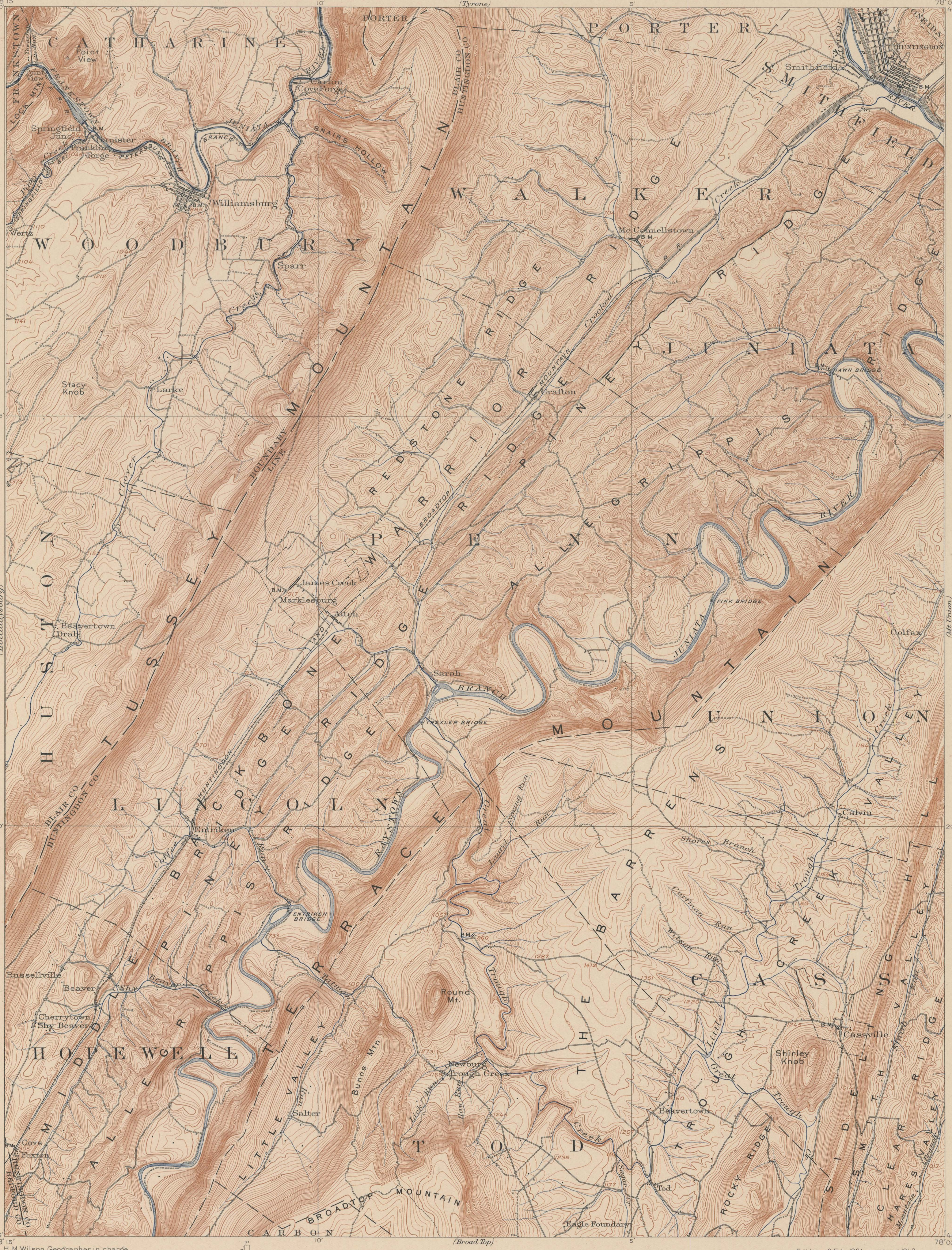
Edition of December 1945

TOPOGRAPHY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF PENNSYLVANIA
REPRESENTED BY THE
DEPARTMENT OF INTERNAL AFFAIRS
TOPOGRAPHIC AND GEOLOGIC SURVEY

PENNSYLVANIA
HUNTINGDON QUADRANGLE



EXPLANATION

RELIEF (printed in brown)

- 1412 — Altitude (above mean sea level instrumentally determined)
- Contours (showing height above sea, horizontal form, and steepness of slope of the surface)

DRAINAGE (printed in blue)

- Streams
- Pond

CULTURE (printed in black)

- City or town
- Roads and buildings
- Church or schoolhouse
- Private or poor roads
- Railroad
- Bridges
- Dam
- County line
- State township line
- City, village, or borough line
- Triangulation or primary traverse monument
- B.M. × 960 — Bench mark giving precise altitude

H. M. Wilson, Geographer in charge.
Control by A. H. Thompson.
Topography by A. M. Walker and E. S. Ela.
Surveyed in 1901.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH
MAGNETIC NORTH
7°
APPROXIMATE MEAN DECLINATION 1940

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards

1000 0 3000 6000 9000 12000 15000 18000 Feet

1 .5 0 1 2 3 4 5 Kilometers

Contour interval 20 feet
Datum is mean sea level

1945

Edition of Feb. 1904, reprinted 1943.
Polyconic projection. North American datum.

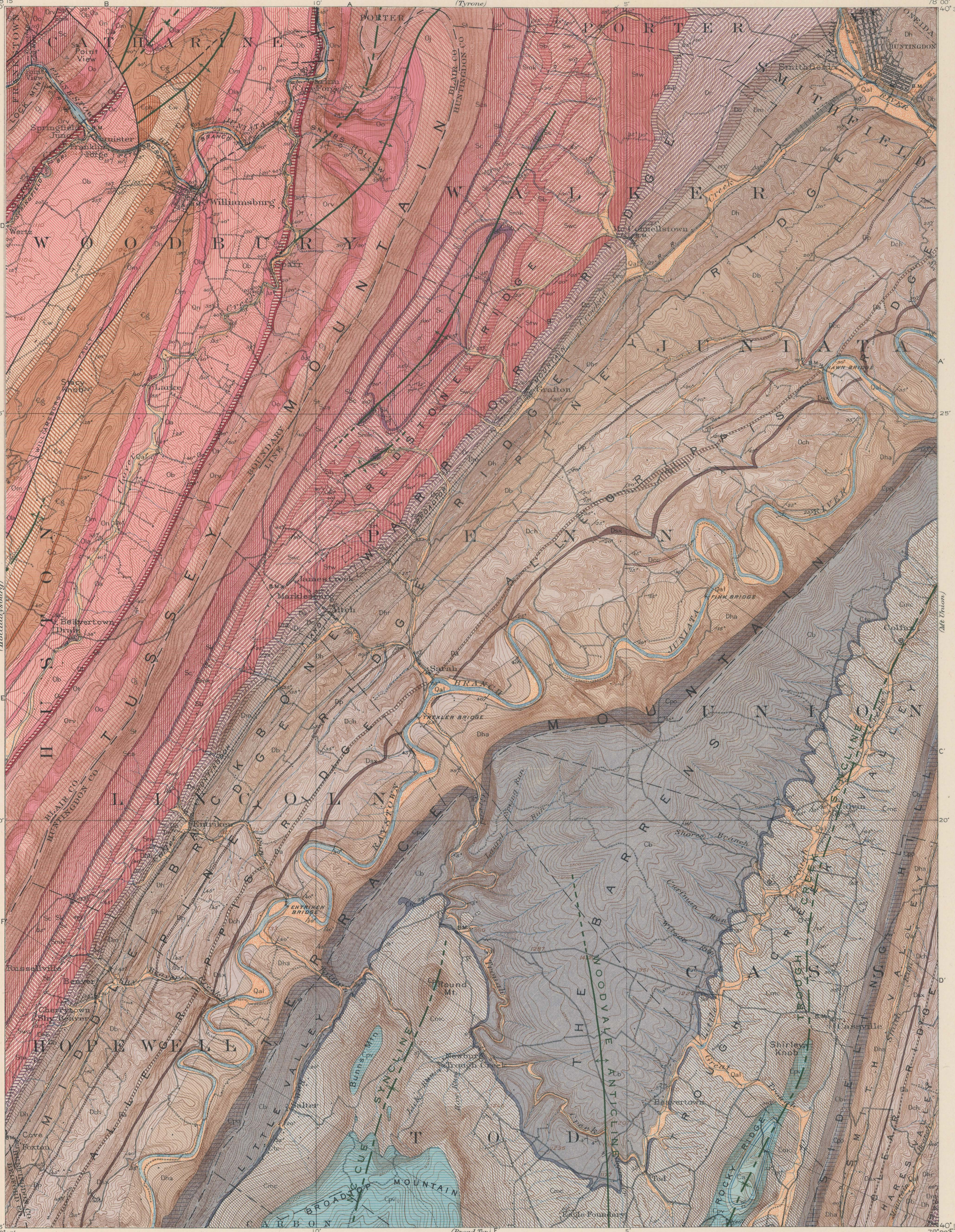
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

AREAL GEOLOGY

STATE OF PENNSYLVANIA
REPRESENTED BY THE
DEPARTMENT OF INTERNAL AFFAIRS
TOPOGRAPHIC AND GEOLOGIC SURVEY

PENNSYLVANIA
HUNTINGDON QUADRANGLE

(Altoona) (Tyrone) (Allensville)



(Everett) (Broad Top) (Orbisonia)

H.M.Wilson, Geographer in charge.
Control by A.H.Thompson.
Topography by A.M.Walker and E.S.Ela.
Surveyed in 1901.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1940

Scale 1/62500

Miles · Yards · Feet · Kilometers

Contour interval 20 feet
Datum is mean sea level

Edition of December 1945

Geology by Charles Butts.
Surveyed in 1913.

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY

Recent

Qal — **Alluvium**
(silt, sand, and gravel constituting the flood plains of present streams)

CARBONIFEROUS

Pennsylvanian

Ca — **Allegheny formation**
(shale and sandstone with beds of coal and clay; bn, Barnett coal bed, and ft, Fulton coal bed, shown by blue lines)

Cpv — **Pottsville formation**
(sandstone, conglomerate, shale, and coal; Homewood sandstone member at top; Mercer shale member in middle; Connoquenessing sandstone member, coarse, thick-bedded sandstone and conglomerate, at bottom)

UNCONFORMITY

Mississippian

Cmc, Ctc — **Mauch Chunk formation**
(mostly red shale or lumpy mud rock with a few thin layers of yellow-green sandstone; Trough Creek limestone member, Ctc, at bottom)

Cb, Cpo — **Pocono formation**
(chiefly gray and olive-green shale with gray sandstone and a little red shale and siliceous limestone; Burgoon sandstone member, Cb, at top; coarse conglomerate at base)

DEVONIAN

Upper Devonian

Dha — **Hampshire formation**
(predominantly red lumpy shale or mud rock and red sandstone; some gray and green shale and sandstone)

Dcc, Dsx, Da, Dch, Dp — **Chemung formation**
(chiefly green, gray, and chocolate-colored shale and thin beds of argillaceous fine-grained sandstone; fossiliferous throughout; includes Saxton conglomerate member, Dsx; Allegrippis sandstone member, Da; Piney Ridge sandstone member, Dp; and conglomerate lentils, Dcc)

Portage group

Db — **Brallier shale**
(micaceous, siliceous slaty green shale with some thin beds of fine-grained sandstone; sparsely fossiliferous throughout, mainly pelecypods of Gardeau type)

Dhr — **Harrell shale**
(soft gray shale and black shale interbedded; highly fossiliferous, small pelecypods and cephalopods of the Naples fauna)

Middle Devonian

Dh — **Hamilton formation**
(principally olive-green shale with even-layered blocky-jointed sandstone and thin limestone at top; ridge-making sandstone at two horizons; sparingly fossiliferous; locally a foot or two of limestone at top with Tully fauna)

Dm — **Marcellus shale**
(black fissile clay shale, grading upward into olive-green shale)

Do — **Onondaga formation**
(gray shale, probably calcareous, and thin argillaceous limestone)

Lower Devonian

Oriskany group

Dr — **Ridgeley sandstone**
(thick-bedded calcareous sandstone weathering to coarse friable sandstone; locally a fine conglomerate at top with quartz pebbles; highly fossiliferous)

Ds — **Shriver limestone**
(thin-bedded siliceous limestone, weathering to fine-grained sandstone; black calcareous shale at bottom; sparingly fossiliferous)

Dhb — **Helderberg limestone**
(lower part is thick-bedded gray limestone with thin gray chert at top, chiefly Keyser limestone member; overlying Coeymans and New Scotland limestone members thin and locally absent; contains valuable quarry rock, called "calico rock"; fossiliferous throughout)

SILURIAN

Cayuga group

Stw — **Tonoloway limestone**
(thin-bedded finely laminated dark limestone; sparingly fossiliferous, chiefly Leperditia)

Swc — **Wills Creek shale**
(chiefly gray calcareous shale and some greenish limestone; fossils scarce)

Sb — **Bloomsburg redbeds**
(lumpy red shale and thick-bedded ridge-making red sandstone)

Smk — **McKenzie formation**
(blue thin-bedded fossiliferous limestone and soft gray and green shale; thin red shale east of Tussey Mountain and a little red shale west of Lock Mountain)

Niagara group

Sk, Sc, Scs — **Clinton formation**
(mainly green and blue shale, weathering purplish, and thin fine-grained green sandstone in middle; Keefer sandstone member, Sk, near top; shale with thin limestone layers above Keefer sandstone member represent Rochester shale; Marklesburg iron-ore bed just beneath Keefer sandstone member; Frankstown iron-ore bed in lower half; hard quartzitic sandstone, red sandstone, and Levant Block iron ore, Scs, at base; generally fossiliferous)

St — **Tuscarora quartzite**
(hard white quartzite and sandstone, largely thick-bedded; quartzite extensively quarried for ganister; contains scolithus worm tubes and Arthrophycus at top)

EXPLANATION

CONTINUED

ORDOVICIAN

Upper Ordovician

Oj — **Juniata formation**
(chiefly red and some green fine-grained cross-bedded sandstone and red lumpy mud rock; nonfossiliferous)

Oo — **Oswego sandstone**
(gray fine-grained thick-bedded cross-laminated sandstone; contains a few small quartz pebbles in lower part; nonfossiliferous)

Orv — **Reedsville shale**
(chiefly olive-green shale, weathering to small slivers, upper part containing argillaceous and ferruginous limestone layers; thick-bedded dark sandstone with abundant brachiopods of the Orthorhyncula zone at top, and a few feet of black shale containing graptolites at base)

Middle Ordovician

Ot — **Trenton limestone**
(thin-bedded black argillaceous limestone weathering to small flat residual pieces; sparsely fossiliferous)

Black River group

Or — **Rodman limestone**
(thick- and thin-bedded dark crystalline limestone, weathering granular; fossiliferous)

Ol — **Lowville limestone**
(thick-bedded dark, fine, even-grained limestone, with conchoidal fracture; mostly high-grade limestone, the upper quarry rock)

UNCONFORMITY

Lower Ordovician

Oc — **Carlim limestone**
(thick-bedded, mainly fine-grained dark limestone, the lower quarry rock; sparsely fossiliferous; Lemont argillaceous limestone member, generally highly fossiliferous (Maclurea magna zone) at top, and separating the two quarry beds)

UNCONFORMITY

Beekmantown group

Ob — **Bellefonte dolomite**
(dark fine-grained dolomite, thick-bedded in lower part, dark shaly layers in upper part; contains heavy chert locally; sparingly fossiliferous)

Oa — **Axemann limestone**
(thin-bedded blue limestone with a few dolomite layers; abundantly fossiliferous)

On — **Nittany dolomite**
(thick-bedded light-gray fine-grained dolomite with some chert layers which weather to heavy chert at surface; chert commonly fossiliferous; a thin limestone, possibly Stonehenge, present near and southeast of Ore Hill)

Ola — **Larke dolomite**
(chiefly thick-bedded dark-blue coarsely crystalline dolomite, generally without chert but locally yields some chert at the surface; lower part is light-gray, fine-grained, and thinly banded by siliceous laminae that weather in relief; sparsely fossiliferous)

Om — **Mines dolomite**
(coarse and fine grained blue dolomite, largely oolitic; on weathering gives rise to great quantity of irregular platy scoriaceous chert, much of which is silicified oolite with black grains and contains two species of Cryptozoon)

CAMBRIAN

Upper Cambrian

Ꞓo, Ꞓg, Ꞓs — **Gatesburg formation**
(chiefly thick-bedded blue coarsely crystalline dolomite, with many layers of sandstone up to 10 feet thick; Stacy dolomite member, Ꞓs, free of sandstone, at base; Ore Hill limestone member, Ꞓo, which contains rare trilobites, in middle)

Ꞓw — **Warrior limestone**
(thin-bedded blue fine-grained magnesian limestone with shaly partings; some layers contain abundant rounded quartz grains; sparingly fossiliferous, including Cryptozoon and trilobites)

Middle Cambrian

Ꞓph — **Pleasant Hill limestone**
(lower part argillaceous thin-bedded limestone weathering to shale; upper part pure thick-bedded dark limestone; contains trilobites, brachiopods, and Hyolithus)

Known fault

Probable fault

Concealed fault
(covered by younger deposits)

T, *Overthrust side of thrust fault*

35° *Strike and dip of stratified rocks*

Strike of vertical beds

⊕ *Horizontal beds*

Axis of anticline

Axis of syncline

STRUCTURE SECTIONS

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF PENNSYLVANIA
REPRESENTED BY THE
DEPARTMENT OF INTERNAL AFFAIRS
TOPOGRAPHIC AND GEOLOGIC SURVEY

PENNSYLVANIA
HUNTINGDON QUADRANGLE

H. M. Wilson, Geographer in charge.
Control by A. H. Thompson.
Topography by A. M. Walker and E. S. Ela.
Surveyed in 1901.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards

1000 0 3000 6000 9000 12000 15000 18000 Feet

1 .5 0 1 2 3 4 5 Kilometers

Edition of December 1945

Geology by Charles Butts.
Surveyed in 1913.

EXPLANATION

SEDIMENTARY ROCKS

SHEET SYMBOL — SECTION SYMBOL

QUATERNARY

Recent

Qal — **Alluvium**
(*silt, sand, and gravel constituting the flood plains of present streams*)

CARBONIFEROUS

Pennsylvanian

Ca — **Allegheny formation**
(*shale and sandstone with beds of coal and clay*)

Cpv — **Pottsville formation**
(*sandstone, conglomerate, shale, and coal; Homewood sandstone member at top; Mercer shale member in middle; Connoquenessing sandstone member, coarse, thick-bedded sandstone and conglomerate, at bottom*)

UNCONFORMITY

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Cmc, Ctc — **Mauch Chunk formation**
(*mostly red shale or lumpy mud rock with a few thin layers of yellow-green sandstone; Trough Creek limestone member,* Ctc *, at bottom*)

Cb, Cpo — **Pocono formation**
(*chiefly gray and olive-green shale with gray sandstone and a little red shale and siliceous limestone; Burgoon sandstone member,* Cb *, at top; coarse conglomerate at base*)

DEVONIAN

Upper Devonian

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Dhr — **Harrell shale**
(*soft gray shale and black shale interbedded; highly fossiliferous, small pelecypods and cephalopods of the Naples fauna*)

Middle Devonian

Dh — **Hamilton formation**
(*principally olive-green shale with even-layered blocky-jointed sandstone and thin limestone at top; ridge-making sandstone at two horizons; sparingly fossiliferous; locally a foot or two of limestone at top with Tully fauna*)

Dm — **Marcellus shale**
(*black fissile clay shale, grading upward into olive-green shale*)

Do — **Onondaga formation**
(*gray shale, probably calcareous, and thin argillaceous limestone*)

Lower Devonian

Oriskany group

Dr — **Ridgeley sandstone**
(*thick-bedded calcareous sandstone weathering to coarse friable sandstone; locally a fine conglomerate at top with quartz pebbles; highly fossiliferous*)

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(*thin-bedded siliceous limestone, weathering to fine-grained sandstone; black calcareous shale at bottom; sparingly fossiliferous*)

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(*lower part is thick-bedded gray limestone with thin gray chert at top, chiefly Keyser limestone member; overlying Coeymans and New Scotland limestone members thin and locally absent; contains valuable quarry rock, called "calico rock"; fossiliferous throughout*)

SILURIAN

Cayuga group

Stw — **Tonoloway limestone**
(*thin-bedded finely laminated dark limestone; sparingly fossiliferous, chiefly Leperditia*)

Swc — **Wills Creek shale**
(*chiefly gray calcareous shale and some greenish limestone; fossils scarce*)

Sb — **Bloomsburg redbeds**
(*lumpy red shale and thick-bedded ridge-making red sandstone*)

Smk — **McKenzie formation**
(*blue thin-bedded fossiliferous limestone and soft gray and green shale; thin red shale east of Tussey Mountain and a little red shale west of Lock Mountain*)

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(*mainly green and blue shale, weathering purplish, and thin fine-grained green sandstone in middle; Keefer sandstone member,* Sk *, near top; shale with thin limestone layers above Keefer sandstone member represent Rochester shale; Marklesburg iron-ore bed just beneath Keefer sandstone member; Frankstown iron-ore bed in lower half; hard quartzitic sandstone, red sandstone, and Levant Block iron ore,* Scs *at base; generally fossiliferous*)

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(*hard white quartzite and sandstone, largely thick-bedded; quartzite extensively quarried for ganister; contains scolithus worm tubes and Arthrophycus at top*)

EXPLANATION

CONTINUED

SHEET SYMBOL — SECTION SYMBOL

ORDOVICIAN

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Oj — **Juniata formation**
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(*thin-bedded black argillaceous limestone weathering to small flat residual pieces; sparsely fossiliferous*)

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(*thick- and thin-bedded dark crystalline limestone, weathering granular; fossiliferous*)

Ol — **Lowville limestone**
(*thick-bedded dark, fine, even-grained limestone, with conchoidal fracture; mostly high-grade limestone, the upper quarry rock*)

UNCONFORMITY

Oc — **Carlim limestone**
(*thick-bedded, mainly fine-grained dark limestone, the lower quarry rock; sparsely fossiliferous; Lemont argillaceous limestone member, generally highly fossiliferous (Maclurea magna zone) at top, and separating the two quarry beds*)

UNCONFORMITY

Lower Ordovician

Beekmantown group

Ob — **Bellefonte dolomite**
(*dark fine-grained dolomite, thick-bedded in lower part, dark shaly layers in upper part; contains heavy chert locally; sparingly fossiliferous*)

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Probable fault

Concealed fault
(*covered by younger deposits*)

T *Overthrust side of thrust fault*

35° *Strike and dip of stratified rocks*

Strike of vertical beds

⊕ *Horizontal beds*

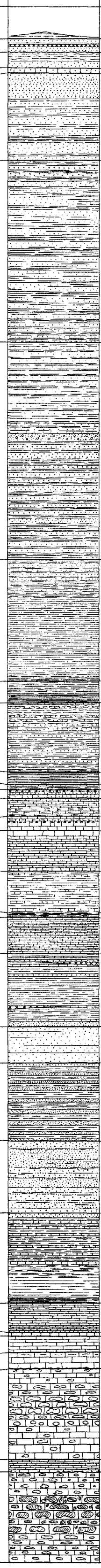
Axis of anticline

Axis of syncline

COLUMNAR SECTION

GENERALIZED SECTION OF THE ROCKS IN THE HOLLIDAYSBURG AND HUNTINGDON QUADRANGLES

SCALE: 1 INCH = 1000 FEET



System	Series	Group	Formation.	Symbol	Thickness in Feet	Minor Divisions	Character of Members	General Character of Formations
CARBONIFEROUS	PENNSYLVANIAN		Allegheny formation.	Ca	50	Brookville coal member.	Probably 4 to 5 feet thick. Impure; inferior quality.	Shale and sandstone with workable coal beds.
CARBONIFEROUS	PENNSYLVANIAN		Pottsville formation	Cpv	130-300	Homewood sandstone member Mercer shale member Connoquenessing sandstone member.	Coarse thick-bedded sandstone. Clay, coal, and shale Coarse thick-bedded sandstone.	Mainly coarse sandstone with shale, coal, and clay in middle.
			UNCONFORMITY					
CARBONIFEROUS	MISSISSIPPIAN		Mauch Chunk formation.	Cmc	180-1000			In Hollidaysburg quadrangle coarse, lumpy, red and green shale, mostly red; 80 feet of sandstone at bottom. In Huntingdon quadrangle a little yellowish-green sandstone in midst of red shale and at top; at bottom, Trough Creek limestone member, red and gray, coarsely crystalline.
CARBONIFEROUS	MISSISSIPPIAN		Loyalhanna limestone.	Cl	40			Siliceous cross-bedded limestone.
CARBONIFEROUS	MISSISSIPPIAN		Pocono formation.	(Cb) Cpo	(300-500) 990	Burgoon sandstone member Patton shale member.	Rather coarse micaceous, arkosic yellowish or greenish-gray thick-bedded sandstone. Red shale on Allegheny Front and westward.	Lower 700 feet in Hollidaysburg quadrangle, shale and sandstone, considerable red shale. Lower 900 feet in Huntingdon quadrangle, shale, sandstone. and conglomerate, very little red shale. Shale mostly stiff, imperfectly fissile, greenish.
DEVONIAN	UPPER DEVONIAN		Hampshire formation.	Dck	2000-2500			About 80 percent bright red shale, alternating with layers of reddish or brown sandstone, which is generally thick-bedded and medium-grained. Some laminated layers. The red shale is in places mottled with bright green, and there are many thin layers of bright green in the red shale. Beds of gray shale and sandstone occur throughout the formation; in these is a sparse marine fauna. No fossils have been found in the red parts.
DEVONIAN	UPPER DEVONIAN		Chemung formation.	Dch	2400-3350			Shale and sandstone. Upper 1,000 feet largely chocolate-colored clay shale and fine-grained, thin-bedded chocolate-colored sandstone. Lower part gray and green shale, mostly gray clay shale, with sandstone. Sandstones from 1-inch layers of argillaceous sandstone to 50-foot beds of siliceous, medium-grained, moderately thick-bedded sandstone. Two thin local beds and two persistent beds of conglomerate and sandstone in the Huntingdon quadrangle; one conglomeratic sandstone bed in the middle in the Hollidaysburg quadrangle. Fossils moderately plentiful throughout.
DEVONIAN	UPPER DEVONIAN	Portage	Brallier shale.	Db	1350-1800			Very fine-grained, sandy and micaceous stiff greenish-gray shale. Much of it thinly laminated, even-surfaced, with lamination cleavage dividing rock into large slaty plates, with weathered surfaces stained black with manganese oxide. Thin fine-grained greenish sandstone layers near top. Small fossils throughout but very scarce. Characteristic Portage (Naples) fauna.
DEVONIAN	UPPER DEVONIAN	Portage	Harrell shale.	Dhr (Dbk)	250 (80)	Burket black shale member.	Black fissile shale in Hollidaysburg quadrangle. Small fossils.	Interbedded black and gray soft, very fissile (paper) clay shale in Huntingdon quadrangle. Soft brownish-gray shale above. Burket black shale member below in Hollidaysburg quadrangle. Small fossils throughout (Naples fauna).
DEVONIAN	MIDDLE DEVONIAN		Hamilton formation.	Dh	750-1200		Olive-green hackly shale. Two persistent sandstone strata, 50 to 75 feet thick, at top and bottom of middle third in Huntingdon quadrangle.	Nearly all shale in Hollidaysburg quadrangle. Layers of very fine-grained sandstone up to 1 foot thick in middle part, characteristically jointed into straight-edged, smooth cuboidal or rhomboidal blocks; partly olive-green shale in upper part; finely laminated, dark shale below. A few feet of gray shale with thin layers of limestone at top crowded with fossils; olive shale, moderately fossiliferous; lower two-thirds almost barren of fossils in Hollidaysburg quadrangle.
DEVONIAN	MIDDLE DEVONIAN		Marcellus shale.	Dm	150			Black fissile shale. Sparsely fossiliferous (*Leiorhynchus limitaris*).
DEVONIAN	MIDDLE DEVONIAN		Onondaga formation.	Don	50			Dark and drab shale, thin limestone at top. Fossiliferous
DEVONIAN	LOWER DEVON.	Oriskany	Ridgeley sandstone.	Dr	100			Calcareous sandstone, coarse siliceous sandstone, and fine conglomerate. Highly fossiliferous.
DEVONIAN	LOWER DEVON.	Oriskany	Shriver limestone.	Ds	200			Thin-bedded siliceous limestone; black calcareous, fossiliferous shale in bottom. 10 feet (Oriskany fauna).
DEVONIAN	LOWER DEVON.		Helderberg limestone.	Dhb	150±	New Scotland limestone member Coeymans limestone member. Keyser limestone member	Cherty limestone.	Thick- and thin-bedded, coarsely crystalline, fine-grained, bluish-gray limestone. Characteristic nodular, argillaceous layers everywhere in Keyser limestone member. Locally cherty layers near bottom of Keyser (Calico rock). Main quarry bed at bottom.
SILURIAN		Cayuga	Tonoloway limestone.	Stw	450			Thick-bedded, dark to black limestone at top, mostly thin-bedded and laminated, dark, fine-grained. A few fossils, mainly *Leperditia*.
SILURIAN		Cayuga	Wills Creek shale.	Swc	400±			Mostly drab fissile clay shale. Some green and dark shale. Probably calcareous. Thin limestone, especially near bottom. Fossils very scarce, mostly small *Leperditia*, a few brachiopods.
SILURIAN		Cayuga	Bloomsburg redbeds.	Sb	50±			Red shale and sandstone east of Tussey Mountain. Red shale and gray limestone in Hollidaysburg quadrangle.
SILURIAN		Cayuga	McKenzie formation.	Smk	400			Thin-bedded blue limestone. Highly fossiliferous; small ostracodes, mostly *Kloedinella*, very plentiful.
SILURIAN		Niagara	Clinton formation.	Sc	(70) 775±	Keefer sandstone member. Marklesburg ore. Frankstown ore. Block or Levant ore and "Iron sandstone."	Thin-bedded coarse ferruginous sandstone east of Tussey Mountain. Siliceous rusty limestone west in Hollidaysburg region. Oolitic and "fossil ore" east of Tussey Mountain. 1 to 2 feet thick. Oolitic and fossil ore in Hollidaysburg region. 1 to 2 feet thick. Hard red sandstone, locally an ore bed in lower part.	Predominantly shale; chocolate at top, greenish and gray in middle, with red layers in lower part; pink, fissile shale at very bottom. Thin limestone at top; rather thick limestone at bottom, interbedded with red shale. Thin impure, limy ore beds near top, and a workable bed in places near middle. Generally fossiliferous, especially so in upper part.
SILURIAN			Tuscarora quartzite.	St	400-600			Gray quartzitic sandstone and quartzite. Supplies the ganister of the region, which is extensively used for refractory brick and furnace linings.
ORDOVICIAN	UPPER ORDOVICIAN		Juniata formation.	Oj	850			Predominantly red shale and sandstone; sandstone medium-grained and much of it finely cross-laminated.
ORDOVICIAN	UPPER ORDOVICIAN		Oswego sandstone.	Oo	800			Almost all gray, brown-speckled medium-grained thick-bedded sandstone; a few layers of red, gray, or green sandy shale.
ORDOVICIAN	UPPER ORDOVICIAN		Reedsville shale.	Orv	1000	Black shale (Utica?).	Black fossiliferous shale with thin black limestone layers. Graptolites.	Olive-green clay shale in lower part, except about 20 feet at bottom, which is generally black. Upper part dark clay shale with many thin shell-limestone bands. Top 30 feet heavy calcareous sandstone with fossils in upper part. Fossils plentiful in the limestone bands in the upper part and in the black shale at the bottom; scarce in the olive-green shale of the lower part.
ORDOVICIAN	MIDDLE ORDOVICIAN		Trenton limestone.	Ot	350			Thin-bedded dark-gray to black fine-grained or nongranular limestone. Sparingly fossiliferous
ORDOVICIAN	MIDDLE ORDOVICIAN	Black River	Rodman limestone.	Or	30			Gray granular limestone. Fossiliferous.
ORDOVICIAN	MIDDLE ORDOVICIAN	Black River	Lowville limestone.	Ol	180			Thick-bedded dark fine-grained to nongranular pure limestone. Moderately fossiliferous. Best quarry rock
			UNCONFORMITY					
ORDOVICIAN	MIDDLE ORDOVICIAN		Carlim limestone.	Oc	180	Lemont argillaceous limestone member.	Highly argillaceous siliceous limestone. Abundantly fossiliferous. Not quarried for flux.	Thick-bedded dark limestone, mostly finely crystalline. Moderately fossiliferous. Quarry rock.
			UNCONFORMITY					
ORDOVICIAN	LOWER ORDOVICIAN	Beekmantown	Bellefonte dolomite.	Ob	1000			Thick-bedded crystalline dolomite, mostly gray; more or less chert throughout, but especially in middle and lower parts. A few fossils in the chert.
ORDOVICIAN	LOWER ORDOVICIAN	Beekmantown	Axemann limestone.	Oa	150			Thin-bedded blue limestone. Fossils rather plentiful
ORDOVICIAN	LOWER ORDOVICIAN	Beekmantown	Nittany dolomite.	On	1000			Thick-bedded gray crystalline dolomite. Much dense chert in middle part and some chert throughout. Fossils in chert; *Lecanospira* zone

COLUMNAR SECTION—Continued

SCALE: 1 INCH = 1000 FEET

System	Series	Group	Formation	Symbol	Section	Thickness in Feet.	Minor Divisions	Character of Members	General Character of Formations
ORD.	LOWER ORDOVICIAN	Beekmantown	Larke dolomite.	Ola		250			Thick-bedded dolomite, without sandstone, and in most of its area without notable development of chert. Locally, yields abundant heavy chert, which is sparingly fossiliferous.
			Mines dolomite.	Om		250			Thick-bedded dolomite like that of the Gatesburg. No sandstone. Abundant development of platy scoriaceous oolitic chert with Cryptozoa, but without other fossils. Basal layer of dolomite locally full of gastropods (*Sinuopea*).
CAMBRIAN	UPPER CAMBRIAN		Gatesburg formation.	(€o)		(100)	Ore Hill limestone member.	Thin-bedded limestone, bluish, fine- or medium-grained. Some thin layers with fossils, including several genera and species of trilobites, mostly undescribed, a few gastropods and brachiopods.	Thick-bedded bluish coarsely crystalline dolomite and fine-grained dolomite with argillaceous bandings giving striped appearance to weathered surfaces. Many interbedded layers of quartzite from a few inches up to 10 feet thick. Makes ridges which are covered with quartz boulders and sand, suggesting only sandstone beneath. Sand in places 40 feet deep, utilized to a considerable extent.
				€g		1750			
				(€s)		(600)	Stacy dolomite member.	Thick-bedded dolomite as in Gatesburg generally but with no or very little quartzite.	
			Warrior limestone.	€w		1250			Generally thin- to thick-bedded, blue to dark bluish-gray, mostly fine-grained limestone, much of which is probably magnesian. Fossils, mainly small trilobites, sparingly distributed at several horizons. A few thin quartzite bands and thicker layers of perfectly rounded grains of quartz, generally 5 millimeters or less in diameter.
	MIDDLE CAMBRIAN		Pleasant Hill limestone.	€ph		(200±) 600			Upper 200± feet thick-bedded dark gray pure limestone, with oolitic and conglomeratic layers containing trilobites and other fossils; lower 400 feet thin-bedded and argillaceous, yielding shaly debris on weathered outcrop.
	LOWER CAMBRIAN		Waynesboro formation.	€wb		250+			Green and red shale above; sandstone, quartzite, and conglomerate below. Not all exposed, and thickness unknown.

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ILLUSTRATIONS I

PENNSYLVANIA
HOLLIDAYSBURG AND HUNTINGDON QUADRANGLES

PLATE 1.—VIEW WEST ACROSS LOGAN VALLEY

From a point near the crest of Dunning Mountain, 1 mile south of Claysburg in the southwestern part of the Hollidaysburg quadrangle. Outlying part of Allegheny Front in the distance, the highest point of which is 3,136 feet above sea level, and more than 1,900 feet above the bottom of the valley.

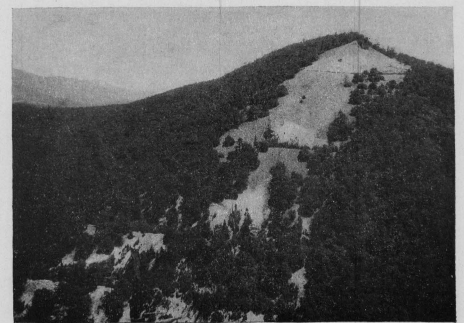

PLATE 2.—POINT VIEW KNOB

In the northwest corner of the Huntingdon quadrangle. View northeast across the valley of Frankstown Branch of Juniata River. Crest of Canoe Mountain in left distance. The white areas are talus of quartzite slide rock from the Tuscarora quartzite, which crops out on the crest of the knob. The horizontal lines are the sites of old tram tracks used in collecting ganister (see p. 18)

PLATE 3.—MORRISONS COVE

View east across limestone valley to Tussey Mountain from crest of Dunning Mountain, west of Royer and 6 miles east of Hollidaysburg. The low wooded ridge in middle distance is on the outcrop of the Gatesburg formation. The gentle slope occupied by cultivated land is on the Nittany and Bellefonte dolomites, and the valley at the foot of the ridge is on the outcrop of the Carlim, Lowville, and Trenton limestones, all of which dip west toward the observer.

PLATE 4.—BROAD TOP MOUNTAIN FROM A POINT ABOUT 3 MILES SOUTHWEST OF CASSVILLE

View west across south end of Trough Creek Valley. Round Mountain in distance on the right. Bunns Mountain to the left of Round Mountain.

PLATE 5.—VIEW SOUTHEAST DOWN JUNIATA RIVER VALLEY ACROSS HUNTINGDON

High point in distance on right formed by the convergence of Terrace Mountain and Sideling Hill on the axis of the Trough Creek syncline. Crest of Jacks Mountain on left.

PLATE 6.—VIEW EAST ACROSS SMITH AND HARES VALLEYS AND CLEAR RIDGE MAINLY ON DEVONIAN ROCKS, TO JACKS MOUNTAIN

From a point on Sideling Hill 3 miles northeast of Cassville. Jacks Mountain formed by Tuscarora quartzite, the same as Tussey Mountain.

PLATE 7.—LAYERS OF WARRIOR LIMESTONE COMPOSED OF *CRYPTOZOON UNDULATUM* BASSLER

Five layers of cryptozoons in about 3 feet of thickness. Quarry at Bakers Summit in the southwestern part of the Hollidaysburg quadrangle. Looking southeast.

PLATE 8.—*CRYPTOZOON UNDULATUM* BASSLER

Top surface of layer of the Warrior limestone. One-fourth mile east of Bakers summit.

PLATE 9.—*CRYPTOZOON UNDULATUM* BASSLER

Same as plate 8. Sectional view showing manner of growth.

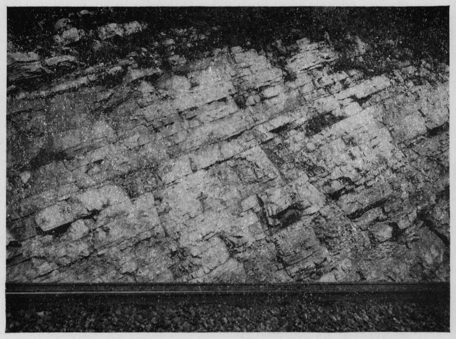

PLATE 10.—DOLOMITE ALONG PENNSYLVANIA RAILROAD ABOUT 1 MILE EAST OF UNION FURNACE

Looking north. This is a part of the Beekmantown group and is believed to be Nittany dolomite.

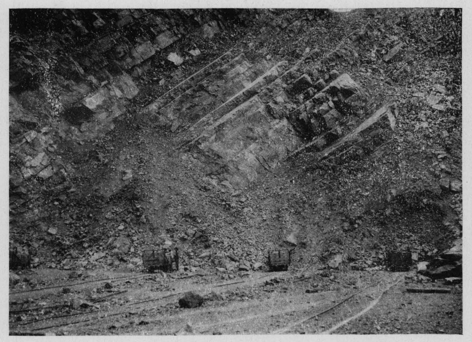

PLATE 11.—LOWVILLE LIMESTONE IN QUARRY OF ST. CLAIR LIMESTONE CO., AT GANISTER

Looking northeast. Layer of limestone near bottom crowded with fucoids (fossil seaweeds).

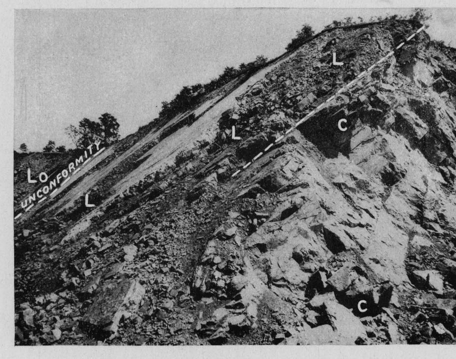

PLATE 12.—VIEW IN QUARRY AT GANISTER SHOWING BEDS JUST BELOW LOWVILLE LIMESTONE

Lo, Lowville limestone; L, Lemont argillaceous limestone member of Carlim limestone; C, lower part of Carlim limestone. Between the Lemont member and the Lowville is a great stratigraphic hiatus due to the absence of formations that in east Tennessee are several thousand feet thick (see p. 4).

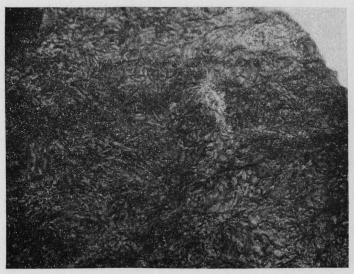

PLATE 13.—FUCOIDS IN BED AT OR NEAR BOTTOM OF LOWVILLE LIMESTONE

Top of a layer 5 feet thick crowded throughout with these forms. Stems one-eighth inch in diameter. On weathering the dark material dissolves out, leaving a honeycombed rock. Quarry at Ganister.

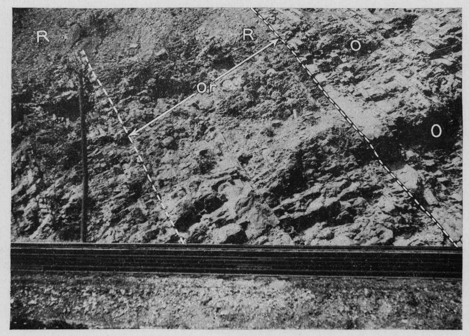

PLATE 14—TOP OF REEDSVILLE SHALE (R), WITH THICK-BEDDED PART (Or) OF MAYSVILLE AGE, CARRYING *ORTHORHYNCULA* AND *BYSSONICHIA*, AND BOTTOM OF OSWEGO SANDSTONE (O)

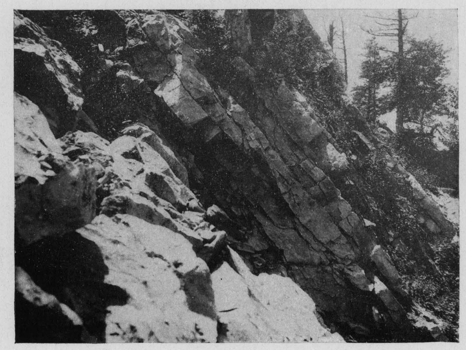

PLATE 15.—TUSCARORA QUARTZITE

North end of Lock Mountain at Point View. Looking south.

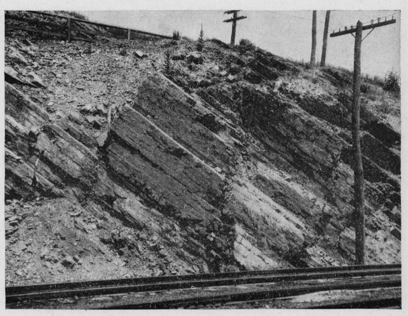

PLATE 16.—SHRIVER LIMESTONE

Railroad cut at south end of Bald Hill 1 mile east of Hollidaysburg. Looking northeast.

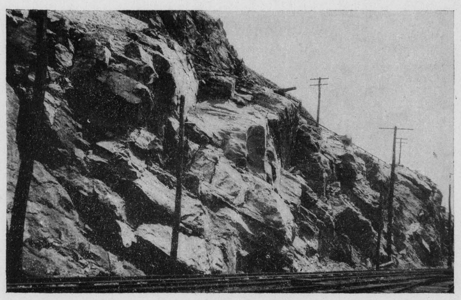

PLATE 17.—THICK-BEDDED BUT LAMINATED LIMESTONE IN UPPER PART OF KEYSER MEMBER OF HELDERBERG LIMESTONE

Cut at south end of Bald Hill 1 mile east of Hollidaysburg. Looking northeast. Shriver limestone at far end of cut (see pl. 16).

PLATE 18.—VIEW OF PLOWED FIELD COVERED WITH SMALL STONES FROM THE UNDERLYING SHRIVER LIMESTONE

North of Cove, in the southwest corner of the Huntingdon quadrangle. Looking east. Characteristic feature of the Shriver throughout the region.

PLATE 19.—CHARACTERISTIC HACKLY FOSSILIFEROUS SHALE IN THE TOP OF THE HAMILTON FORMATION SOUTH OF HUNTINGDON

Looking northeast.

PLATE 20.—BRALLIER SHALE

These thick beds are thinly laminated and break down into thin chips on weathering. Cut on Pennsylvania Railroad about half a mile east of Huntingdon. Looking north.

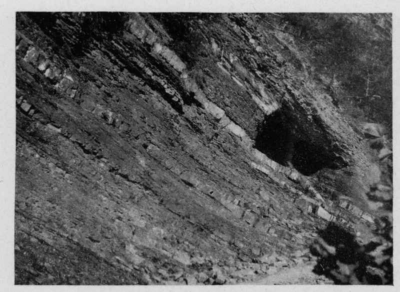

PLATE 21.—CHEMUNG FORMATION, SHOWING ALTERNATING THIN SHALE AND SANDSTONE LAYERS

Along road a short distance north of Hawn Bridge, in the northwestern part of the Huntingdon quadrangle. Looking northeast.

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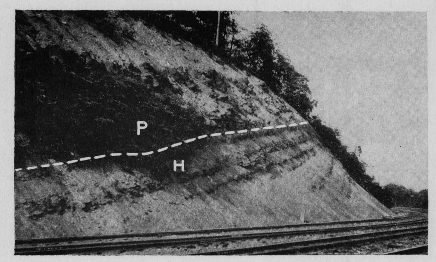

PLATE 22.—HAMPSHIRE-POCONO BOUNDARY
Curve on Pennsylvania Railroad at entrance to gorge of Sugar Run, about 2 miles south of Kittanning Point. P, Pocono; H, Hampshire.

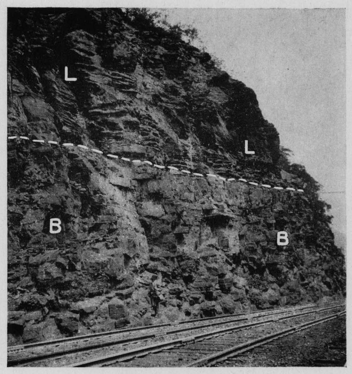

PLATE 23.—LOYALHANNA LIMESTONE (L) OVERLYING BURGOON SANDSTONE (B)
Pennsylvania Railroad on Allegheny Front near old Allegrippis Station. Looking northeast.

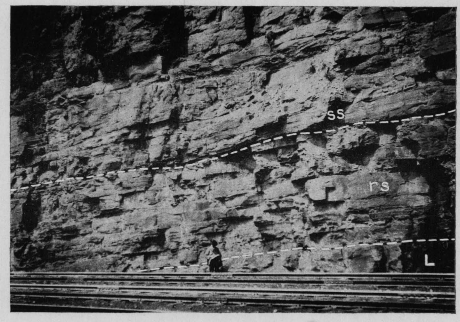

PLATE 24.—SANDSTONE FORMING THE LOWER PART OF THE MAUCH CHUNK FORMATION ON THE ALLEGHENY FRONT
Cut on Pennsylvania Railroad in gorge of Sugar Creek. Looking north. ss, Sandstone in bottom of Mauch Chunk formation; rs, red shale; L, Loyalhanna limestone.

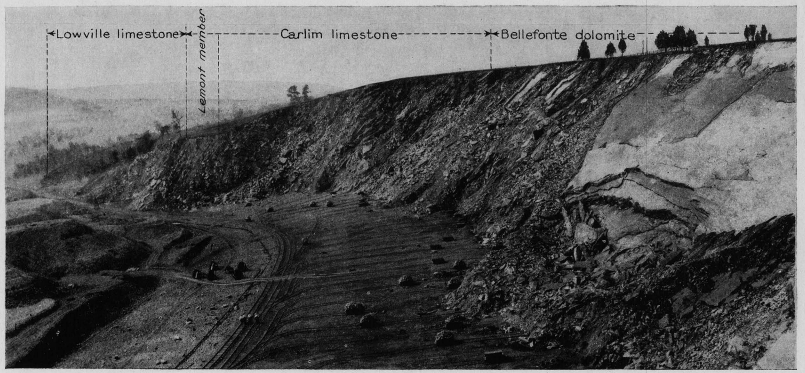

PLATE 25.—VIEW OF CLOVER CREEK QUARRY AT SPARR
Mainly in Carlim limestone. Beekmantown dolomite at bottom. Looking southwest.

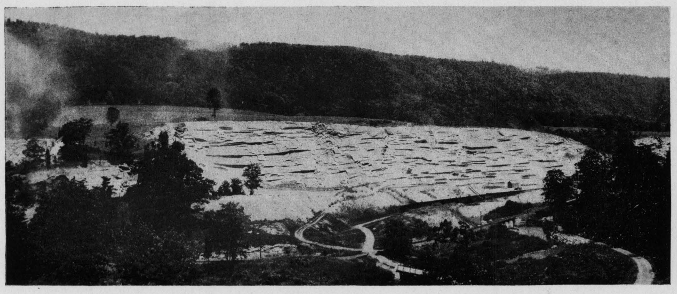

PLATE 26.—VIEW OF QUARRY JUST SOUTH OF GANISTER
Looking northwest. Trenton limestone on slope above. Lock Mountain in distance. Rodman limestone at top margin of quarry.

PLATE 27.—CLAY PIT 1 MILE SOUTH OF OREMINIA (MINES)
Residual clay accumulated on the outcrop of the Mines dolomite. Looking north.

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[c]185	Murphysboro-Herrin	Illinois	50
186	Apishapa	Colorado	Out of stock.
187	Ellijay	Ga.-N. C.-Tenn	do.
[d]188	Tallula-Springfield	Illinois	25
189	Barnesboro-Patton	Pennsylvania	Out of stock.
190	Niagara	New York	do.
191	Raritan	New Jersey	do.
192	Eastport	Maine	do.
193	San Francisco	California	do.
194	Van Horn	Texas	do.
195	Belleville-Breese	Illinois	25
196	Phillipsburg	Montana	Out of stock.
197	Columbus	Ohio	do.
198	Castle Rock	Colorado	do.
199	Silver City	New Mexico	do.
200	Galena-Elizabeth	Illinois-Iowa	do.
201	Minneapolis-St. Paul	Minnesota	do.
202	Eureka Springs-Harrison	Arkansas-Missouri	do.
203	Colorado Springs	Colorado	do.
204	Tolchester	Maryland	25
[d]205	Detroit	Michigan	50
206	Leavenworth-Smithville	Missouri-Kansas	Out of stock.
207	Deming	New Mexico	do.
208	Colchester-Macomb	Illinois	25
209	Newell	South Dakota	25
210	Herman-Morris	Minnesota	25
211	Elkton-Wilmington	Md.-Del.-N. J.-Pa	Out of stock.
212	Syracuse-Lakin	Kansas	do.
213	New Athens-Okawville	Illinois	25
214	Raton-Brilliant-Koehler	New Mexico-Colorado	Out of stock.
215	Hot Springs	Arkansas	do.
216	Carlyle-Centralia	Illinois	25
217	Ray	Arizona	Out of stock.
218	Riddle	Oregon	do.
219	Central Black Hills	South Dakota	do.
220	Gillespie-Mount Olive	Illinois	25
221	Bessemer-Vandiver	Alabama	50
222	Gaffney-Kings Mountain	N. Carolina-S. Carolina	50
223	Coatesville-West Chester	Pennsylvania-Delaware	50
224	Somerset-Windber	Pennsylvania	50
225	Fairfield-Gettysburg	Pennsylvania	50
226	Montevallo-Columbiana	Alabama	50
227	Hollidaysburg-Huntingdon	Pennsylvania	$2.00

[a] Order by number.
[b] Payment must be made by money order or in cash.
[c] Octavo edition only of this folio is in stock.
[d] These folios are also published in octavo form at 50 cents each.

Circulars showing the location of the area covered by any of the above folios, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, Geological Survey, Washington, D. C.