DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS

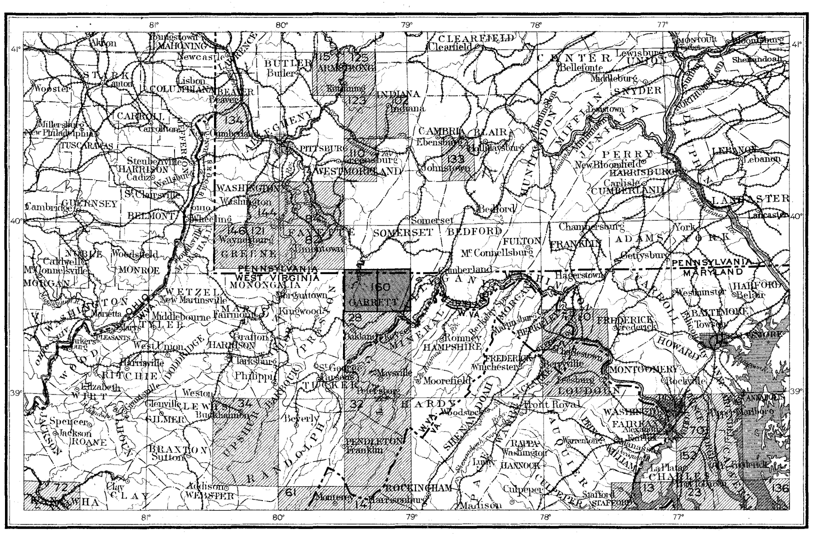
OF THE

UNITED STATES

ACCIDENT-GRANTSVILLE FOLIO

MARYLAND-PENNSYLVANIA-WEST VIRGINIA

INDEX MAP



SCALE: 40 MILES-1 INCH

ACCIDENT-GRANTSVILLE FOLIO

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GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES

The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the altitudinal interval represented by the space between lines being the same throughout each map. These lines are called *contours*, and the uniform altitudinal space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map (fig. 1).

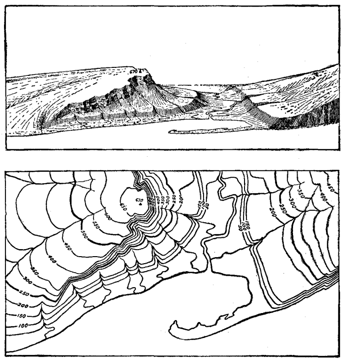

FIG. 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply, forming a precipice. Contrasted with this precipice is the gentle slope from its top toward the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above sea; along the contour at 200 feet, all points that are 200 feet above sea; and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say, every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. These relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise 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 ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is serviceable for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If a stream flows the entire year the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, are printed in black.

Scales.—The area of the United States (excluding Alaska and island possessions) is about 3,025,000 square miles. A map representing this area, drawn to the scale of 1 mile to the inch, would cover 3,025,000 square inches of paper, and to accommodate the map the paper would need to measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the *scale* of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale $\frac{1}{125,000}$, about 4 square miles; and on the scale $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles in English inches, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree—i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-fourth of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles.

The atlas sheets, being only parts of one map of the United States, disregard political boundary lines, such as those of States, counties, and townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic map.—On the topographic map are delineated the relief, drainage, and culture of the quadrangle represented. It should portray to the observer every characteristic feature of the landscape. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property; save the engineer preliminary surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land, and the structure sections show their underground relations, as far as known and 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.—These are rocks which have cooled and consolidated from a state of fusion. Through rocks of all ages molten material has from time to time been forced upward in fissures or channels of various shapes and sizes, to or nearly to the surface. Rocks formed by the consolidation of the molten mass within these channels—that is, below the surface—are called *intrusive*. When the rock occupies a fissure with approximately parallel walls the mass is called a *dike*; when it fills a large and irregular conduit the mass is termed a *stock*. When the conduits for molten magmas traverse stratified rocks they often send off branches parallel to the bedding planes; the rock masses filling such fissures are called *sills* or *sheets* when comparatively thin, and *laccoliths* when occupying larger chambers produced by the force propelling the magmas upward. Within rock inclosures molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. When the channels reach the surface the molten material poured out thru them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks thus formed upon the surface are called *extrusive*. Lavas cool rapidly in the air, and acquire a glassy or, more often, a partially crystalline condition in their outer parts, but are more fully crystalline in their inner portions. The outer parts of lava flows are usually more or less porous. Explosive action often accompanies volcanic eruptions, causing ejections of dust, ash, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs. Volcanic ejecta may fall in bodies of water or may be carried into lakes or seas and form sedimentary rocks.

Sedimentary rocks.—These rocks are composed of the materials of older rocks which have been broken up and the fragments of which have been carried to a different place and deposited.

The chief agent of 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 are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. In smaller portion the materials are carried in solution, and the deposits are then called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the deposits may be separately formed, 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 glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks, with reference to the sea, over wide expanses; and as it rises or subsides the shore lines of the ocean are changed. As a result of the rising of the surface, marine sedimentary rocks may become part of the land, and extensive land areas are in fact occupied by such rocks.

Rocks exposed at the surface of the land are acted upon by air, water, ice, animals, and plants. They are gradually broken into fragments, and the more soluble parts are leached out, leaving the less soluble as a *residual* layer. Water washes residual material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of standing water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it is called *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. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by a variety of processes, rocks may become greatly changed in composition and in texture. When the newly acquired characteristics are more pronounced than the old ones such rocks are called *metamorphic*. In the process of metamorphism the substances of which a rock is composed may enter into new combinations, certain substances may be lost, or new substances may be added. There is often a complete gradation from the primary to the metamorphic form within a single rock mass. Such changes transform sandstone into quartzite, limestone into marble, and modify other rocks in various ways.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried and later have been raised to the surface. In this process, through the agencies of pressure, movement, and chemical action, their original structure may be entirely lost and new structures appear. Often there is developed a system of division planes along which the rocks split easily, and these planes may cross the strata at any angle. This structure is called *cleavage*. Sometimes crystals of mica or other foliaceous minerals are developed with their laminæ approximately parallel; in such cases the structure is said to be schistose, or characterized by *schistosity*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are important exceptions.

FORMATIONS.

For purposes of geologic mapping 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, a rapid alternation of shale and limestone. When the passage from one kind of rocks to another is gradual it is sometimes necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation is constituted of one or more bodies either containing the same kind of igneous rock or having the same mode of occurrence. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics.

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

AGES OF ROCKS.

Geologic time.—The time during which the rocks were made is divided into several *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by naming the time interval in which it was formed, when known.

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

(Continued on third page of cover.)

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be determined by observing their positions. This relationship holds except in regions of intense disturbance; in such regions sometimes the beds have been reversed, and it is often difficult to determine their relative ages from their positions; then *fossils*, or the remains and imprints of plants and animals, indicate which of two or more formations is the oldest.

Stratified rocks often contain the remains or imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed 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 peculiar forms, which 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. When two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains found in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it.

Similarly, the time at which metamorphic rocks were formed from the original masses is sometimes 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 of their metamorphism.

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.

Symbols and colors assigned to the rock systems.

	System.	Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent; Pleistocene	Q	Brownish-yellow.
	Tertiary	Pliocene; Miocene; Oligocene; Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ꞧ	Peacock-blue.
Paleozoic	Carboniferous.	Permian; Pennsylvanian; Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian	Saratogan; Acadian; Georgian	Є	Brick-red.
	Algonkian		A	Brownish-red.
	Archean		Æ	Gray-brown.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea or in lakes. 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 known to be of sedimentary or of igneous origin.

The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system. The symbols by which formations are labeled consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters. The names of the systems and recognized series, in proper order (from new to old), with the color and symbol assigned to each system, are given in the preceding table.

SURFACE FORMS.

Hills and valleys and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow thru them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; sea cliffs are made by the eroding action of waves, and sand spits are built up by waves. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are produced in the making of deposits and are inseparably connected with them. The hooked spit, shown in fig. 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, and these are, in origin, independent of the associated material. 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 first built and afterwards partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the even surface thus produced is called a *peneplain*. If the tract is afterwards uplifted the peneplain at the top is a record of the former relation of the tract to sea level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—This map shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any colored pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—This map represents the distribution of useful minerals and rocks, showing their relations to the topographic features and to the geologic formations. The formations which appear on the areal geology map are usually shown on this map by fainter color patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A mine symbol is printed at each mine or quarry, accompanied by the name of the principal mineral mined or stone quarried. For regions where there are important mining industries or where artesian basins exist special maps are prepared, to show these additional economic features.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks, and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface, and can draw sections representing the structure of the earth to a considerable depth. Such a section exhibits what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

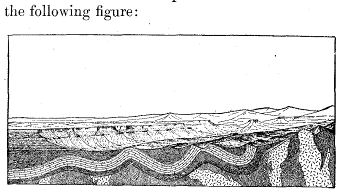

Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which 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 symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

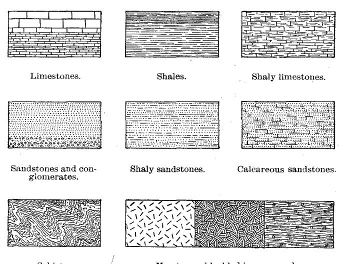

Fig. 3.—Symbols used in sections to represent different kinds of rocks.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a 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 strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

Strata are frequently curved in troughs and arches, such as are seen in fig. 2. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets; that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in fig. 4.

On the right of the sketch, fig. 2, the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be

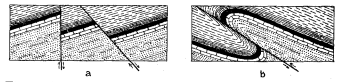

Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

The section in fig. 2 shows three sets of formations, distinguished by their underground relations. The uppermost of these, seen at the left of the section, is a set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been raised from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger rocks thus rest upon an eroded surface of older rocks the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum which appears in the section may be measured by using the scale of the map.

Columnar section sheet.—This sheet contains a concise description of the sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness of each is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest formation at the bottom, the youngest at the top.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

GEORGE OTIS SMITH,

Director.

May, 1908.

DESCRIPTION OF THE ACCIDENT AND GRANTSVILLE QUADRANGLES.[a]

Prepared under the supervision of William Bullock Clark, cooperating geologist.

By G. C. Martin.

INTRODUCTION.

LOCATION AND AREA.

The Accident and Grantsville quadrangles are adjacent and are situated for the most part in the northwest corner of Maryland. They are bounded by parallels of latitude 39° 30′ and 39° 45′ and by meridians of longitude 79°, 79° 15′, and 79° 30′. Each quadrangle covers one-sixteenth of a square degree, or about 230 square miles.

The greater part of these quadrangles lies in Garrett County, Md. A strip about 2 miles wide extending across the northern edge of both quadrangles is in Fayette and Somerset counties, Pa., and another strip two-thirds of a mile wide on the western edge of the Accident quadrangle is in dispute between Garrett County, Md., and Preston County, W. Va. The southeast corner of the Grantsville quadrangle lies in Allegany County, Md. The largest towns are Friendsville, Md., and Accident, Md., in the Accident quadrangle, and Elklick, Pa., Grantsville, Md., and Barton, Md., in the Grantsville quadrangle.

RELATION TO SURROUNDING REGION.

These quadrangles are but a small portion of a large region—the Appalachian Province—with part of which it has much in common. It is consequently necessary to note these broader features in order to grasp the full significance of the more detailed local descriptions which follow.

APPALACHIAN PROVINCE.

The Appalachian Province consists of three well-marked physiographic and geologic subdivisions, which form parallel belts, each being more or less continuous from north to south throughout the greater part of the province. These divisions are a moderately high plateau region on the west, which includes the Allegheny Plateaus in the northern part of the province; a ridge-and-valley region (the "Appalachian valley") in the center; and a region of much dissected mountains and low plateaus on the east. Only the first district is represented in these quadrangles.

The rocks of the Appalachian Province are in large part of Paleozoic age, of sedimentary origin, are fully consolidated, and include both metamorphosed and unmetamorphosed types. All the rocks of the Allegheny Plateaus are of Paleozoic age, chiefly Devonian and Carboniferous, and are unaltered. The structure is comparatively simple. The strata lie in the main nearly flat and are disturbed by only small faults and by low, broad folds which, compared with the larger folds farther east, usually have but slight effect on the general geologic features and topography. East of the Allegheny Plateaus, throughout much of the province, are areas of alternating ridges and valleys, where the rocks are nonmetamorphosed sediments entirely of Paleozoic age, which are steeply folded and faulted, and occur in parallel belts in which the same rocks are repeated in their outcrop many times from west to east. The eastern part of the province contains rocks which are greatly disturbed by folds and faults and which are in places so metamorphosed that their original characters can be determined with difficulty. Some of these rocks are of pre-Paleozoic age, some are of igneous origin, and at places they include areas of Mesozoic sedimentary and igneous rocks, which rest unconformably on the much older crystallines.

ALLEGHENY PLATEAUS.

Position and boundaries.—The Allegheny Plateaus extend from an indefinite western boundary in the Mississippi and Ohio valleys to a much more distinct eastern boundary on the Allegheny Front and its southern extension. The Allegheny Front, which constitutes a distinct escarpment with a steep eastern face, holds a fairly constant linear position throughout central Pennsylvania. It does not, however, continue southward on this line until Maryland is reached, but may be considered as swinging eastward in southeastern Somerset County and taking a new position farther east. This line crosses Maryland a few miles east of the Grantsville quadrangle, thus placing the entire area here under discussion within the Allegheny Plateaus.

The geologic structure, surface features, and drainage arrangement of the Allegheny Plateaus have been described by Campbell (Latrobe folio, No. 110) substantially as follows:

Geologic structure.—The structure of the Allegheny Plateaus is comparatively simple. The strata lie nearly flat, and their regularity is broken only by small faults and low, broad folds which usually have little effect upon the general features of geology and topography.

The most pronounced fold is a low, broad arch known as the Cincinnati anticline. The main axis of this fold enters the Allegheny Plateaus from the direction of Chicago, and a minor fold from the western end of Lake Erie joins the major axis near the type locality, Cincinnati. From Cincinnati the anticline passes due south to Lexington, Ky., and there curves to the southwest, parallel with the Appalachian Valley, as far as Nashville, Tenn. Its maximum development is in the vicinity of Lexington, where the Trenton limestone is exposed at the surface at an altitude of 1000 feet above sea level; but in Tennessee it again swells into a domelike structure which is represented topographically by the central basin of Tennessee.

This anticline separates the Allegheny Plateaus into two structural basins, which are best known by the coal regions that they contain. The western basin extends far beyond the limit of the province and contains the Eastern Interior coal region of Illinois, Indiana, and Kentucky. The eastern basin lies entirely within the limits of the Allegheny Plateaus and is generally known as the Appalachian coal region. * * *

Since the Appalachian coal region is a structural basin or trough, the strata around its margin generally dip toward the center of the field. This is particularly noticeable on the two sides, the rocks on the northwestern side dipping gently but regularly to the southeast and those of the southeastern side dipping more strongly to the northwest. In Pennsylvania and West Virginia the regularity of the dip on the southeastern limb of the trough is interrupted by parallel folds which, where hard rocks are involved, give rise to anticlinal ridges and synclinal valleys. These undulations are similar to the great folds east of the Allegheny Front, except that they are developed on a very much smaller scale and have not been broken by faults, as have many of the folds farther east. Across the northern extremity of the basin, where the rocks are nearly flat, there are a great many of these minor folds, which extend southwestward at least halfway across Pennsylvania from its northern boundary. In the southern part of the State there are only six pronounced anticlines, and two of these disappear near the West Virginia line. Farther south the number is reduced, until on Kanawha River the regular westward dip is interrupted by only one or two small folds.

Drainage.—Most of the surface water of the Allegheny Plateaus finds its way into the Mississippi, but that which drains the northeastern end flows either northwestward into the Great Lakes or southeastward through Potomac, Susquehanna, Delaware, and Hudson rivers into the Atlantic Ocean.

The arrangement of the drainage lines in the northern part of the province is largely due to the advance of the ice sheet during the glacial epoch. Before that time, it is supposed, all the streams north of central Kentucky flowed northward and discharged their waters through the St. Lawrence system. The encroachment of the great ice sheet closed this northern outlet, and new drainage lines were established along the present courses of the streams.

In the southern half of the province the westward-flowing streams have their sources on the summit of the Blue Ridge and flow across the Appalachian Valley as well as the Cumberland Plateau.

Surface relief.—The surface of this division of the province is composed, as its name implies, of a number of plateaus of different altitude and extent. The most pronounced of these occupies the southeastern portion of the division and extends nearly the whole length of the province. This plateau is very old, and its surface is so greatly dissected that its plateau character is not always apparent. It emerges from beneath the Cretaceous cover in central Alabama at a height of 500 feet above sea level. From this altitude it ascends to 1700 feet at Chattanooga, 2400 feet at Cumberland Gap, 3500 feet at New River, and probably 4000 feet at its culminating point in central West Virginia. From this point it descends to about 2600 feet on the southern line of Pennsylvania and to 2100 or 2200 feet in the central part of the State. Farther north the plateau increases in width, including most of the northern counties of Pennsylvania and the southern counties of New York, and ranges in altitude from 2000 to 2400 feet.

The character and altitude of this plateau vary greatly in different parts of the province, depending upon the character of the underlying rocks, the general drainage conditions, and the crustal movements which have affected this region. In its southern part conditions have been very favorable to the preservation of the plateau, and large areas of its even surface are still visible in Lookout and Sand mountains and in the Cumberland Plateau. North of Tennessee the cap of hard sandstone which protects the Cumberland Plateau is lacking and the surface is completely dissected, showing only rounded hilltops as the possible representatives of its once even surface. In northern West Virginia a few remnants of the original plateau are preserved where conditions are especially favorable, but generally the surface is so deeply eroded that it is difficult to realize that it was once approximately flat and extended over most of the Appalachian region. In the northern part of Pennsylvania conditions are similar to those prevailing in Tennessee, and areas of considerable size are still preserved intact where they are protected by the massive sandstones of the Pottsville formation.

Throughout most of the province knobs and ridges rise to a greater height than the old surface of this plateau. Usually these may be distinguished by the fact that they stand above the general level of the surrounding hills.

The plateau slopes westward, but it is generally separated from the next lower plateau by a more or less regular westward-facing escarpment. This feature is most pronounced in Tennessee, where it has a height of 1000 feet and separates the Cumberland Plateau on the east from the Highland Plateau on the west. Its height diminishes toward the north, falling to 500 feet in central Kentucky; and north of Ohio River it is so indistinctly developed that it is doubtful whether it has been recognized. In southern Pennsylvania it becomes more pronounced where the hard rocks of Chestnut Ridge rise abruptly above the plain formed on the soft rocks of the Monongahela Valley, but the surface of the upper plateau is so greatly dissected that it can be recognized with difficulty. Toward the central part of the State the plateau surfaces that usually are separated by this escarpment approach each other, and the escarpment is merged in a mass of irregular hills which seem to represent all that is left of the higher plateau.

The lower plateau surface is best developed as a distinct feature in Tennessee and Kentucky. In the former State it is known as the Highland Plateau, and in the latter as the Lexington Plain. Its surface slopes gently to the west, but along its eastern margin throughout these States it holds a constant altitude of about 1000 feet above sea level. North of Ohio River it is less perfectly developed, but presumably it constitutes most of the surface of Ohio, eastern Indiana, western Pennsylvania, and southern New York. Throughout most of this territory the plateau was developed on harder rocks than in Kentucky and Tennessee, and the result is that the surface is less regular and the position of the base-level of that epoch is difficult to determine. It seems to rise eastward from an altitude of 700 or 800 feet in Indiana to 1000 feet in central Ohio, 1200 to 1300 feet in southwestern Pennsylvania, and probably reaches 2200 feet at its culminating point in the northern part of the State.

The surface features of this plateau are variable, but there is not so much diversity as is shown in the surface of the higher plateau. In Kentucky and Tennessee it is preserved over large areas as a nearly featureless plain, but in other States it was less perfectly developed, and it has suffered greatly from dissection since it was uplifted to its present position.

West of this intermediate zone there is a third plain, which is developed only in the great central basin of Tennessee and in the western parts of Kentucky and Indiana.

INDUSTRIES AND COMMERCE.

The two quadrangles described in this folio are in an essentially agricultural region, although the Georges Creek Valley, which has very important coal mining interests, forms a small part of the southeast corner of the Grantsville quadrangle. The industries of the remainder of both quadrangles are restricted to farming and lumbering; the latter was formerly of considerable importance, but has become a minor industry by reason of the exhaustion of the most valuable timber.

The best soils are situated on the ancient lowland surfaces, especially on that now existing as an upland on the areas of Devonian rocks.

The greater part of the region is lacking in good facilities for transportation. The main line of the Baltimore and Ohio Railroad, extends for a short distance along the southern margin of the Grantsville quadrangle, and the Cumberland and Pennsylvania Railroad crosses its southeast corner. Branches of the Baltimore and Ohio Railroad reach points in the lower parts of the valleys of Castleman and Youghiogheny rivers. The National Road crosses the northern part of both quadrangles and was formerly an important highway between the Atlantic coast and the Ohio Valley, but since the construction of railways it has fallen into disuse and is now only one of the poorer of the local highways.

TOPOGRAPHY.

DRAINAGE.

The divide between the Ohio and the Potomac drainages passes through the Grantsville quadrangle. The waters of the Accident quadrangle all ultimately flow north and west in Youghiogheny and Castleman rivers, which join the Ohio. The drainage of the Grantsville quadrangle is equally divided between the Youghiogheny and Castleman tributaries of the Ohio drainage, and Savage River and Georges Creek, which flow into the Potomac.

There is in general a close relationship between the position of the larger streams and the character and attitude of the underlying rocks. Georges Creek, Castleman River, and a large part of the course of Youghiogheny River flow down the axes of synclines which are occupied by the soft rocks of the coal-bearing formations. Many other smaller streams have longitudinal courses on the long, narrow outcrops of the easily eroded Greenbrier limestone. There are, however, other streams, such as Youghiogheny River in part of its course and its tributaries Muddy Creek, Deep Creek, Bear Creek, and White Creek; Piney Run in the Castleman drainage; and Savage River, which have courses that are independent of the present surface distribution of the rocks.

None of the streams of this region are navigable, and none are used for waterpower, except on a small scale, although the best power which is on Youghiogheny River, is not utilized.

Youghiogheny River basin. — Youghiogheny River crosses the Accident quadrangle from south to north, receiving tributaries which drain the greater part of this quadrangle. To the south of this quadrangle the Youghiogheny Valley is situated for the most part on the weak rocks of the Allegheny and Conemaugh formations in synclinal attitude, where the river has a low grade and the valley is broad, with gentle slopes. Where it

[a] These quadrangles have been surveyed in cooperation with the Maryland Geological Survey, the field work having been completed by G. C. Martin when a member of that Survey. A fuller discussion of the area, accompanied by a geologic map, will be found in the Maryland Survey "Report on the physical features of Garrett County," by Mr. Martin, also in other reports issued by the Maryland Survey.

This folio is one of several describing the quadrangles that lie between the Allegheny Plateau and the sea along the northern border of Maryland, to be published in cooperation with the Maryland Geological Survey. These folios will form an educational series to illustrate the geology of the middle Atlantic slope enters the quadrangle, however, it has left these rocks and is flowing through the more resistant Pottsville sandstone. For this reason the river has a steep and irregular grade, often with cascades, and is in a deep and rugged valley. The Pottsville is entirely cut through and the Mauch Chunk shale and Greenbrier limestone occupy the bottom of the valley in the vicinity of Sang Run. The river then leaves these weak rocks, cuts again through a ridge of Pottsville, and enters another syncline occupied by the weak rocks of the Allegheny and Conemaugh formations. It then flows down the axis of this syncline, the stream grade lessening and the valley widening as the river passes from the Allegheny to the Conemaugh. An alluvial flat extends along the river course from Friendsville to the northern edge of the quadrangle. The cause of this flat may be found in the fact that the river is here flowing in the soft shales overlying the Mahoning sandstone, while the sandstone itself rises above the river banks at the north end of the flat, forming a resistant dam above which the river is widening its valley and spreading sediments over its floor.

The Youghiogheny receives as tributaries in the southern part of the quadrangle, Deep Creek, Muddy Creek, and Saltblock Run, which, after draining flat areas in the easily eroded Greenbrier and Mauch Chunk formations, cross the ridges of resistant Pottsville sandstone in deep gorges. Of these Deep Creek has a tributary (Cherry Creek) which rises on the soft shales of the Allegheny and Pottsville formations, near the headwaters of Castleman River, flows up the axis of the syncline, across the Pottsville Ridge on the nose of the fold, and, falling steeply, joins Deep Creek on its flat Greenbrier belt. Youghiogheny River also receives, in the northeastern part of the quadrangle, Bear Creek, Mill Run, and Whites Creek, which have their sources on soft Catskill shales and cross transversely over both the Mauch Chunk and Greenbrier weak rocks and the Pocono and Pottsville ridges, joining the Youghiogheny in its lower synclinal valley. It also receives in the northwestern part of the quadrangle, many streams having their sources within the synclinal basin, flowing in natural courses down the flanks of the fold, and joining the main stream near the axis of the fold.

Castleman River basin.—The Castleman drainage basin is situated in the northwest half of the Grantsville quadrangle and the southeast quarter of the Accident quadrangle. It occupies in general a northward-pitching syncline of upper Carboniferous rocks. Castleman River flows along and down the axis of this syncline and drains the entire area except a few square miles at the south end, which Cherry Creek drains out across the ridge of Pottsville sandstone into the valley of Deep Creek. It has the course which the original drainage of this basin would naturally take and is thus an apparent trough-consequent or a resequent stream. The tributaries of Castleman River occupy apparent lateral consequent courses down the flanks of the syncline, and all head within the rim of Pottsville except Piney Run, which crosses the Pottsville and Pocono ridges on the east rim of the basin, near the Pennsylvania–Maryland line, having its sources on the softer areas of Devonian and lower Carboniferous rocks. Piney Creek is the only one of the Castleman tributaries of this area which has been able to break the Pottsville and Pocono ridges and establish tributaries on the weaker rocks beyond. Its downstream position doubtless aided in enabling it to do this, which the higher tributaries of the Castleman have failed to do.

Savage River basin.—Savage River drains an area about 17 miles long from northeast to southwest and 6 miles broad, extending through the south-central part of the Grantsville quadrangle. This area is bounded on the northwest and southeast respectively by Meadow Mountain and Big Savage Mountain, two Pottsville ridges, between which is an anticlinal region occupied by Devonian and lower Carboniferous rocks. Savage River rises on the eastern edge of this area, just beyond the limits of the quadrangle, and flows southwestward along the eastern part of the belt in a deeply incised, somewhat meandering valley until it approaches the south-central edge of the quadrangle, where it turns abruptly east through the Pottsville ridge made by Big Savage Mountain and joins Potomac River. Its most interesting tributaries are a series of remarkably straight streams flowing along belts of Greenbrier limestone. Those on the eastern Greenbrier belt, after rather long, straight, low-grade courses, drop steeply into the Savage. Those on the western belt have shorter courses on the limestone and then turn east through deep valleys which cross the Pocono and Devonian rocks, joining the Savage near the eastern edge of the latter. Two small tributaries, having their courses on the upper Carboniferous rocks east of Big Savage Mountain, join Savage River near the southern margin of the quadrangle.

Georges Creek basin.—Georges Creek, which has both its mouth and its sources and the greater part of its length and drainage area east of the region here described, crosses the southeast corner of the Grantsville quadrangle and drains all of the area east of Big Savage Mountain except the two small valleys already described as tributary to Savage River. Georges Creek flows from northeast to southwest along the axis of a syncline in upper Carboniferous rocks. It has its source near the lowest point on the axis of the syncline and flows up the axis until it joins Potomac River, which, coming down the same syncline from the south, crosses the fold from northwest to southeast, in line with the lower course of Savage River. The tributaries of Georges Creek all rise on upper Carboniferous rocks within the syncline and flow from either side toward the axis.

RELIEF.

The most striking features of the relief of this region are a series of high, approximately parallel, even-topped ridges, sustained by monoclinal beds of Pottsville sandstone; a series of lower, even-topped ridges, marking the outcrop of the Pocono sandstone, which are parallel to the Pottsville ridges and are separated from them by valleys situated on the outcrops of the Mauch Chunk shale and the Greenbrier limestone; broad areas of lower country on which rather flat areas of accordant elevation are well developed; and deeply incised valleys which cut across both topography of diverse types and rocks and structures of various kinds.

Pottsville ridges.—Wherever in this region the Pottsville sandstone has for a considerable distance uniform strike and lithologic character and steep dip, it outcrops as a long, high, straight ridge with fairly uniform though gently undulating crest, not gashed by deep gaps save where large streams cross it, and usually overtopping the surrounding country. Such ridges are Big Savage, Meadow, and Negro mountains. Where the strike or character of the rock is less uniform and the dip lower the ridge is less regular in course and summit. It becomes sinuous, its higher tops still rise to the same general elevation as the crests of the more regular ridges, but fewer attain that height and deeper gashes cut the crest line. Winding Ridge and the irregular group of high summits to the south of it, including Dog Ridge, Whites Knob, Lewis Knob, Snaggy Mountain, and Marsh Hill, represent this condition. The crest of the Pottsville ridge is usually very close to the base of the formation, and is always nearer the base than the top. The elevation of the Pottsville ridges may be seen in the following table:

Summary of elevations on the Pottsville ridges.

	Highest top.	Mean of tops.	Lowest top.	Mean of crest.	Highest saddle.	Mean of saddles.	Lowest saddle.
Dans Mountain	2898	2517	2000	2478	2800	2433	1820
Big Savage Mountain	3022	2905	2770	2863	2910	2819	2650
Great Backbone Mountain	3400	3129	2820	3086	3300	3042	2800
Meadow Mountain	3031	2945	2730	2898	2970	2843	2690
Negro Mountain	3082	2948	2830	2899	2930	2847	2730
Winding Ridge	3073	2822	2610	2767	2850	2650	2470
Snaggy Mountain	3110	2932	2790	2893	2930	2833	2770

Pocono ridges.—The Pocono outcrops follow the general law of topographic expression stated above for the Pottsville. The Pocono ridges are consequently long and straight, with evenly undulating crests, where the strike and lithologic character are uniform and the dip is steep. They are less regular in trend and in the altitude of their lower peaks and of their gaps and saddles where the dip and rock character are less regular and the dip is gentler. They differ from the Pottsville ridges only as the character of the rock composing them differs from that of the Pottsville. Since the Pocono sandstone is in general less resistant than the Pottsville sandstone and conglomerate, the Pocono ridges are in general lower than the Pottsville ridges. The elevation of the Pocono ridges is shown in the following table.

The table shows that the Pocono ridges have almost or quite as great a regularity in crest line as the Pottsville ridges, though the general elevation is from 100 to 200 feet lower. Keyser Ridge and its extension to the southwest is much higher than the other Pocono ridges and is even higher than the neighboring Pottsville belt on Winding Ridge. This is due to the fact that the Pocono in this part of the region is composed largely of very massive conglomerate. The Pocono ridge west of this, which extends northward from Hoyes probably owes its lower elevation to recent active erosion which has not yet reached the headwater drainage on Keyser Ridge.

Summary of elevations on the Pocono ridges.

	Highest top.	Mean of top.	Lowest top.	Mean of crest.	Highest saddle.	Mean of saddles.	Lowest saddle.
Fourmile Ridge	2110	2801	2710	2769	2850	2733	2610
Red Ridge	2870	2718	2630	2693	2730	2662	2590
Keyser Ridge	3004	2853	2570	2796	2870	2725	2550
Hoyes	2790	2646	2430	2602	2710	2546	2350

The crests of the Pocono ridges, like those of the Pottsville, are nearer the base than the top of the formation and are usually not far from the base.

Devonian uplands.—A region of low relief extends across the northeast corner of the Grantsville quadrangle from Red Ridge to Fourmile Ridge, which is extended beyond the eastern edge of the quadrangle in Little Savage Mountain. This is an area of Devonian rocks which rise in an anticlinal arch between the Pocono ridges. It is a region of unevenly distributed, low, rounded hills, most of which have their summits at elevations of 2600 to 2700 feet and their bases at 2400 to 2500 feet. The elevation and position of these hills bear no relation to the structure of the underlying rocks and little relation to their lithologic character. Their linear direction, where they have one, is usually across the strike of the rocks. A similar Devonian upland may be seen in the southwest corner of the same quadrangle, whence it extends southwestward for many miles and is better developed than in these quadrangles. Within the deeply dissected valley of Savage River are flat-topped hills and ridges, such as Pea Ridge, Turkey Lodge Hill, Jenkins Hill, Peapatch Ridge, Solomans Ridge, and Tom Ridge, which retain upon their summits surfaces of the same character and of the same altitudes as the broader uplands already described. They are separated by deep valleys whose slopes have a different profile and a different significance from the gentler upland surfaces. There is thus an upland existing on the Devonian rocks and extending at the same general elevation throughout the length of this anticline, save where Savage River and its tributaries are eating out a more rugged topography below it.

Another area of Devonian rocks is exposed in the vicinity of Accident, where it is encircled by Pocono sandstone ridges, the structure being that of a steeply domed anticline. Here again are upland areas whose general surface has altitudes of 2400 to 2700 feet and which are characterized by a much gentler and more regular topography than either the Pocono ridges above them or the gorges of Bear and Whites creeks below.

Synclinal valleys.—It has already been shown that much of the valley of Youghiogheny River and all of the valleys of Castleman River and Georges Creek occupy structural basins in which the main stream flows near the axis, the divide is upon the bounding rim of Pottsville ridges, and the tributaries flow down the dip at right angles to the axis from either side.

The Castleman syncline and river basin is an excellent example of a synclinal valley of this kind. There is here, however, a basin within a basin. The rim of the inner basin is held up by the Mahoning sandstone, which outcrops on the crest of Chestnut Ridge and Salt Block Mountain, at the east end of Maynardier Ridge, and along a series of less prominent and unnamed hills and ridges which may be traced in the same relative position throughout the greater part of the valley. The same feature is present, though less clearly shown, in Georges Creek valley, and suggestions of it may be found at places in the lower Youghiogheny Valley. There is of course a line of saddles and short valleys between these Mahoning ridges and the Pottsville ridges. The same relation of rock outcrop to topography holds in these valleys as in the Greenbrier valleys described below. The upper resistant bed (in this case the Mahoning sandstone) has its base near the crest of the ridge, the underlying weak rocks (here the Allegheny formation) occupies the steep slope of the valley on the side in the direction of the down dip, and the contact of the soft rock with the underlying resistant rocks (Pottsville) is near the bottom of the valley. Another phase of the relationship has been stated by the writer (Maryland Geol. Survey, Garrett County, 1902, p. 101) as follows:

> It may be stated as a law that where the Pottsville outcrops as a mountain ridge, the basal contact will lie not far from the crest of the mountains and on the side opposite to the direction of dip, while the upper contact will be marked by a line of headwater streams which come together in pairs at a series of points which usually mark the places of greatest width of the Pottsville. On Big Savage Mountain the contacts follow this law very closely.

The elevation of the Mahoning ridges is variable, but appears to be in general about the same as the higher summits of the Devonian upland. The higher saddles in these ridges and the higher valley zones between the Mahoning and the Pottsville ridges agree fairly well in altitude with the lower slopes of the Devonian upland.

Within the inner synclinal valleys the relief has a variety of form which does not admit of much broad generalization. The higher hills are irregularly distributed and usually have their longest dimension in the direction of dip rather than of strike. Their summits are in general higher toward the edge of the basin, and have as limits of altitude the upper and lower limits of the Devonian upland. The crests of these hills are usually capped by sandstone, and the hills are plateau topped or linear according as the dip is flat or steep. The hills become lower as the axis of the syncline and the line of main drainage is approached, and are in this position frequently terraced, the terraces being local but agreeing in position and in slope with the more resistant sandstones.

Limestone valleys.—The Pottsville and Pocono ridges are separated by a valley occupied by the outcrops of the Mauch Chunk shale and the Greenbrier limestone. The Mauch Chunk usually extends from near the crest of the Pottsville ridge to the base of the steeper slope of the valley. The Greenbrier occupies the lower part of the valley, extending from the base of the steeper slope on the Pottsville side usually to the bottom of the valley or a little beyond, but never above the base of the steeper slope on the Pocono side. These valleys follow the strike of the rocks and the trend of the Pocono and Pottsville ridges. They maintain in general a fairly uniform altitude, and where they depart from it the higher limits are nearly constant. The Greenbrier limestone does not occur within these quadrangles, either at or below the surface, at a greater altitude than 2700 feet, and the greater part of its outcrop is above 2500 feet. This means that a base-level at or above the present 2500-foot level was maintained until it reduced the entire outcrop of the Greenbrier below the 2700-foot level and most of it to a series of flat valleys with almost no grade. The greater part of the present Greenbrier areas still remain near the position of this old surface. It is in general only where the country is deeply trenched by youthful streams which cut the Pottsville ridges that this old surface on the Greenbrier has been destroyed and the limestone exposed at lower levels.

Transverse valleys.—It has already been stated in the chapter on drainage that Youghiogheny River with several of its branches, Savage River, and Potomac River cut across the Pottsville ridges in deep gorges.

The Youghiogheny gorge leads from one synclinal basin of upper Carboniferous rocks into another. Savage River and the eastern tributaries of the Youghiogheny flow from anticlinal areas of Devonian rocks across the Pottsville ridges into the upper Carboniferous synclinal basins. Potomac River turns from its course along and down the axis of a syncline occupied by the upper Carboniferous formations, and cuts directly through a Pottsville ridge and flows thereafter over older rocks. These valleys, including both the narrow gaps through the Pottsville ridges and the valleys in the Devonian rocks above the gaps, are deep and rugged. Their courses are not determined by any distinct structural lines. They cross all the rocks of the quadrangles and consequently bear no constant relationship to the lithology. They constitute a feature of the drainage and relief which is entirely independent of the features already discussed, and they bear no simple relationship to the existing general outline of the topography; they must therefore be regarded either as an inheritance from topographic conditions which are past or as the product of a chance succession of headwater captures and diversions. They are, in short, youthful valleys which have cut below a topography that formerly extended over the region and which are destroying that topography and bringing into existence a new and different series of features of drainage and relief. The top of the scarp which separates these young valleys from the Devonian upland is at a very well-marked elevation of 2400 to 2600 feet on Savage River and 2300 to 2600 feet on the eastern tributaries of the Youghiogheny. A similar scarp having an elevation of 2400 to 2500 feet divides the gorge of Youghiogheny River from the more even-topped Pottsville areas on either side.

Summary.—The following features of the relief of these quadrangles have been discussed in detail and may now be summarized, compared, and interpreted:

Pottsville ridges; having summits at elevations of 2600+ to 3100 feet, average crests at 2767 to 2899 feet, and saddles at 2460+ to 2960+ feet.

Pocono ridges; having summits at 2420+ to 3004 feet, average crests at 2602 to 2796 feet, and saddles at 2340+ to 2860+ feet.

Devonian uplands; having a general elevation where not sharply dissected of 2400 to 2770 feet.

Synclinal valleys in the upper Carboniferous rocks; containing higher summits which range in elevation from 2500 to 2800 feet and lower well-marked elevations near the axes of the basins, the best developed of which are at 1900 and 2100 feet and all of which are influenced in position and in degree of development by resistant sandstones with low dips.

Limestone valleys; having remarkably uniform elevations of 2400 to 2700 feet, most of the area being between 2500 and 2600 feet, and lower outcrops present only in areas of youthful drainage.

Transverse valleys; which cross the Pottsville ridges as deep gorges and drain steep-sided valleys cut in all kinds of rock with no regard to structure or lithologic character. These valleys are sharply incised below mature upland plateau and ridge topography and separated from it in a well-marked scarp having an altitude of 2400 to 2600 feet.

The most sharply drawn boundary line in the physiographic features and in the physiographic history of this region is the top of the scarp which separates the rugged and youthful gorges of Savage River from the old, even-featured upland which extends over the Devonian rocks of the anticline between Big Savage and Meadow mountains. A similar scarp exists at almost the same elevation between the gorges of Bear Creek and Whites Creek and the Devonian upland, and another is found at about the same altitude between the Youghiogheny gorge and the mature slopes on the adjacent Pottsville areas.

The topographic features above this scarp could not have been produced under the conditions which are now producing the features below the top of the scarp. The conditions that are causing the latter are destroying the former. The Devonian upland was produced in at least its present degree of maturity before the gorges of Savage and Youghiogheny rivers and Bear and Whites creeks were cut.

The Greenbrier limestone valleys, the high summits in the synclinal valleys, most of the saddles in the Pocono ridges, and a few of the Pottsville saddles agree in elevation with the Devonian uplands. We may therefore conclude that the same conditions which reduced the Devonian uplands reduced the synclinal and the limestone valleys and cut notches in the Pocono and Pottsville ridges at the same general level.

This restored upland would have had upon it lines of Pocono hills with elevations of 120 to 700 feet above its present general lower portions, or 0 to 300 feet above its present summits, and Pottsville ridges with elevations of 300 to 800 feet, or 0 to 400 feet above the same datum planes. The average Pocono crests would be 300 to 500 feet above the lower, or 0 to 100 feet above the higher datum, while the average Pottsville crests would be 460 to 600 feet above the former and 60 to 200 feet above the latter.

The question arises as to whether these higher elevations on the Pocono and Pottsville rocks can be considered as contemporaneous in origin with the Devonian upland. The writer believes that in the formation of such a surface as the latter, the uneroded Pocono and Pottsville residuals could have assumed such forms as these, and that consequently the assumption of a still earlier truncation with the land standing at a different level is unnecessary and unwarranted. He would consider the 2500- to 2700-foot mature upland as representing the highest and oldest record of conditions of erosion of which we have proof or significant indication in this region.

The 2100- and 1900-foot levels in the synclinal valleys will now be considered. These levels show most clearly in the Youghiogheny Valley where the top of the scarp along both sides of the river is at the 1900-foot elevation. Back of the scarp are broad areas not exceeding 100 feet in relief, while farther back is a second less distinct scarp with 2100-foot flats above it. Where best developed these levels and scarps usually coincide in position with beds of weak and resistant rock. For example, the Connellsville sandstone outcrops on the edge of the scarp opposite Friendsville and opposite Guard, while the flat areas back of it are occupied by the easily eroded shales and limestones of the upper 100 feet of the Conemaugh formation. Similar relations hold at many other points, but the essential character of these features is that the altitude, not the relation to the rock, is persistent—that the character of the rock determines the degree of perfection and not the position of the bench. Castleman River, where it leaves the Grantsville quadrangle, is flowing in a broad alluvial valley at an elevation of 2000 feet. Benches at elevations of 2100 and 1900 feet are well developed in the Georges Creek valley. An approximately level surface slightly below 2100 feet in elevation is well developed just west of the northwest corner of the Accident quadrangle, where it is probably on the Mahoning sandstone. A surface at the same elevation is well developed and has been described by Campbell in the adjacent Uniontown quadrangle, where he regarded it as recording a halt of problematical age, in the elevation of the land, "long enough to broaden the valleys and reduce much territory nearly to drainage level." The same level or a slightly lower one may be seen in the crests of some of the ridges in the Potomac Valley east of the Grantsville quadrangle.

It seems well established that there was throughout this region a clearly defined base-level corresponding to the present 1900- or 2100-foot surface, and that large areas were reduced to it. The rugged transverse valleys contain no indication of this surface. If it was ever developed there it has been cut away.

Lower erosion levels have been recognized in the surrounding areas, but the land of these quadrangles stands too high to contain them.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

The rocks of the Accident and Grantsville quadrangles consist of fully indurated but otherwise unaltered shales, sandstones, conglomerates, limestones, and coal beds. They represent material derived from the destruction of older rocks and laid down in water. Metamorphic and igneous rocks are entirely absent.

The rocks which outcrop at the surface in these quadrangles have been named and grouped as shown below and also on the columnar section sheet.

- Quaternary:
  - Stream deposits and residual soil.
- Carboniferous:
  - Permian (?)—
    - Dunkard formation.
  - Pennsylvanian—
    - Monongahela formation.
    - Conemaugh formation.
    - Allegheny formation.
    - Pottsville formation.
  - Mississippian—
    - Mauch Chunk formation.
    - Greenbrier limestone.
    - Pocono sandstone.
- Devonian:
  - Catskill formation.
  - Jennings formation.

No rocks as old as the base of the Jennings formation have been exposed in these quadrangles, and there is no record of the underlying rocks in deep wells or shafts. There is, however, little doubt that most of the Paleozoic formations which outcrop east of the Allegheny Front extend under this area as continuous beds retaining much of their lithologic and faunal character. The concealed rocks of this region may consequently be expected to consist of a totally unknown complex of crystalline rocks at the base, overlain by Cambrian sandstones, shales, and limestones of problematical thickness, followed by Ordovician limestones and shales, Silurian sandstones, shales, and limestones, and Lower and Middle Devonian shale, sandstone, and limestone. On these rest the Upper Devonian and Carboniferous rocks described in the following pages.

DEVONIAN SYSTEM.

The Devonian rocks exposed in these quadrangles consist of the Catskill and Jennings formations.

JENNINGS FORMATION.

Areal distribution.—The Jennings formation, named from its typical development at Jennings Gap, Va., outcrops in one area in the Accident and one in the Grantsville quadrangle and underlies all of the remainder of the region at various depths. The largest of these areas is along the crest of the Deer Park anticline in a belt about 20 miles long and from $1\frac{1}{2}$ to $2\frac{1}{2}$ miles wide, the greater part of which is in the valley of Savage River. It extends in a general longitudinal direction of about N. 40° E. Both the southeastern and the northwestern boundaries of this belt are too irregular for verbal description, depending on variations in topography and in strike and dip. The other area is in the center of the Accident anticline, and occupies an irregular oval, about a mile long and three-fourths of a mile wide, the center of which is about 2 miles west of Accident.

Lithologic character.—This formation consists predominantly of a succession of beds of shales and sandstones of yellowish gray, drab, olive, and brown color. Only the upper part of the formation is exposed in these quadrangles, no beds older than the Chemung having been definitely recognized.

The beds carrying a Chemung fauna, which probably include all of this formation exposed at the surface in these quadrangles, consist of olive-green and brownish-red shales and sandstones with at least two prominent beds of conglomerate. Of these the upper occurs about 50 feet below the top of the formation and is in places strongly developed. A second conglomerate occurs approximately 500 to 600 feet below the top of the formation and appears to be more persistent. The thickness of the latter bed has not been observed in these quadrangles, but the size and abundance of the derived bowlders indicate at least 10 feet and probably much more. About $1\frac{1}{2}$ miles above Corrigansville, Allegany County, Md., a similar conglomerate having a thickness of 35 feet has been observed. This conglomerate consists of a mass of pebbles of white vitreous quartz with a few pebbles of jasper, in a dark gritty ferruginous cement. The pebbles are characteristically flat and lenticular in shape. The joints which cut through the pebbles are frequently coated with drusy quartz. The rock breaks straight across the pebbles in a direction at right angles to the bedding. Bowlders of this conglomerate are found along a more or less distinct line of hills parallel to and about half a mile from the outer and upper contact of the formation. They are especially abundant where the National Road crosses the Jennings belt, and have also been observed near the center of the Jennings area to the west of Accident. The thickness of the Chemung in this area is not known, its base not having been observed. About 1400 feet of strata are exposed in the section of this formation on Middle Fork.

Correlation.—The beds in the upper part of the formation are correlated with the Chemung of the type region in New York on the identity of faunas and similarity of stratigraphic succession. The lower conglomerate noted above closely resembles in lithologic character the Lackawaxen conglomerate of Pennsylvania. A conglomerate also occurs at approximately the same position for many miles east and south.

CATSKILL FORMATION.

Areal distribution. — The Catskill formation, which derives its name from the Catskill Mountains, resting as it does upon the Jennings formation with apparent conformity, flanks the eastern area of that formation on either side and surrounds the western area. There are thus three large areas of Catskill in this region, and three small detached ones.

The more easterly of these areas extend the entire length of the county along either side of the belt of Jennings already described. The outer boundaries of these belts follow parallel and very close to the crest of two ridges or lines of hills which are upheld by the more resistant rocks of the Pocono formation. These belts vary in width from half a mile to 2 miles.

The third area of Catskill entirely surrounds the small area of Jennings already described as lying to the west of Accident. The outer boundary of this area is likewise defined by an encircling line of hills which are capped by the overlying Pocono sandstone. This area has a length of about 9 miles and a width from the Jennings to the Pocono of about $2\frac{1}{2}$ miles on the eastern side and about one-half mile on the western. The average width of the area from the eastern to the western Pocono boundary is a little more than 3 miles.

North of this area are the three small detached ones.

Lithologic character.—The Catskill formation consists of a series of shales and sandstones which are red or green in color. The soil derived from this formation is brick-red in color and contrasts sharply with the yellow soils of the underlying Jennings and the overlying Pocono. Various shades of red predominate. The basal beds are argillaceous shale with a few thin interbedded sandstones. The middle beds consist of alternating argillaceous shale, sandy shale, and flaggy sandstone. The upper beds contain more massive sandstone with some conglomeratic sandstone and beds of argillaceous shale. The sandstones of this formation are characteristically micaceous and in many places cross-bedded. The thickness of the formation varies from 1800 to 2200 feet in the eastern part of the country, and decreases toward the west. In the western area the thickness is about 1200 to 1400 feet. The thickness can not anywhere be accurately measured because there is no place where a direct vertical measurement can be made, and the uncertainty of the dip (because of cross-bedding) makes any estimate liable to an error of several hundred feet.

Correlation.—This formation, which was described under the name Hampshire formation in the Piedmont folio (No. 28) and the State report on Garrett County, occupies a position in this region between the highest beds carrying the marine Chemung fauna and the lowest Carboniferous beds. It is the equivalent of a part at least of the Catskill beds of New York and Pennsylvania. The Catskill of the type region is a lithologic unit which is synchronous wholly or in part with the Chemung and with the lowest Carboniferous. The formation in this area is younger than the highest Chemung and older than the lowest Carboniferous of this region. Whether it may be synchronous with any beds of Chemung or of Pocono age of other regions and how much of the typical Catskill it may represent can not be determined until more work has been done in the intermediate region in Pennsylvania.

No fossils except possibly a few poorly preserved fish plates have been authentically recorded from the Catskill of these quadrangles.

CARBONIFEROUS SYSTEM.

The Carboniferous rocks of these quadrangles consist of the following formations:

Carboniferous rocks of Accident-Grantsville region.

	Thickness in feet.
Permian (?) series:	
Dunkard formation	180
Pennsylvanian series:	
Monongahela formation	240–270
Conemaugh formation	570–635
Allegheny formation	260–350
Pottsville formation	325–375
Mississippian series:	
Mauch Chunk formation	650
Greenbrier limestone	225
Pocono sandstone	450

These formations can all be recognized in the adjoining region, except where they have been removed by erosion. They hold their general lithologic characters for considerable distances, the most marked changes being the thickening of the Pocono to the east, the thickening of the Greenbrier to the southwest and thinning to the north and west, and the thickening of the Pottsville to the south and southwest. The several members of the formations constituting the Pennsylvanian and Permian (?) series, together with their correlatives, are discussed at length by Clark and Martin in an article on "Correlation of the Coal Measures of Maryland." [a]

POCONO SANDSTONE.

Distribution.—The Pocono sandstone, named from the Pocono Mountains, Pennsylvania, outcrops in four areas in these quadrangles. The most easterly extends across the Grantsville quadrangle from northeast to southwest, outcropping on the crest and eastern slope of the ridge which is parallel to and about two-thirds of a mile west of Savage and Backbone mountains and which is known in its various parts as Little Savage Mountain, Fourmile Ridge, Elbow Mountain, and Little Mountain. The next area is on the western flank of the same anticline. It extends in a long narrow belt parallel to the last and about 4½ miles northwest of it, outcropping along the crest and western slope of the ridge known in various parts as Red Ridge and Hoop Pole Ridge. The third area encircles the dome of Devonian rocks at Accident. The inner edge of this belt is very irregular because of the small angle of dip and the irregularity of the topography. The fourth area extends along the West Virginia line for about 6 miles south from Cranesville.

Lithologic character.—This formation consists of sandstone and conglomerate with some shale. The shaly beds are predominant toward the base. Exposures of the formation in place are very infrequent, and no complete local section has been obtained. The following section, which was obtained in the Baltimore and Ohio railroad cut at Altamont, a short distance south of the southern boundary of the quadrangle, shows in detail the character of the lower beds in that region:

Section of lower part of Pocono formation at Altamont, Garrett County, Md.

	Feet.
1. Gray sandstone	20
2. Gray, yellow, and dark shales	12
3. Sandstone	1
4. Yellow, gray, and white, fine-grained shales	5
5. Dark shales with marine invertebrates	12
6. Gray sandstone with interstratified shale	33
7. Green sandy shales	3
8. Massive yellow sandstone	15
9. Yellowish- and greenish-gray sandstone with cuboidal fracture and with interstratified thin brown shales and yellow sandy shales, which predominate at the base	60
10. Light-blue shales	6
11. Yellow sandy shales	5
12. Brown micaceous sandstone (Catskill formation).	
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[a] Bull. Geol. Soc. America, vol. 13, 1902, pp. 27–40.

Massive sandstone and conglomerate seem to make up the middle part of the formation, and are especially prominent in the western part of the area. The thickness of the conglomerate beds is not known. In the area around Accident they are very prominent and appear to constitute the greater part of the formation. In the more easterly areas conglomerate is almost lacking and fine-grained gray sandstone is the prevailing rock.

Above the coarse sandstone and conglomerate of the middle part of the formation are beds of greenish, somewhat shaly sandstone, which resembles certain rocks in the Catskill and Mauch Chunk formations. The rocks are well exposed in the valley of Bear Creek.

Section 2½ miles east of Friendsville, Garrett County, Md.

	Feet.
1. Greenbrier limestone.	
2. Thin-bedded green sandstone and concealed	120
3. Massive conglomerate and sandstone	15
4. Concealed	10
5. Thin-bedded green sandstone	5
	150

The thickness of the formation is apparently about 450 feet.

Correlation.—The Pocono formation, which was named from its typical development in northeast Pennsylvania, is the eastern representative of part at least of the Waverly group of Ohio. Like the Waverly, it carries a marine fauna. The fossils have not been studied carefully enough to determine whether or not the faunas are identical. It is the lithologic equivalent and the stratigraphic continuation of the "Montgomery sandstone" of Virginia.

GREENBRIER LIMESTONE.

Distribution.—The Greenbrier limestone, named from Greenbrier River, West Virginia, occurs at the surface in four areas. The most easterly of these areas is situated parallel to and about one-half mile west of the crest of Savage Mountain. It occupies a valley between the Pottsville (Savage Mountain) and the Pocono (Little Savage Mountain) ridges. The second area extends along the eastern side of Meadow Mountain, in the valleys of Red Run and Meadow Mountain Run, as far as the confluence of the latter with Deep Creek near Thayerville. Thence it extends northwest through the valleys of Deep Creek and Marsh Run, to McHenry, where it bifurcates. One prong extends in a north-northeasterly direction, in the valley parallel to and about one-half mile west of Negro Mountain, as far as and across the Pennsylvania line. The other extends in a northwesterly direction to Sang Run. From here it extends up and down the valley of the Youghiogheny River to points 1½ miles north and 2½ miles south of Sang Run where it dips under the overlying formation. Another prong, leaving this about a mile east of Sang Run, extends north and northeast until it crosses the Pennsylvania line at Oakton. It occupies a sinuous line of valleys parallel to and about one-half mile east of the crest of Winding Ridge. A small outlier caps a hill one-half mile southeast of Wasa Mill. The fourth area extends along the West Virginia line near Cranesville and south along the valley occupied by Pine Swamp and Muddy Creek.

Lithologic character.—The Greenbrier limestone consists of limestone, red and green shale, and calcareous sandstone. The following sections show in detail the character of the formation:

Section of Greenbrier limestone at Crabtree, Garrett County, Md.

	Ft.	in.	Ft.	in.
1. Green micaceous sandstone (Mauch Chunk)				
2. Argillaceous limestone	4	8		
3. Massive sandy limestone	13			
4. Red sandy limestone	2			
5. Gray limestone	3		65	2
6. Red calcareous shale	3	6		
7. Red sandy limestone	8			
8. Gray sandy limestone with red bands	21			
9. Gray limestone	10			
10. Red shale interstratified with thin bands of gray sandstone	80		88	
11. Pure white sandstone	8			
12. Gray limestone	27		27	
	180	2		

In the western part of Allegany County, Md., the formation is somewhat thicker, as may be seen by the very complete section at Stony Run, given in the next column.

From these sections it will be seen that the Greenbrier consists of an upper calcareous member, 65 to 85 feet thick; a middle sandy and shaly member, 88 to 98 feet thick; and a lower calcareous member, 27 to 46 feet thick. This division into members appears to be constant in the region here studied.

Section of Greenbrier limestone at Stony Run, Allegany County, Md.

	Ft.	in.	Ft.	in.
1. Heavy, dark bluish gray fossiliferous limestone	4	6		
2. Argillaceous shale; fossiliferous, especially in the upper part; drab colored on fresh surface, but inclined to show as a dull red shale on account of its prominent ferruginous surface coating		8		
3. Massive, bluish fossiliferous limestone	7			
4. Concealed	10			
5. Massive, bluish fossiliferous limestone	1	6		
6. Massive, bluish, highly fossiliferous limestone, weathers very irregularly	3	6	85	3
7. Thinly bedded fossiliferous limestone with thin bands of olive-green fossiliferous shale	10	10		
8. Concealed	9			
9. Reddish brown, much disintegrated sandstone		9		
10. Concealed	20			
11. Heavy, pinkish green, mottled, slightly fossiliferous limestone	2	6		
12. Concealed	11			
13. Red sandy shale with thin green layers near top and bottom	3			
14. Greenish red, shaly arenaceous limestone	1			
15. Concealed	3			
16. Red sandy shale with a few thin, poorly defined, green argillaceous bands	32			
17. Concealed	6			
18. Red shaly sandstone	1	6		
19. Massive sandstone in streaks or layers of pink, green, and white	6		98	6
20. Red arenaceous shale	10			
21. Red shaly sandstone	9			
22. Calcareous pinkish-gray sandstone	2	6		
23. Concealed	7			
24. Shaly sandstone	1	6		
25. Mostly concealed, some shaly sandstone showing	20			
26. Very arenaceous pinkish-green limestone	26			
27. Concealed	5		46	
28. Bluish arenaceous limestone	7			
29. Concealed	8			
	229	9		

The lower limestone member rests with apparent conformity upon the Pocono formation. There are a few feet of transition beds from the upper beds of the Pocono into the calcareous sandstone and siliceous limestone of the basal Greenbrier, and it is very difficult to draw an exact line between the formations. The lower member is well exposed in the valley of Bear Creek about 2½ miles east of Friendsville.

Section on Bear Creek 2½ miles east of Friendsville, Garrett County, Md.

	Ft.	in.
1. Red shale	11+	
2. Blue limestone	7	
3. Red limestone, becoming more siliceous toward the bottom	23	6
4. Pocono sandstone.		
	41+	6

The middle shaly member is nowhere very well exposed because it does not form good natural outcrops and is not of sufficient economic value for good artificial exposures to be made in it. Lithologically it is very much like the Mauch Chunk formation, except that it contains some calcareous beds. The Stony Run section contains the most complete representation of the beds of this member known in this region.

The upper limestone member consists more largely of limestone and contains the purest and most valuable limestone in the entire formation. Most of the limestone quarried in Garrett County is from this member. For this reason, and because it has a larger number of natural exposures this member is better known than either of the others. It is also far more fossiliferous than the underlying members.

Section on Baltimore and Ohio Railroad east of Crabtree, Garrett County, Md.

	Feet.
1. Gray sandstone (Mauch Chunk).	
2. Red shale	5
3. Red shale and limestone	16
4. Red limestone with corals	5
5. Concealed	10
6. Gray shaly and sandy limestone with occasional fossils	15
7. Massive reddish limestone	15
	66

Neither the top nor the bottom of this member is represented in the following section. In the Snaggy Mountain section the top is concealed, perhaps the bottom also. This contains an unusual amount of shale for this member.

Section 2 miles southeast of Friendsville, Garrett County, Md.

	Ft.	in.
1. Massivelimestone	2	
2. Shaly limestone	3	
3. Massive limestone	5	
4. Shale		8
5. Limestone		9
6. Shale		7
7. Massive blue limestone	12	
	24	

Section on western slope of Snaggy Mountain, Garrett County, Md.

	Ft.	in.
1. Decomposed limestone	4	
2. Massive fossiliferous limestone	20	
3. Concealed	7	
4. Broken limestone	2	
5. Green shale	3	
6. Green and red shale	3	6
7. Impure bluish-white limestone	1	6
8. Red shale	5	6
9. Bluish-white impure limestone	1	9
10. Red sandy shales	6	5
11. Bluish-white limestone, sparingly fossiliferous	4	3
	58	11

Correlation.—The Greenbrier limestone carries the fauna of the Ste. Genevieve limestone of the Mississippi Valley. It is the equivalent of the Maxville limestone of Ohio and of part of the Greenbrier and Newman limestones of the southern Appalachians. Toward the southwest it thickens at the expense of the overlying Mauch Chunk, or its representative the Pennington shale, until it attains a thickness many times as great as that which it possesses in Maryland. Toward the north in Pennsylvania it thins rapidly. This change consists in an increase in the thickness and amount of shale in the middle member, a decrease in the thickness of the upper or pure limestone member, and an increase in the amount of sandy material in the lower member. The result is that the formation changes along the bedding and along the strike into a series of red and green shales and sandstones which in central and northeastern Pennsylvania constitute part of the Mauch Chunk formation. The basal bed of the Greenbrier limestone as here mapped is the Loyalhanna limestone of southwestern Pennsylvania, which in the folios relating to that region has been included in the Pocono as its uppermost member, inasmuch as it is there impossible to separate the Loyalhanna from the Pocono.

MAUCH CHUNK FORMATION.

Areal distribution.—The Mauch Chunk formation, so called from Mauch Chunk, Pa., outcrops in five areas in these quadrangles. The most easterly area is along the western slope of Big Savage Mountain. The second area extends along the western flank of the anticline of which the first area is on the eastern side. It occupies a position on the eastern slope of Meadow Mountain for its entire length. At the southern end it swings around to the west and joins a similar belt which extends along the western slope of Negro Mountain. The third area flanks the Accident anticline on the south and west. About 1 mile north of Sang Run it crosses Youghiogheny River and occupies the valley of that river to a point about a mile below Swallow Falls. Two other areas are situated in the southwest corner of the Accident quadrangle.

Lithologic character.—The Mauch Chunk formation consists of thinly bedded green sandstones at the base, overlain by a considerable thickness of irregularly alternating red and green shales and green sandstones. These beds apparently contain no characteristic strata upon which any subdivision of the formation can be based. The sandstones are either green or dark red, and are micaceous, thinly bedded and cross-bedded. The shales are of various shades of red and green, and are arenaceous and argillaceous.

The thickness of the formation is about 650 feet.

Correlation.—The Mauch Chunk formation of Maryland is the equivalent of the upper part of the Mauch Chunk shale of the typical locality in the anthracite field of northeastern Pennsylvania. The change which takes place in the formation in passing southwestward across Pennsylvania has been discussed above under the heading "Greenbrier limestone." The formation is represented in the southern Appalachian region by the Pennington shale, which agrees with it in general lithologic character, although the Pennington is somewhat calcareous. The upper part of the Bangor and Newman limestones of the southern Appalachian region may be partly synchronous with the lower part of the Mauch Chunk of Maryland.

POTTSVILLE FORMATION.

Areal distribution.—The Pottsville formation, named from Pottsville, Pa., outcrops in three important areas in this region. The most easterly of these extends along the crest of Savage Mountain. The western border of this area lies a short distance (possibly 100 yards) west of the crest of the mountain; the eastern border lies at a distance varying from one-fourth to one-half mile east of it. A second belt extends in a southwesterly direction along the crest and western flank of Meadow Mountain from the northern limit of the quadrangle to the southern end of the mountain at the valley of Deep Creek, where it joins a similar belt which extends thence in a northerly direction along the crest and eastern flank of Negro Mountain to the Pennsylvania line. A third belt extends along the crest and western slope of Winding Ridge from the north edge of the Accident quadrangle to Youghiogheny River between Krug and Sang Run. Here it joins a large area of very irregular outline which covers considerable territory in the southwest corner of the Accident quadrangle. Four outliers occur along the margin of this belt.

Lithologic character.—The Pottsville formation consists of a series of coarse and massive conglomerate, sandstone, shale, fire clay, and coal. The character of the formation is well shown in the following section, which was measured in the Youghiogheny gorge at and below Swallow Falls, a short distance south of the margin of the Accident quadrangle.

Section of Pottsville formation near Swallow Falls, Garrett County, Md.

			Ft.	in.
1.	Massive sandstone, Homewood		50	
2.	Shale		6	
3.	Flint fire clay and plastic fire clay		4	
4.	Coal, Mount Savage	Coal 4″; Bone 8″; Coal 1′ 4″; Shale 2″; Coal 6″	3	
5.	Shale		5	
6.	Sandstone		5	
7.	Coal, Lower Mercer			10
8.	Conglomeratic sandstone, upper part of Connoquenessing		75	
9.	Black shale		2	
10.	Coal, Quakertown		1	6
11.	Shale			6
12.	Concealed		8	
13.	Massive conglomeratic sandstone, lower part of Connoquenessing		75	
14.	Concealed		60	
15.	Shale		5	
16.	Coal, Sharon	Coal 5″; Shale 6″; Coal 5″	1	4
17.	Shale			6
18.	Sandstone		25	
			327	8

The following members of the Pottsville formation have been recognized in this region:

Homewood sandstone.	
Mercer coal group	Mount Savage or Upper Mercer coal. Mount Savage fire clay. Lower Mercer coal.
Connoquenessing sandstone (upper part).	
Quakertown coal.	
Connoquenessing sandstone (lower part).	
Sharon coal group.	
Sharon (?) sandstone.	

An exposure of the contact between the Mauch Chunk and Pottsville one-half mile east of Westernport, Allegany County, Md., shows the basal bed of the Pottsville as a fine-grained sandstone which rests upon greenish Mauch Chunk shale with (local at least) discordance of bedding. This exposure fully establishes the fact that the Pottsville rests upon the Mauch Chunk, locally at least, with unconformity. This unconformity may explain the slight development or absence of the lowest Pottsville beds (the Sharon conglomerate, etc.) in this region. Throughout the northern Appalachian region the base of the Pottsville is formed here by one bed and there by another. It has been shown that the earlier Carboniferous sea bottom was raised and eroded over this entire region before the coal measures were deposited, and that the subsequent subsidence was so slow and the differential movements so large that great thicknesses of Pottsville were accumulated in other regions while this was yet land.

If the Sharon conglomerate is represented in this region it is by the 25 feet of sandstone at the base of the Swallow Falls section and the four feet at the base of the Westernport section.

The Sharon coal group is here represented by a series of shale beds with one or two thin coal seams. These beds are about 60 feet thick at Westernport and of a doubtful thickness which does not exceed 10 feet at Swallow Falls. The correlation is based upon the stratigraphic position of the beds with reference to those above and below, and upon the flora contained in the shale, which according to David White is that of the Sharon coal.

Above the coal and shale of the Sharon coal group is a great thickness of sandstones and conglomerates which represent the Connoquenessing sandstone, of which the type locality is in Lawrence County, Pa. It is clearly shown in the Swallow Falls gorge that here, as in Pennsylvania, the Connoquenessing is capable of a threefold subdivision. Immediately overlying the Sharon is the lower part of the Connoquenessing sandstone, which is hard, white, and conglomeratic, and has a thickness of about 75 feet. Above this is a small thickness of shale with a thin coal which is the equivalent of the Quakertown coal of eastern Ohio and western Pennsylvania. In Allegany County, Md., this coal has split into two seams separated by 4 feet of shale. The shale associated with the Quakertown coal is overlain by another bed of very hard and massive white conglomeratic sandstone which has a thickness of about 75 feet. This is the upper part of the Connoquenessing sandstone.

Resting with apparent conformity upon the upper part of the Connoquenessing sandstone is a series of shale beds with some fire clay and coal, which are both stratigraphically and paleontologically the equivalent of the Mercer coal group of Pennsylvania. The lithologic character of this group is well shown in the following section, which was measured a short distance east of this region.

Section at Savage Mountain fire-clay mine.

		Ft.	in.
Sandstone, Homewood	Sandstone 28′; Soft shale 1′; Sandstone 8′ 6″	37	6
Shale		1	
Coal, Mount Savage	Coal 1′ 2″; Shale 11″; Coal 2′	4	1
Shale		6	
Fire-clay, Mount Savage		10	
		58	7

This section shows the relationships of the divisions of the Mercer coal group to one another and to the underlying and overlying strata. The Lower Mercer coal is usually absent in Maryland, having been reported only from Swallow Falls and from the Henry bore hole. The Mount Savage coal, which is identical with the Upper Mercer (where there are two Mercers) of Pennsylvania, is always present. The Mount Savage fire clay lies immediately or a very short distance under it. At Swallow Falls conditions are abnormal, for there is no clay under the coal, while a fire clay of exactly the same character as the Mount Savage clay overlies it. This state of affairs has not been recognized elsewhere.

The Mount Savage fire clay is apparently one of the most constant members of the "Coal Measures," even where its outcrop is concealed its presence being revealed by the occurrence of flint bowlders in the soil.

The Mercer limestones, which are very characteristic at this horizon in Pennsylvania, have not been recognized in Maryland.

Resting conformably upon the shale at the top of the Mercer is a very quartzose and massive sandstone, which is the equivalent of the Homewood sandstone of Pennsylvania. It was formerly called the "Piedmont sandstone," but its identity with the Homewood sandstone is now satisfactorily established. It differs from the Connoquenessing sandstone in being less conglomeratic, and from the overlying Allegheny sandstones in being more massive and quartzitic. The thickness varies from about 30 to almost 100 feet, and is usually over 60 feet.

Correlation.—The Pottsville formation of this region represents the upper part of the formation in its type locality in northeastern Pennsylvania. Two hypotheses have been suggested by David White (Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, p. 821) to account for the thinning of the Pottsville and the absence of its lower members in the bituminous coal fields of western Pennsylvania, Maryland, and West Virginia. While he regards the problem as still an open one, Mr. White is inclined to believe that the oldest Pottsville in the very thick sections rests upon the underlying Mauch Chunk conformably, and is contemporaneous with the highest Mauch Chunk of those regions where the Pottsville is thin; and that the Pottsville of the latter regions was deposited in an encroaching sea, and is hence unconformable upon the Mauch Chunk by overlap. It is probable that the Pottsville and Mauch Chunk of Maryland are separated by an unconformity. Whether this unconformity represents the whole of lower Pottsville (i. e., pre-Sharon) time, or whether part of that period is represented by the highest Mauch Chunk of this region, is a problem on which the rocks of this region have shed no light.

The uppermost beds of the Pottsville in this region (i. e., the Mount Savage coal and fire clay and the overlying sandstone) are to be most definitely correlated with the Mercer coal group and the Homewood sandstone, which are found at the top of the Pottsville throughout the entire coal fields of Pennsylvania, eastern Ohio, and northern West Virginia. This means that Pottsville sedimentation ended almost simultaneously in all parts of the northern Appalachians. So far as is known the same is approximately true toward the south.

ALLEGHENY FORMATION.

Areal distribution.—The Allegheny formation, which was named from Allegheny River, Pennsylvania outcrops in five large and important areas and many small outliers and inliers. The first of these extends in an almost straight line along the eastern slope of Savage Mountain from the Pennsylvania line to the valley of Savage River at a point about 2½ miles east of Crabtree. The second area extends along the western slope of Meadow Mountain from the Pennsylvania line to the junction of Meadow and Negro mountains, thence along the eastern slope of Negro Mountain to the Pennsylvania line. It completely encircles the Castleman Valley. The third area extends along the western slope of Winding Ridge from the Pennsylvania line to Elder. About 1½ miles below Krug it crosses Youghiogheny River, and extends along its western bank, and thence westward up the valley of White Rock Run to the West Virginia line. The fourth area covers the greater part of the region drained by Youghiogheny River above Swallow Falls, lying between Snaggy Mountain on the west and the Roman Nose–Halls Hill ridge on the east. Two prongs of this area extend into the Accident quadrangle from the south. The fifth area lies in the northwest corner of the Accident quadrangle and is very irregular in outline. It occupies the entire valley of Feik Run and sends a long irregular prong across into the valley of the north branch of Buffalo Run. There are smaller areas near Marklesburg, in the valley of the south fork of Buffalo Run about 3 miles west of Friendsville, on three hills east of Youghiogheny River between Krug and Sang Run, and at various other places.

Lithologic character.—The Allegheny formation, which consists of a conformable succession of sandstone, shale, coal, and limestone beds, overlies the Pottsville with apparent conformity. The following section which extends from a depth of 193 feet to 451 feet, shows the character of the formation:

Section of Allegheny formation in bore hole at Jennings Mill, Garrett County, Md.

			Ft.	in.
1.	Coal, Upper Freeport	Coal 2″; Bone 3″; Black shale 10′ 10″; Coal 2′ 2″	13	5
2.	Shale		4	
3.	Shaly sandstone		9	
4.	Gray shale		35	5
5.	Brecciated fire clay			8
6.	Gray shale		12	
7.	Coal			2
8.	Gray shale		11	7
9.	Black shale			9
10.	Coal, Lower Freeport		1	2
11.	Black shale		1	
12.	Gray shale		18	9
13.	Sandy shale		15	
14.	Coarse sandstone		12	
15.	Gray shale		1	
16.	Coarse sandstone		3	
17.	Black shale		8	10
18.	Coal, Middle and Lower Kittanning	Coal 1′ 4″; Black shale 3′; Gray shale 2′ 4″; Coal 10″; Gray shale 5′ 3″; Coal 1′ 10″	14	1
19.	Gray shale		8	6
20.	Coarse sandstone		10	
21.	Coarse cross-bedded sandstone		20	
22.	Coarse sandstone		11	
23.	Shaly sandstone		10	
24.	Gray shale		6	6
25.	Sandy shale		7	
26.	Dark-gray and black shale		7	
27.	Coal, Clarion			8
28.	Gray shale		4	
29.	Gray sandy shale		5	
30.	Black shale		5	
31.	Coal, Brookville (?)		1	
			257	6

Section of Allegheny formation in bore hole No. 1, Henry, Garrett County, Md.

			Ft.	in.
	Mahoning sandstone.			
1.	Coal, Upper Freeport	Bony coal 22″; Coal 40″	5	2
2.	Shale		2	2½
3.	Limestone			11½
4.	Shale		7	6½
5.	Sandstone with streaks of shale		10	3
6.	Sandstone		13	3
7.	Conglomerate		1	7½
8.	Conglomeratic sandstone		5	6
9.	Light-gray sandy shale		13	3
10.	Sandstone		17	5
11.	Shale		2	
12.	Shaly sandstone		21	3
13.	Shale		15	1
14.	Shaly sandstone		24	10
15.	Bone			2
16.	Shale		3	
17.	Sandstone		1	10
18.	Shale		1	1
19.	Limestone		1	
20.	Shale		16	3
21.	Black shale with streaks of bone		1	1
22.	Shale		11	6½
23.	Sandstone and shale		14	5½
24.	Black shale		3	1½
25.	Sandy shale		3	8
26.	Sandstone		2	3½
27.	Black shale		2	4
28.	Coal, Middle and Lower Kittanning	Coal 2″; Shale 1″; Coal 33½″; Shale 4½″; Bone 7½″; Coal 24″; Shale 1½″; Coal 24″; Shale 1″; Bone 2½″	8	5½
29.	Shale		19	2½
30.	Rough coal and shale (Split-six)		2	1½
31.	Sandstone and black shale		4	4
32.	Black shale		4	5
33.	Shale and bone			7½
34.	Shale		6	5
35.	Limestone		2	8
36.	Shale		12	8½
37.	Hard flinty sandstone		13	
38.	Conglomerate		7	4½
39.	Sandstone		5	11
40.	Shale and sandstone		22	11½
41.	Sandstone		8	4½
42.	Shale		1	2
43.	Coal, Clarion	Coal with sulphur 11″; Shale ½″; Coal 6″; Sulphur 1″	1	6½
44.	Shale		10	2
45.	Coal, Brookville	Coal 17″; Shale 8½″; Bone 2½″; Shale and bone 5½″; Coal 8″	3	5½
46.	Shale		4	7½
47.	Homewood sandstone, etc.			
			341	8½

Subdivisions.—The individual beds making up the Allegheny formation in this region have been classified as follows:

Freeport coal group	Upper Freeport coal. Upper Freeport limestone (absent?). Bolivar fire clay. Middle Freeport coal (absent?). Lower Freeport coal. Lower Freeport limestone (absent?). Lower Freeport sandstone.
Kittanning coal group	Upper Kittanning coal. Middle Kittanning coal. Lower Kittanning coal. Split-six coal.
Clarion coal group	Vanport ("Ferriferous") limestone. Clarion sandstone. Clarion coal. Brookville coal.

As far as is known the shale which forms the base of the Allegheny formation lies conformably upon the underlying Pottsville. A few feet above the top of the Pottsville there is sometimes found a coal seam which is the equivalent of the Brookville coal of Pennsylvania. Here, as in other regions, this coal is very irregular and uncertain in its occurrence.

The Clarion coal is one of the most persistent and characteristic members of the "Coal Measures" in this region. Its position varies from 15 to 45 feet above the top of the Pottsville. It usually contains about 2½ feet of coal. A mass of sandy shale about 10 feet thick which contains very abundant nodules of siderite overlies the Clarion coal. At places these are abundant enough to suggest the possibility of profitable mining.

This shale is usually overlain by a thick and massive sandstone which resembles the underlying Homewood sandstone and is known as the Clarion sandstone. It can be readily distinguished, however, by the presence of siderite concretions instead of flint nodules in the underlying shale.

The Vanport ("Ferriferous") limestone belongs a few feet above the Clarion sandstone and is separated from it by shales. This limestone has not been seen within these quadrangles, but is exposed both to the north and to the south of it. The Vanport limestone in southwestern Pennsylvania and in Ohio carries a marine invertebrate fauna. This fauna is absent to the south and southeast of this region, in West Virginia and Maryland, and is in some cases replaced by a fresh-water fauna, indicating a change in character of deposition from the north and west to the south and east. These quadrangles are in this transition zone, and if the limestone is discovered here it may be of either character or of both.

The Split-six coal occurs at an interval varying from 65 to 115 feet above the Clarion coal, and a short distance above the Vanport limestone. In its normal position with reference to the next higher coal it has been seen at only two localities in this area, one of which is on the south bank of White Rock Run. Here it is 24 feet below the Lower Kittanning. In the vicinity of Franklin, Allegany Co., Md., this interval is somewhat greater (28 feet).

The Middle and Lower Kittanning coals in the southern part of the Georges Creek basin are separated by less than a foot of shale and constitute one workable seam. In the upper Youghiogheny basin the intervening shale is usually about 3 feet in thickness. In the lower Youghiogheny basin it varies from 1 to 10 feet. In the Castleman basin the Kittanning (and in fact the entire Allegheny formation) is known in continuous section only from the bore hole at Jennings Mill. Here the Kittanning coals are all thin and occur within a total thickness of about 15 feet. In the Georges Creek basin this coal is locally known as the Six-foot, Five-foot, or Davis coal. It was called by the last name in the report on the Geology of Allegany County, but is now known to be the equivalent of either the Lower or the Lower and Middle Kittanning. In the Castleman basin it is known at only three points. In the lower Youghiogheny basin it is locally known as the White Rock seam, and sometimes as the Four-foot. A massive cross-bedded sandstone about 25 feet in thickness is separated from the top of this coal by an interval of usually only a few inches of shale. This sandstone is characterized by the presence of abundant brownish mica flakes.

The Upper Kittanning coal occurs at an interval varying from 35 to 65 feet above the top of the Middle Kittanning coal. The intervening strata are sandstones and shales, the former predominating, and of them the massive micaceous cross-bedded sandstone above described is the most conspicuous. This coal is far less persistent than the Middle and Lower Kittanning. Frequently it is absent or represented by black shale or a few coaly streaks. No good exposure of it has been seen within these quadrangles. The best development of it in this region is at Harrison, W. Va., where it has a thickness of 43 inches.

The strata between the Upper Kittanning coal and the top of the Allegheny formation constitute the Freeport coal group. The lithologic characteristics of the members are well shown in the following section:

Section at Piedmont, W. Va.[a]

		Feet.
1. Coal, Upper Freeport	Coal 2′; Shale and bone 1′; Coal 2′	5
2. Concealed		10
3. Shale, bluish		10
4. Coal, Lower Freeport		2
5. Fire clay		2
6. Concealed		10
7. Sandstone, hard		2
8. Sandstone, shaly		2
9. Shales, sandstones, and concealed		55
10. Coal, Upper Kittanning.		

The individual beds of this group are not usually very well exposed in this region. The Lower Freeport sandstone is apparently present, but is less conspicuous than another sandstone which is immediately under the Upper Kittanning coal. The Lower Freeport limestone has not been seen at the surface.

[a] White, I. C., Bull. U. S. Geol. Survey No. 65, 1891, p. 126.

The Lower Freeport coal is often represented by a thin bed, but it is not at all persistent.

The Middle Freeport coal has not been seen in this region.

The Upper Freeport coal is practically always present at the very top of the Allegheny formation. The areas in which it is entirely absent are extremely local and infrequent. In the Georges Creek basin this bed is known as the Four-foot and sometimes as the Three-foot. In the lower Youghiogheny basin it is sometimes called the Sandrock vein, but that name has also been applied to other beds in the region. In the Castleman basin it is not well known and has no local name. It will be described more fully under the heading "Mineral resources."

Correlation.—The Allegheny formation was named and described from its typical development along Allegheny River in Pennsylvania. Under this name, and as the "Lower Productive Coal Measures," it was studied and mapped in great detail by the Second Geological Survey of Pennsylvania. The several areas in this region are the continuation of the areas mapped by the Pennsylvania surveys. The correlation is based not only on this lithologic continuity but on the similarity of local sections and the identity of sequence of the members.

The formation has been traced westward into Ohio by the Ohio Geological Survey, and southward into West Virginia. In these States it has been called the "Lower Productive Measures." It constitutes the Savage formation and the lower part of the Bayard formation of Darton and Taff, and was thus mapped by them in the Piedmont folio (No. 28).

CONEMAUGH FORMATION.

Areal distribution.—The Conemaugh formation, named from Conemaugh River, in Pennsylvania, outcrops within the limits of the Accident and Grantsville quadrangles in four large and important areas, neighboring which are a number of small outliers. The first is situated in the Georges Creek valley, and extends from the eastern edge of the Grantsville quadrangle to a line which is, in its general position, approximately parallel to the crest of Savage Mountain and about a mile east of it. In part of this area the Conemaugh is buried under younger formations whose areal extent will be described later. One small outlier adjoins this area. The second area is in the Castleman Valley, and is a single oblong area 18 miles long and from $2\frac{1}{2}$ to $5\frac{1}{2}$ miles wide. There is one neighboring outlier. The third area is in the lower part of the Youghiogheny Valley. It covers the greater part of the area north of the valley of White Rock Run and west of Youghiogheny River and extends east of the Youghiogheny from a point two-thirds of a mile above Friendsville to the northern edge of the Accident quadrangle. The eastern and southern boundaries of this area are roughly parallel to and about $1\frac{3}{4}$ miles west and north of the crests of Winding and Dog ridges. Eight outliers adjoin this area. The fourth area is on the southern edge of the Accident quadrangle just east of Youghiogheny River, and is part of the margin of a larger area to the south.

Lithologic character.—The Conemaugh formation consists of a varied but conformable succession of sandstone, shale, limestone, and coal beds, whose total thickness varies from 575 to 635 feet. The usual thickness is about 600 feet. The following sections are each typical of the formation, in the respective basins.

Section of Conemaugh formation at Barton, Allegheny County, Md.[a]

		Ft.	in.
1. Coal, Pittsburg.			
2. Concealed, shale toward the base		41	
3. Gray shale		8	
4. Concealed		18	6
5. Black bituminous shale		2	
6. Yellowish shale with iron-band markings		26	9
7. Concealed, with sandstone near base		29	
8. Arenaceous shale and thin-bedded sandstone		8	
9. Concealed		10	6
10. Coal, Franklin	Coal 9″; Shale 2″; Coal 3″; Bituminous shale 12″; Coal 8″; Shale 24″; Coal 24″+	6	10
11. Ferruginous shale		4	3
12 Concealed		26	9
13. Dark-gray shale		20	9
14. Coarse sandy shale		10	6
15. Massive, gray cross-bedded sandstone		9	9
16. Concealed		94	9
17. Brownish-gray massive sandstone		7	9
18. Concealed		84	6
19. Coal, Bakerstown	Bone 4″; Coal 28″; Coal and shale 4″	3	
20. Concealed		77	
21. Sandy shale		15	
22. Coal, Brush Creek		1	7
23. Sandy shale		3	5
24. Shale		12	
25. Sandstone		28	
26. Shale		8	
27. Sandstone		33	6
28. Shale		3	6
29. Coal, Upper Freeport.			
		594	7

[a] Nos. 1 to 20 of this section were measured at Swanton plane, and Nos. 21 to 29 were obtained from the American Coal Company's bore hole at Barton.

Section of Conemaugh formation in Castleman Valley, Garrett County, Md.[a]

		Ft.	in.
1. Strata eroded to top of hill		10	
2. Shale		6	
3. Sandstone		5	
4. Shale		16	
5. Coal			6
6. Shale		4	6
7. Concealed		20	
8. Yellow shale		5	
9. Concealed		8	
10. Sandy shale		6	
11. Sandstone		1	
12. Black shale		14	
13. Coal			11
14. Shale		2	
15. Limestone		3	
16. Concealed		46	
17. Sandstone		41	
18. Black fissile shale		10	
19. Limestone, Ames	Black limestone 9″; Shaly fossiliferous limestone 39″	4	
20. Coal, Harlem		1	9
21. Gray shaly limestone		4	
22. Concealed		52	
23. Sandy shale		40	
24. Coal, Maynardier	Coal, bony 24″; Shale 3″; Coal 11″	3	2
25. Shale			2
26. Limestone			3
27. Shale			6
28. Limestone		1	
29. Shale		11	
30. Limestone			8
31. Black shale		26	
32. Coal, Bakerstown		2	4
33. Gray shale		7	6
34. Concealed		39	
35. Green shale		8	2
36. Red shale		4	2
37. Green shale		4	9
38. Red shale		13	4
39. Green shale		1	2
40. Red shale		2	8
41. Gray shale		7	
42. Gray shaly sandstone		8	
43. Gray sandstone		11	6
44. Dark shale			3
45. Gray sandstone		3	
46. Black shale		4	
47. Fossiliferous limestone, Lower Cambridge		3	
48. Black shale		7	7
49. Coal, Brush Creek	Coal 1′ 4″; Bone 3″	1	7
50. Black shale		1	
51. Gray shale		20	3
52. Green shale		5	4
53. Gray shale		4	9
54. Green shale		4	10
55. Gray shale		3	2
56. Fine-grained greenish-gray sandstone		24	
57. Gray shale		2	
58. Fined-grained shaly sandstone		17	
59. Coarse sandstone		9	
60. Greenish and grayish shale		6	1
		571	10

[a] Nos. 1 to 22, measured on north end of Ridgleys Hill, 23 to 33, in railroad cut a mile south of the National Road; 34 to 60, from a bore hole at Jennings Mill.

Section of Conemaugh formation one-half mile northwest of Friendsville, Garrett County, Md.

		Ft.	in.
1. Probable position of Pittsburg coal.			
2. Strata removed by erosion		10±	
3. Concealed		62	
4. Coal, Little Pittsburg.	Coal 6″; Shale 2″; Coal 1′ 5″; Shale 1″; Coal 1′ 6″	3	8
5. Limestone		1±	
6. Concealed		6	
7. Flaggy sandstone		26	
8. Concealed, and massive conglomeratic sandstone		50	
9. Fine-grained sandstone		8	
10. Shale		2	
11. Limestone, Clarksburg	Limestone 2′ 6″; Shale 1′; Limestone 3′ 6″	7	
12. Shale		1	
13. Concealed		15	
14. Shale		5	
15. Concealed		18	
16. Sandstone and shale		15	
17. Fine-bedded sandstone		21	
18. Massive conglomerate		9	
19. Shaly cross-bedded sandstone		18	
20. Coal, Elklick			6
21. Gray calcareous shale		3	
22. Massive sandstone		20	
23. Shaly limestone and fossiliferous shale, Ames limestone		10	
24. Coal, Harlem		1	3
25. Yellow shale		5	
26. Fine-grained cross-bedded sandstone		30	
27. Gray shale		1	
28. Concealed		31	
29. Sandy fossiliferous shale		4	
30. Yellow shale and concealed		15	
31. Black shale		2	
32. Coal, Bakerstown		1	6
33. Shale and sandstone		36	
34. Red shale		2	
35. Limestone		2	
36. Red and green shales		7	
37. Sandy shale		10	
38. Limestone		1	
39. Sandy shale		27	
40. Black fossiliferous shale		5	
41. Limestone, Lower Cambridge			6
42. Black shale		5	
43. Coal, Brush Creek		1	9
44. Concealed		80	
45. Black shale with coal smut on top		6	
46. Coal, Mahoning	Bone 7″; Shale 6″; Coal 9″	1	10
47. Black shale		10	
48. Sandstone			4
49. Shale		4	
50. Concealed		25±	
51. Approximate position of Upper Freeport coal.			
		635	4

Subdivisions.—The characteristic members of the Conemaugh formation are as follows:

Little Pittsburg coal.
Pittsburg limestone.
Connellsville sandstone.
Little Clarksburg or Franklin coal.
Clarksburg limestone.
Morgantown sandstone.
Elklick coal.
Ames limestone.
Harlem coal
Saltsburg sandstone.
Bakerstown coal.
Upper Cambridge limestone.
Buffalo sandstone.
Lower Cambridge ("Brush Creek") limestone.
Brush Creek coal.
Mahoning sandstone (upper part).
Mahoning coal.
Mahoning limestone.
Mahoning sandstone (lower part).

The Mahoning sandstone does not show as prominently in sections in this region as it has been reported to show elsewhere. But even here it is a very important rock because of the influence that it has upon the topography. It has been the direct means of preserving large areas of the Upper Freeport coal from erosion and is of great value in locating the position of that coal.

This rock has exerted the most striking influence upon the topography in the Castleman basin, where there is an inner rim of Mahoning sandstone within an outer rim of Pottsville conglomerate. This inner rim is best shown on the eastern side of the basin, where it includes Chestnut Ridge, Salt Block Mountain, and Maynardier Ridge. In the Lower Youghiogheny basin it forms the spurs of Winding Ridge which come down to Friendsville on either side of Bear Creek. The rock is well exposed in the bed of Bear Creek immediately above the covered bridge at Friendsville and on the road from Friendsville to Elder. In the northwest corner of the county it holds up a very prominent ridge, of which Sickle Hill and Division Ridge are parts, and outcrops in the beds of Buffalo Run and Laurel Run. It holds up also a number of prominent knobs in the southern end of the basin. From a short distance above Friendsville to the Pennsylvania line Youghiogheny River is flowing along the upper surface of this rock, and to this fact is due the flatness of the valley bottom. In the upper Youghiogheny basin this is the surface over wide areas. In the Potomac and Georges Creek basins the rock is less prominent but nevertheless holds up a number of hills along its western outcrop and forms numerous bluffs in the valley of the Potomac.

The Mahoning sandstone is usually complex, consisting of two prominent sandstones with shale between them. This shale usually contains a thin coal and sometimes a limestone. Of the two divisions of the sandstone the lower is the more prominent and is practically always present, while the upper is absent or replaced by shale in many places.

There is no record of the occurrence of the Mahoning limestone in this region, but the Johnstown iron ore, which frequently replaces it in Pennsylvania, has been observed in the Castleman Valley.

The Mahoning coal is present in many places in the Potomac basin. In the lower Youghiogheny basin it is thicker and more persistent than elsewhere in this region and has been mined for local use.

The strata immediately overlying the Mahoning sandstone, or the beds which replace the upper part of the Mahoning, consist of 15 to 25 feet of very argillaceous shale.

The Brush Creek coal, which overlies this shale, is one of the most persistent and characteristic strata in the entire coal measures. It has been observed at various localities in each coal basin except in the upper Youghiogheny basin, where it has been almost entirely removed by erosion.

Overlying the Brush Creek coal is a bed of fissile black shale from 5 to 8 feet thick, which is in turn overlain by the Lower Cambridge limestone. This limestone is of distinctly marine origin and is filled with marine fossils. It varies in thickness from 6 inches to 3 feet. Considering the extreme thinness of this stratum, its persistence is remarkable. In not a single known instance has the position of this bed and of the underlying Brush Creek coal been exposed without both the limestone and the coal being present. Above the limestone is a series of black shales which carry the same marine fauna. These become more sandy above and finally grade into a fairly persistent and massive sandstone which is the equivalent of the Buffalo sandstone described by I. C. White, from Butler County, Pa. (Second Geol. Survey Pennsylvania, Rept. Q, p. 33).

Above the Buffalo sandstone is a succession of strata which have as yet been seen only in the river bluff north of Friendsville, which are recorded as Nos. 34 to 38 of that section, and which are described in somewhat greater detail below:

Section of rocks above Buffalo sandstone in river bluff north of Friendsville, Md.

	Feet.
Red shale	2
Limestone, hard and black where fresh, but weathering deeply but irregularly to a yellow ocherous mass; carries marine fossils	2
Shale, argillaceous, green at the base but becoming red toward the top	7
Shale, sandy	10
Limestone, hard and with marine fossils	1

These two limestones with the 17 feet of shales probably represent the Upper Cambridge limestone. In the bore hole at Jennings Mill this interval is represented by a series of alternating red and green shales.

These beds are succeeded by about 35 feet of shales and sandstones, the latter predominating. Then comes a coal bed of great persistence and considerable value. This is the Bakerstown coal of Pennsylvania, or, as it was called in the Geology of Allegany County, the Barton coal (not the Barton coal of Stevenson described in Rept. KK of Pennsylvania Geol. Survey, pp. 67, 68).

In the Georges Creek Valley the Bakerstown coal is locally known as the Four-foot and sometimes as the Three-foot. In the Castleman basin it is locally known as the Honeycomb. There is another bed in the Castleman basin which is locally known as the Beachey bed or Four-foot; this may be a local development of the Honeycomb or Bakerstown, or may belong as much as 60 feet below that bed. It is, however, more than 80 feet above the Brush Creek coal. The various possibilities in regard to the actual local position of this coal will be discussed under the heading "Mineral resources." In regard to its correlation, it may be said that if it is not a local phase of the Bakerstown it has no equivalent in the other coal basins of Maryland. In the Salisbury basin of Pennsylvania, of which the Castleman basin is the southern continuation, there are three coal beds between the Bakerstown and the Brush Creek which have no recognized equivalent elsewhere. The Beachey bed is probably one of these, but there is no positive evidence as to which it is. It has been named the Grantsville coal, from its typical development near the town of that name.

The strata immediately overlying the Bakerstown coal are well exposed in the Castleman Valley in the railroad cut a mile south of the National Road. This section is part (Nos. 24 to 34) of the complete Conemaugh section given above. The coal bed 40 feet above the Bakerstown and the limestones underlying it have not been recognized in Maryland outside of this basin, but the coal at least appears to be very constant within the basin. The name Maynardier coal was given it from its development at the west end of Maynardier Ridge. Neither the coal nor the limestone can be correlated with any members of the Conemaugh hitherto described from other regions. In other basins this interval is generally concealed or only poorly exposed.

In the river bluff northwest of Friendsville there are good exposures of a fine-grained cross-bedded sandstone about 30 feet thick which occupies the interval of 50 to 80 feet above the Bakerstown coal. This is apparently the equivalent of the Saltsburg sandstone, described by Stevenson,[a] from Saltsburg, Indiana County, Pa.

The Saltsburg sandstone is overlain by a bed of shale, never more than 10 feet thick, above which is the thin but very characteristic and persistent Harlem coal.

The Harlem coal, is the equivalent of the Crinoidal coal of the Pennsylvania reports and of Coal 8b or the Crinoidal coal of the Ohio reports. This bed is well developed in the vicinity of Friendsville, where it is exposed in the bank of Youghiogheny River one-half mile north of the town, at an elevation of 250 feet above the river, and is opened at several small mines west and southwest of the town. It has been mined at many places in the Castleman Valley, where it is locally known as the Fossil coal.

The Ames ("Crinoidal") limestone immediately overlies the Harlem coal. This limestone apparently is always either present or is represented by a bed of calcareous shale. Both the limestone and the shale carry abundant marine fossils. The relations of the coal and limestone are well shown in the following sections:

Section at David Herring's mine, 1 mile southwest of Friendsville, Garrett County, Md.

	Feet.
Black and gray shales	6
Fossiliferous calcareous shale	1
Fossiliferous limestone (Ames)	2
Coal (Harlem)	1⅓

Section one-half mile northwest of Grantsville, Garrett County, Md.

	Feet.
Massive sandstone	15
Concealed	41
Black shale	10
Fossiliferous limestone (Ames)	1
Coal (Harlem)	1½
Limestone	4
Shale	1

The limestone below the coal is present in many places. It is No. 21 of the Castleman Valley section, given above. The interval above the Ames limestone is not well exposed. In the bluff northwest of Friendsville there is a thin coal about 40 feet above the Ames limestone, and the beds between them consist principally of sandstone. This thin coal is probably the equivalent of the Elklick coal. In Garrett County it seems to be irregular in occurrence and always very thin.

Immediately overlying the Elklick coal is a very massive, persistent, and characteristic sandstone, which is the equivalent of the Morgantown sandstone of West Virginia. It is well exposed in an old quarry in the western outskirts of Grantsville, on numerous hills to the southwest along the axis of this syncline, in the bluffs of the Youghiogheny below Friendsville, on the higher hilltops in the Potomac Valley, and at numerous places in the Georges Creek valley. The thickness varies from 25 to 50 feet. Toward the base it is usually conglomeratic, but it becomes finer toward the top and finally grades into shale.

An important limestone, which is the equivalent of the Clarksburg limestone of West Virginia, occurs about 40 feet above the top of the Morgantown sandstone. It is well exposed in Mr. Rumbaugh's quarry a mile northwest of Friendsville; and is probably the limestone (No. 15) in the Castleman Valley section which is exposed one-half mile northeast of Bevansville. This limestone, which usually has a thickness of about 7 feet, differs from the Cambridge and Ames limestones in lacking the marine faunas, having no fossils except ostracods and fish. It fauna and its lithologic character give it a very distinctive and characteristic appearance.

[a] Second Geol. Survey Pennsylvania, Rept. KKK, p. 22.

A coal bed, which is known in the Georges Creek basin as the Franklin or Dirty Nine-foot, and in West Virginia as the Little Clarksburg, overlies the Clarksburg limestone. This coal is very variable in thickness and quality, especially in Garrett County, and is absent in places.

The very massive conglomeratic Connellsville sandstone occurs a short distance above the Franklin coal. No sections have been observed which give the full thickness of the sandstone, but the marked influence upon the topography and the amount and character of the talus derived from it indicate a thickness of probably 50 feet. It is this sandstone that holds up the bench which is always below the Pittsburg coal. This bench and the immense amount of talus which surrounds it are very strikingly developed in the Georges Creek basin. The broad, flat plateau between Crab Run and Niverton is held up by this sandstone, and the summit of Ridgley Hill is probably capped by it. In the Youghiogheny basin the great flat plateau which overlooks the valley on the western side of the river from Friendsville to Watsondale is determined by the presence of this sandstone, which outcrops along the top of the bluff and whose talus conceals much of the underlying beds.

The Connellsville sandstone is overlain by a group of rocks of slight resistance, which consequently yield few good sections. The predominating rock is shale, and accompanying it are at least one bed of coal and one of limestone. In some regions there are two of each. The relations of the strata are shown in the following section:

Section one-half mile northwest of Gise, Garrett County, Md.

		Ft.	in.
Sandy shale		10	
Shale		3	
Coal, Little Pittsburg	Coal 12″; Shale 3″; Coal 12″	2	3
Shale		1	3
Limestone, Pittsburg		3	
Concealed, mostly shale		20±	
Sandstone, Connellsville.			
		39	6

The strata from the upper Little Pittsburg coal to the top of the formation consist of shale and have a thickness varying from 35 to 90 feet.

Correlation.—The Conemaugh formation is the same as the formation mapped by that name and as the "Lower Barren Coal Measures" by the Pennsylvania Geological Surveys. The correlation is based upon the continuity of the belts in the northern part of Garrett County with those mapped in the adjacent part of Pennsylvania, on the similarity of sequence of the individual beds with those of the type region on Conemaugh River, and on the presence of identical faunas in the Ames and Cambridge limestones. The formation is clearly defined here, as in Pennsylvania, between the Upper Freeport coal below and the Pittsburg coal above.

The formation is identical with that mapped in Ohio and West Virginia as the "Lower Barren Measures." In both of these States, as in the western part of Pennsylvania, the faunas of the Ames and Cambridge limestones have been followed as horizon markers of the greatest value in correlation.

The Fairfax formation and the upper part of the Bayard formation of Darton and Taff are identical with this formation.

MONONGAHELA FORMATION.

Areal distribution.—The Monongahela formation, named from Monongahela River, in Pennsylvania, occupies eighteen small areas in the Grantsville quadrangle, fourteen being in the Georges Creek valley, in Maryland, and four in the Castleman Valley in Pennsylvania.

Lithologic character.—The Monongahela formation consists of a series of sandstones, shales, limestones, and coal beds having a total thickness of about 260 feet. Sections of this formation are so poor and incomplete that it will be necessary to quote the following sections from the region adjoining this on the east, in order to describe the formation in detail.

The Monongahela formation is conformable upon the underlying Conemaugh. The base of the formation is the floor of the Pittsburg coal. This dividing plane is everywhere present and everywhere easily recognized.

Section of Monongahela formation in pumping shaft 2 miles south of Frostburg, Allegany County, Md.

		Ft.	in.
1. Coal, Waynesburg		1	10
2. Concealed		20	
3. Limestone, Waynesburg		5	7
4. Siliceous fire clay		3	11
5. Sandstone			10
6. Shale		4	10
7. Sandstone		1	8
8. Shale		20	
9. Coal, Uniontown			5
10. Shale		5	8
11. Sandstone, Sewickley		14	2
12. Shale		38	
13. Coal, Upper Sewickley	Coal 10″; Shale 3′; Coal 1′ 8″	5	6
14. Shale		16	
15. Sandstone		4	
16. Shale		25	
17. Sandstone		1	
18. Coal, Lower Sewickley		2	6
19. Shale		18	
20. Sandstone			10
21. Shale		9	6
22. Limestone, Fishpot		5	6
23. Shale		7	8
24. Coal and shale, Redstone		7	4
25. Shale		18	9
26. Sandstone		1	2
27. Coal, Pittsburg	Coal and shale 3′ 7″; Coal 9′ 6″	13	1
		252	9

Section of Monongahela formation at Koontz, Allegany County, Md.

		Ft.	in.
1. Coal, Waynesburg	Coal 3′ 4″; Shale 3″; Coal 6″; Bone 6″; Shale 1′ 8″; Coal 2′	8	3
2. Concealed		106	
3. Coal, Upper Sewickley		3	6
4. Concealed		107	
5. Shale		2	2
6. Coal, Pittsburg	Coal, wild 11″; Shale 10″; Coal, top 1′ 6″; Coal, breast 7′ 6″; Shale 1″; Coal 2″; Shale 1″; Coal, bottom 2′	13	1
		240	

The Pittsburg (or Elkgarden, Big vein, or Fourteen-foot, as it has been locally called in this region) is the thickest, most constant, and best known coal not only in this region but in the entire northern Appalachian field. Because of the shallowness of the other basins and the amount of erosion, its occurrence in these quadrangles is limited almost exclusively to the Georges Creek basin. In this and in the Potomac basin south of it there is a geographic variation in the character of the bed. In the northern end of the basin both the coal and the shale partings are thin, but toward the south the coal thickens, while the shales remain constant or decrease somewhat in thickness, until the maximum thickness of the coal is obtained in the central part of the Potomac basin. South of here the tendency was evidently for the shales to thicken enormously while the coal remained almost constant. In the Castleman Valley (Salisbury basin of Pennsylvania) the Pittsburg coal varies in thickness from 8 to 11 feet, exclusive of the roof or rider coals.

The strata overlying the Pittsburg coal are typically shown in the following section:

Section one-half mile south of Niverton, Somerset County, Pa.

	Feet.
1. Sandstone	2
2. Shale	12
3. Coal, Redstone	3
4. Shale	6
5. Limestone, Redstone	10
6. Shale	30
7. Coal, Pittsburg	9
	72

The Redstone limestone is well developed in the Castleman Valley, but has not been recognized in the Georges Creek basin. The overlying Redstone coal appears to be generally present in both basins. A short distance above the Redstone coal is a thin limestone (the Fishpot limestone), which is the only representative of the great thickness of limestone in about this position in southwestern Pennsylvania. This and all higher beds have been removed by erosion except in the Georges Creek valley. In western Allegany County there is a bed of coal about 30 feet above this limestone, which represents the Lower Sewickley coal. This bed has not been exposed in the Garrett

County part of the Grantsville quadrangle, but may be confidently expected there. About 45 feet above the Lower Sewickley coal, and separated from it by shales and sandstones, is the Upper Sewickley coal, or Tyson bed, as it has been called in Allegany County. A sandstone about 40 feet still higher is the representative of the Sewickley sandstone. A short distance above this there is found in western Allegany County the very thin representative of the Uniontown coal, but this has not been seen in Garrett County. About 30 feet higher is the Waynesburg limestone, which occupies a position about 30 feet below the upper member of the formation, or the Waynesburg coal. The Waynesburg coal is a very constant stratum, but its area in Garrett County is small and exposures of it are infrequent. It was called the Koontz coal in the report on the geology of Allegany County. The roof of this coal marks the top of the Monongahela formation.

Correlation.—The strata here mapped and called the Monongahela formation are correlated with the restricted formation which was long ago given that name and mapped by the Pennsylvania Geological Survey. They have also been called, in Pennsylvania, West Virginia, and Ohio, the "Upper Productive Coal Measures."

The correlation with the rocks of the type section of the Monongahela formation is based upon the general similarity of stratigraphic succession, on the presence of the large coal at the base, which corresponds in general section with the Pittsburg coal, and on the presence of the underlying beds, which, not only in their stratigraphic sequence but in their faunas, are proved to be the equivalent of the Conemaugh formation.

The question has been raised (West Virginia Geol. Survey, vol. 2, 1903, pp. 145–146) whether the writer has correctly correlated the coal which is here and has been previously (Geology of Garrett County, Maryland Geol. Survey, 1902, pp. 140–144) referred to the Waynesburg. I. C. White suggests that this coal may be the Uniontown, while the Waynesburg is the coal here called the Washington. The possibility of this interpretation is admitted, but the correct correlation can be proved only by paleontologic evidence, which is not now at hand.

The "Elkgarden formation" of Darton and Taff was named and mapped in the folio (No. 28) that describes the Piedmont quadrangle, which adjoins these quadrangles on the south, and is the exact equivalent of the beds here referred to the Monongahela formation.

DUNKARD FORMATION.

Areal distribution. — The Dunkard formation occupies four small areas in the Grantsville quadrangle. These are all in the Georges Creek basin, close to the Allegany-Garrett County line; three are on the summit of Detmold Hill, and the fourth is on Swanton Hill west of Barton.

Lithologic character.—The Dunkard formation lies with an apparent conformity upon the Monongahela. The areas are all so small and so near to the summits of gently rounded hills above the drainage lines that there are no good exposures. Consequently it is impossible to say anything definite about the strata, except that they are apparently shales or limestones which do not show through the soil.

The following section gives the best known sequence of the strata composing the Dunkard formation in this region.

Section of Dunkard formation on hill east of Pumping Shaft station, Allegany County.

	Ft.	in.
Massive sandstone	10	
Concealed	25	
Shale, limestone, and concealed	37	
Coal, Jollytown	2	2
Concealed	20	
Limestone, Upper Washington	4	
Concealed	80	
Limestone, Middle Washington	2	
Concealed	110	
Shale	1	
Limestone		8
Black shale		10
Coal, Washington	3	6
Concealed	10	
Limestone	2	
Concealed	81	
Monongahela formation		
	389	2

The Waynesburg sandstone, which is almost always seen a short distance above the base of the formation in other regions, has not been recognized in Maryland. The thickness of the part of the formation exposed in the Grantsville quadrangle nowhere exceeds 180 feet, which thickness is on Swanton Hill. The strata as exposed in this quadrangle are not at all distinct from the upper beds of the Monongahela formation, and the only reason for showing the Dunkard on the map is that these hills are high enough above the base of the Monongahela to include more than the normal thickness of that formation as shown immediately to the east. In Allegany County, east of this area, the thickness of the Dunkard formation is about 400 feet, and in southwestern Pennsylvania it is more than 1000 feet but in this region all but the lowest beds have been removed by erosion.

Correlation.—The correlation of these rocks with the Dunkard formation of southwestern Pennsylvania rests upon the supposed identity of the coal 232 feet above the Pittsburg coal at Koontz with the Waynesburg coal. The doubt as to the correctness of this identification has already been mentioned. The rocks above the bed here referred to the Washington coal are, in any case, part of the Dunkard. These strata are a small part of the great thickness of Dunkard which remains in southwestern Pennsylvania, and all are the equivalent of beds belonging in its lower division, the Washington formation. These rocks, together with the 210 feet which overlie them in the region adjoining this on the east, were formerly called the "Frostburg formation," but this name has been abandoned as a synonym.

The equivalents of these beds in Pennsylvania and West Virginia have, from a study of their floras and faunas been referred to the Permian series of the Carboniferous. Some doubt still exists as to their age, but in all probability they are, in part at least, Permian.

QUATERNARY SYSTEM.

The Paleozoic rocks of these quadrangles, except where they are constantly being swept clean, are covered by a mantle of unconsolidated material of diverse character. The age of this mantle extends from the immediate present back through a somewhat indefinite but not very long period in geologic history.

On the basis of origin the surface deposits of this region may be classified as follows:

Untransported products of agencies still at work=the soil.
Sediments (fluviatile) still being formed=river bottoms.
Sediments produced by past conditions=river terraces.
Untransported material produced under past conditions=the residual soil of the glades.

The glades.—The oldest and most constant and characteristic of the unconsolidated deposits of this region consist of a thick mantle of residual clay and sand which is best developed in the regions of flat, open marsh and meadow lands known as "glades." The thickness and exact lithologic character of these deposits are not well known as there are no good sections, either natural or artificial. The glades are a series of local plains which were in general both caused and preserved from subsequent destruction by the resistance of the Pottsville and Pocono ridges.

River terraces.—Terraces are very prominent along some of the streams in these quadrangles, but for the most part the streams are without any distinct and extensive system of terraces. There are benches on the sides of most of the valleys, but these are formed by ledges of resistant rock, are not horizontal, and are not of constructive origin. However, there are some terraces which are horizontal and constant in position and are composed of sedimentary material younger than the valley itself.

These terraces are best developed in the Castleman Valley a few miles south of Grantsville. Here is at least one terrace which is distinctly of constructive origin. It lies at an elevation of about 2200 feet above tide, or about 30 feet above the bottom of the valley. It is composed of well-stratified sand and sticky blue clay, with a surface of loam. In the sand and clay are rounded quartz pebbles and rolled crusts of limonite. The thickness of the deposits exceeds 20 feet in places. This terrace extends along both sides of the valley from the mouth of Shade Run to and somewhat above the mouth of the North Fork. A similar terrace exists, but is not quite as well developed, in the Youghiogheny Valley from Friendsville to the northern edge of the quadrangle. This is at an elevation of about 1500 feet, and shows most distinctly at the mouths of the side valleys.

The origin of these terraces can not at present be explained.

River bottoms.—Most of the rivers, especially those which are not actively lowering their beds, have built flood plains of varying width and character. Most of them are narrow and consist only of belts of coarse detritus extending from the edge of the channel to the base of the steep hillside. Castleman River meanders for much of its course through a broad, swampy flood plain which is still in process of construction. Youghiogheny River from near Friendsville to and beyond the northern edge of the quadrangle is flowing through a broad flood plain whose surface is of fine loam and which is almost high enough above the river to be regarded as a terrace. Many of the smaller streams are bordered by narrow flood plains which are still in process of construction and change. The best developed of these are along Savage River.

Soil.—The most extensive and most recent of the Quaternary deposits is the soil.

STRUCTURE.

GENERAL FEATURES.

The rocks of this region are unaltered sediments which have been thrown into a series of open, nearly symmetrical folds with axes trending toward the northeast and southwest. The region presents a structure which is similar to that of the adjacent regions on the northeast and southwest, but different from that of the regions on the southeast and northwest, although with each of the latter it has certain points in common, being transitional between them. While on the whole it has a marked individuality, yet it has within itself certain divergent types which render it capable of division into structural subprovinces.

There are seven major folds which enter these quadrangles, including four synclines and three anticlines. In the southeast corner of the Grantsville quadrangle is the Georges Creek syncline. This is succeeded on the west by the Deer Park anticline, which extends from near the northeast corner to near the southwest corner of the same quadrangle. West of this are two synclines (the Castleman syncline at the north and the Upper Youghiogheny syncline at the south) which are disconnected by a low uplift and are neither quite in line nor quite parallel. The axis of the latter is situated farther to the northwest, and its direction is more nearly north and south, than the axis of the former. West of these two synclines are two anticlines, the Accident anticline at the north and the Cranesville anticline at the south, which like the synclines last described are also disconnected, and whose axes are both out of line and divergent. The discrepancy in the position and direction of the axes is similar to that of the axes of the above-mentioned synclines, but is even greater in amount. Northwest of these anticlines is the Lower Youghiogheny syncline. The Upper Youghiogheny syncline, from its position flanking the Deer Park anticline on the west, would seem to be more closely related to the Castleman than to the Lower Youghiogheny syncline; but it is structurally more closely related to the latter, as it is joined with it at a point on the axis 200 feet lower than with the former, and is a fold of the same broad unsymmetrical type.

Faults are small, infrequent, and inconspicuous. They do not affect the areal distribution of the formations or the general character of the structure.

The folds are in general unsymmetrical, the steepest dips being on the eastern limbs of the synclines and the western limbs of the anticlines. In other words, the northwestward dips are steeper than the southeastward. This is in general true throughout the entire Appalachian Province. The amount and the regularity of the dip decrease from the southeastern to the northwestern part of the quadrangle. The amount of pitch increases in the same direction. This regular change in the dip and pitch from the southeast to the northwest entirely changes the general character of the structure. The continuation of the change beyond the limits of the quadrangles in either direction makes this area a transition zone between two radically different structural districts. To the southeast and east is the division of the Appalachian Province which has been designated the Appalachian Valley, while in this area and northwest of it are the Allegheny Plateaus. The former is characterized by the canoe-shaped syncline and the cigar-shaped anticline. The latter are characterized by the spoon-shaped syncline and the domed anticline. The eastern edge of the Georges Creek syncline forms the western boundary of the former region. The eastern edges of the Accident anticline and the Upper Youghiogheny syncline form the eastern boundary of the more typical portion, structurally, of the latter region. The intervening area, comprising here the Georges Creek syncline, the Deer Park anticline, and the Castleman syncline, is structurally transitional between them.

The details of the structure are shown by the structure sections and contours on the geologic structure sheet. The former show, in natural scale, the rocks as they would appear on the side of a trench cut down to sea level. The latter represent the position of imaginary horizontal lines, 100 feet apart vertically, drawn on the upper surface of the Pottsville formation. They show the height of the top of the Pottsville above sea level, and in connection with the surface contours show the depth of the top of the Pottsville below the surface of the ground.

GEORGES CREEK SYNCLINE.

Location.—The easternmost structural feature is a broad, rather deep synclinorium, only part of the western limb of which lies within the limits of these quadrangles. It is named from the stream which flows along the axis. The southern part of this fold was called by Darton and Taff (Piedmont folio, No. 28) the North Potomac syncline, while the northern part was called by O'Harra the Georges Creek syncline. The further continuation of this fold into Pennsylvania has been called the Wellersburg syncline.

The western edge of this syncline may be considered as located along the line of steepest dip, where the beds change from an upward to a downward concavity. This line coincides approximately with the outcrop of the base of the Pottsville, with the 3200-foot contour drawn on the top of the Pottsville, and with the crest of the Great Backbone–Big Savage ridge. The course of the western edge of the fold is remarkably uniform, being about N. 35° E., except for about 4 miles in a region east of Altamont, where it is about N. 50° E. The syncline is continued toward the northeast into Pennsylvania and southwestward into West Virginia.

The axis of the fold lies within the area under consideration for only a short distance, in the southeast corner of the Grantsville quadrangle. Beyond the borders of the quadrangle it extends through the towns of Mount Savage, Frostburg, Borden Shaft, Lonaconing, and Westernport, in Maryland. Thence it passes into West Virginia and lies somewhat east of Potomac River from Piedmont to Elkgarden.

General features.—The most striking features of this fold are the very uniform strike and dip along the western flank and the flattening of the center of the fold and steepening of the western flank in the valley of Savage River.

The strata outcropping within this syncline are those of the Mauch Chunk, Pottsville, Allegheny, Conemaugh, Monongahela, and Dunkard formations.

Attitude of the strata.—The strike averages about N. 35° E. along the western edge of the fold. Toward the axis it becomes less regular. The dip varies from 20° to 45° along the edge of the fold, averaging about 30°. Toward the center of the syncline it becomes steadily smaller and less regular. Along Potomac River it is small but quite irregular in amount and direction. The pitch on the part of the axis lying in the Grantsville quadrangle is very slight but apparently is continuously northeastward at the rate of about 15 feet per mile.

DEER PARK ANTICLINE.

Location.—The Deer Park anticline bounds the Georges Creek syncline on the west throughout its length. Its western border may be somewhat arbitrarily placed at the outcrop of the base of the Pottsville formation along the crest of Meadow Mountain. This coincides approximately with the 3200-foot contour drawn on top of the Pottsville formation.

The axis extends S. 35° W. from the Pennsylvania line, halfway between Big Savage and Meadow mountains, through Avilton to Tom Ridge.

General features.—This is a long, approximately straight, simple anticline, with few if any subordinate folds. The anticline is most elevated and most steeply arched at the southern end, which is beyond the limits of these quadrangles. At the central depressed point the top of the arch is very flat. This depression is bounded on the west by a zone of steeply dipping rocks. This abruptly terminates the depression on the west, so it does not effect the adjacent syncline. The steepest dips in the region are at this place, where the rocks stand vertical.

The rocks involved in this fold which outcrop at the surface are those of the Jennings, Catskill, Pocono, Greenbrier, and Mauch Chunk formations. The axis is in the outcrop of the Jennings formation throughout the entire length of the fold.

Attitude of the strata.—The strike is very uniform throughout the entire fold. Except at a few points near the center of the fold it remains parallel to the axis. The dip varies from 0° to 90°. A very noticeable feature in this anticline is the occurrence of very steep dips at no great distance from the axis. The steepest dips are in general on the west side of the axis. The average dip in the zone of greatest inclination is about 35°. The dip in general is greater toward the southern end of the fold. The pitch from the southern edge of the quadrangle to Middle Ridge is about 130 feet per mile northeastward. From this point north it is about 160 feet per mile southwestward.

In the center of the fold there has been some faulting, but the displacement is apparently slight. In the fissures and fault planes are veins of calcite which contain small amounts of galena, sphalerite, and pyrite.

CASTLEMAN SYNCLINE.

Location.—The Castleman syncline adjoins the north end of the Deer Park syncline on the west side of the latter. It occupies the area between the crests of Meadow and Negro mountains, the boundaries being approximately the outcrop of the base of the Pottsville formation on the crests of those mountains, or the position of the 3200-foot contour drawn on the top of the Pottsville formation. The southern end of the syncline may be placed at Deep Creek, which flows along a small low anticline that cuts off this syncline from the Upper Youghiogheny synclines outhwest of it.

The axis of this fold extends from Niverton, Pa., through the eastern end of Grantsville and on to Castleman River at a point a mile south of Grantsville. Thence it lies along the course of the Castleman as far as the forks of that stream. From here it extends to Bittinger, and thence in a course about S. 45° W. to the southern end of Meadow Mountain.

General features.—This is, so far as the portion in this region is concerned, a typical canoe-shaped syncline. Subordinate folds and undulations of the axis are apparently lacking. It is a more simple fold than the Georges Creek syncline or the synclines farther west.

The strata involved in this fold and outcropping in it are those of the Mauch Chunk, Pottsville, Allegheny, Conemaugh, and Monongahela formations.

Attitude of the strata.—The strike on the flanks of that part of the syncline southwest of Bevansville is in general parallel to the axis. Northeast of Bevansville it gradually diverges from the direction of the axis toward the east on the eastern limb of the fold and toward the north on the western limb. The dip is gentle and regular. It averages about 12° or 15° on the crests of Meadow and Negro mountains and decreases rapidly and regularly toward the axis. The axis pitches to the northeast at a rate of about 55 feet per mile from Niverton, Pa., to a point about $2\frac{1}{2}$ miles southwest of Bittinger. From that point to the southern end of the syncline it pitches to the northeast at a rate of 200 feet per mile.

There is a fault in the sandstones and shales of the Conemaugh formation in the west bank of Castleman River just east of Grantsville. For a distance of about 100 feet along the roadside there can be seen a massive sandstone resting horizontally upon the upturned edges of steeply dipping shales. The dip of the shales is unusual for this region, the normal dip at this point being that of the almost horizontal sandstone. The disturbance is all the more remarkable for occurring in the center of a very open syncline where the strata are usually very slightly disturbed. The amount of displacement could not be measured, but appearances at this locality indicate that it may be considerable. There are, however, no indications of it in any other exposures.

ACCIDENT ANTICLINE.

Location.—The Accident anticline lies west of the Castleman syncline and north of the Upper Youghiogheny syncline. Its western boundary is the crest of Winding Ridge. This fold forks at the southern end; one prong, extending southeastward through the valley of Deep Creek, connects with the Deer Park anticline; the other, extending southwestward, connects with the Cranesville anticline.

The axis extends in an almost straight line from a point on the Pennsylvania line S. 37° W. to a point a mile west of Accident. Thence it extends S. 26° W. for almost 4 miles, where it becomes obscured toward the rim of the fold. A bifurcation takes place, however, one axis passing southeastward through McHenry and the valley of Deep Creek, and the other southwestward through the high hill south of Sang Run toward the center of Pine Swamp.

General features.—This fold is the southern end of a very long, narrow arch which extends for many miles into Pennsylvania and is there known as the Negro Mountain anticline. Its most striking feature is the development of a great dome near the southern end, beyond which it pitches rapidly downward into the end of a syncline. It is an anticline of a type different from that of the anticlines toward the east, and is the counterpart of the Youghiogheny synclines, with which it characterizes the structure of this topographic and structural subprovince.

The strata involved at the surface are those of the Jennings, Catskill, Pocono, Greenbrier, and Mauch Chunk formations.

Attitude of the strata.—The strike is rather regular, being roughly parallel to the rim of the fold, especially at points not far removed from the rim. The most marked exception to this is in the interior of the fold for a distance of about 5 miles northeast of Accident. Here the strike diverges from the direction of the axis southwesterly on the western limb of the fold and southeasterly on the eastern limb. The dip is quaquaversal except in the vicinity of the Pennsylvania line. The steepest dip is on the western limb of the fold about $2\frac{1}{2}$ miles west of Accident, where a maximum of 25° was observed in one exposure. It seldom exceeds 10° or 12° and is irregular. The axis pitches northeastward at a rate of about 160 feet per mile from the Pennsylvania line to a point about a mile west of Accident. From here south it pitches southwestward at a rate of 200 feet per mile for about 3 miles and then increases to a maximum of about 500 feet per mile toward the rim of the adjacent syncline.

It is possible that there has been faulting on the western limb of the fold in the region of steepest dip. The occurrence of abundant blocks of slickensided sandstone on the surface and an apparently abnormal thinness of the Catskill formation suggest the presence of a fault west of Accident. Its actual occurrence, however, could not be established.

CRANESVILLE ANTICLINE.

Location. — This anticline adjoins the Upper Youghiogheny syncline on the west flank of the latter. It is bounded on the north by Feik Hill and Dog Ridge, beyond which is the Lower Youghiogheny syncline. The western and southern limits of this fold, as well as the greater part of its area, are in West Virginia.

The axis extends through the valley east of Nettle Ridge and the town of Cranesville in a southwesterly direction.

General features.—The end of this fold which enters this region resembles the southern end of the Accident anticline, and the similarity appears to continue southwestward into Preston County, W. Va.

The surface rocks involved in the part of the fold which lies within the quadrangle are those of the Pocono, Greenbrier, Mauch Chunk, and Pottsville formations. Along the axis in West Virginia the Jennings and Catskill formations are exposed.

Attitude of the strata.—The strike is fairly regular in direction, keeping parallel to the edge of the fold on the contour lines shown on the economic geology and structure maps. The dip, so far as the Maryland end of this fold is concerned, seems to be quaquaversal. It is fairly regular, although of small amount, seldom exceeding 8° or 10° in the northern end of the fold, but increasing to a maximum of about 20° northwest of Corinth. The pitch along that part of the axis which lies in this area is about 500 feet per mile northeastward.

LOWER YOUGHIOGHENY SYNCLINE.

Location.—This syncline adjoins the Accident anticline on the west, the Upper Youghiogheny syncline on the northwest, and the Cranesville anticline on the northeast. It extends northward into Pennsylvania and westward into West Virginia. It is connected with the Upper Youghiogheny syncline across the low anticline connecting the Accident and Cranesville domes.

The axis follows a somewhat sinuous course near the eastern border of the syncline. It crosses the Pennsylvania line about $1\frac{1}{2}$ miles east of Youghiogheny River and extends in a south-southwesterly direction. Crossing Youghiogheny River about a mile below Selbysport, it continues west of that stream and about one-half mile from it as far as the mouth of Trap Run. Here it takes a southerly direction, the river winding back and forth across it as far as Sang Run. From this point it extends southward into the high hill south and west of the river, and joins the western fork of the Upper Youghiogheny syncline.

General features. — This fold differs from the Georges Creek and Castleman synclines in being very markedly unsymmetrical. Its most striking feature is the very strong regular dip on the eastern limb as compared with the weak irregular dip of the western limb. It should be noted that the pitch is greater than in any of the synclines described above. This is due to the abrupt termination of the syncline at the south against the end of a steeply pitching anticline. This deflects the strike at almost a right angle, and the pitch practically passes into the dip of the southern limb.

The strata exposed are those of the Greenbrier, Mauch Chunk, Pottsville, Allegheny, and Conemaugh formations.

Attitude of the strata.—The strike on the eastern limb of the fold is very uniformly N. 35° E. as far south as a point 2 miles north of Sang Run. Between here and Sang Run there is great irregularity of strike. On the western limb of the fold the strike is in general north and south, except in the southern end of the fold, where it is northwest and southeast. The dip is very regular on the eastern limb of the fold. The maximum angle is about 20°. On the western limb of the fold the dip is very irregular in amount and in direction. It seldom exceeds 5° or 8°. A low secondary anticline occurs in the northwest corner of the county, on Sickle Hill and the ridge toward the north. The dip on the western flank of this is very slight. A very strong minor fold occurs at the mouth of Laurel Run and very near the axis of the syncline. This disturbance is evidently of slight extent. The axis descends to the northward from the southern end of the basin to the Pennsylvania line. It pitches at an average rate of about 200 feet per mile above the mouth of Salt Block Run. From the mouth of Salt Block Run to the mouth of White Rock Run the pitch is about 330 feet per mile. From this point to Krug it is about 150 feet per mile. Here it increases again and maintains an average pitch of 260 feet per mile as far as Friendsville. The pitch is very slight below Friendsville, but maintains its direction to the northeast.

UPPER YOUGHIOGHENY SYNCLINE.

Location.—This syncline lies west of the southern end of the Deer Park anticline, and only its extreme northern end is within these quadrangles. Its western boundary is the outcrop of the base of the Pottsville formation along the crest of Snaggy Mountain. On the northeast it is separated from the Castleman syncline by the crest of a subordinate anticline, referred to below. On the northwest it is separated from the Lower Youghiogheny syncline by a low anticline in the high hill south of Sang Run. On the north, between the two low anticlines above mentioned, is the Accident anticline, of which they are both prongs.

So small a part of this fold enters this region that a detailed discussion is not given here. The most noticeable structural features are its unsymmetrical character, the shortness in proportion to the width, the strong pitch compared with the relatively gentle dip, the irregular strike and dip, the bifurcating axis (the point of bifurcation being outside the quadrangle), and the presence of four subordinate spoon-shaped synclines. This syncline differs in type from those described above. It is of the class typically developed in western Pennsylvania, which have short, rapidly plunging, bifurcating, offsetting axes, and contrast sharply with the long, straight, regular, canoe-shaped synclines farther east.

The strata outcropping in this fold are those of the Mauch Chunk, Pottsville, Allegheny, and Conemaugh formations.

HISTORICAL GEOLOGY.

EARLY PALEOZOIC SEDIMENTATION.

During the earliest known periods of geologic history large areas of what is now the continent of North America were covered by the sea. Land areas existed in what is now Canada and probably along a belt near the present Atlantic shore. These lands grew intermittently by uplift, and were worn away by the processes of erosion which are always attacking land surfaces. The shores shifted back and forth by uplift and subsidence, in addition to the general narrowing and shoaling of the sea through its receiving the sediments of land waste.

The details of this early history are complex and varied. The uplift of the land was sometimes rapid and consequently large amounts of sediment were delivered to the sea within short periods. At other times the land surface stood near sea level for great lapses of time, and then the sediment which reached the sea was fine in texture and small in volume. The land itself was at times submerged beneath the sea, so that marine sediments were spread over the old land surface. At still other times the sea bottom was raised above water level and the recently formed strata were eroded and redeposited.

There is no positive evidence as to what took place in the area of these quadrangles during early Paleozoic time. It is, however, highly probable that for the most part the region was submerged and lay at a considerable distance from shore. Sedimentation was probably slow but continuous.

DEVONIAN SEDIMENTATION.

EARLY DEVONIAN EPOCHS.

The rocks which were laid down at the beginning of the Devonian period are not exposed in these quadrangles. Their character in adjacent regions shows, however, that the entire district was submerged and was receiving sediments from a land mass which lay to the east. This land was near base-level, forming a low plain from which little sediment was derived. In early Devonian time the continent gradually rose, initiating erosion and causing muddy sediments to reach the sea. The continent was, however, largely a lowland until the middle of the Devonian, when the local record begins.

JENNINGS EPOCH.

A marked uplift of the lands east of the Appalachian sea began in Middle Devonian time. This resulted in the growth of a great highland area along the present shore of the northern Atlantic States. In this region of uplift erosion was very active and a vast amount of sediment was furnished to the sea. This material was transported by powerful rivers and deposited as a very imperfectly sorted mass of sand and clay upon a subsiding sea bottom. Marine fossils are abundant in these rocks, which shows that they were laid down, in large part at least, in the sea. The character of the material and the bedding suggest that the bulk of the material was laid down in a series of deltas.

It is difficult to obtain a measure of the length of Jennings time. The thickness of strata accumulated is great, but the process was rapid; and both the thickness of the rocks and the rapidity of the accumulation were local phenomena. In the southern Appalachians the same beds are represented by only a few feet of black shale. There the sediments were lacking and accumulation was slow.

Jennings time was not marked by any legible episodes. There was monotonous uniformity, except as to minor details, such as the shifting of deltas. The uplift and erosion of the highland, the rapid transportation of poorly sorted detritus to the ocean, and the deposition of the sediments upon the sinking sea floor were all uninterrupted.

Toward the end of Jennings time uplift failed to keep pace with erosion in some portions of the continent and these regions became well worn down. A deep residual soil then began to accumulate. Other changes took place. The sea began to fill with sediment and a coastal plain formed. This grew westward by the filling of the sea and eastward by the reduction of the land to an even plain over which rivers meandered and spread the coarser part of their burden.

CATSKILL EPOCH.

Conditions little understood, which resulted in the formation of a great series of red and green shales and sandstones, in which marine fossils are absent, came into existence toward the close of the Devonian. These beds constitute the Catskill formation.

The Catskill epoch is not to be considered as a fixed and definite time in geologic history, to which the age of certain formations can everywhere be referred. It represents rather a migrating set of conditions which began in eastern New York and northeastern Pennsylvania in Middle Devonian time and continued there until after the beginning of the Carboniferous. In western New York and northwestern Pennsylvania it did not begin until the close of the Devonian. In Maryland and in the adjacent regions it began immediately after the close of the Chemung as here recognized and ended before the deposition of the earliest known Carboniferous sediments.

Catskill time differed from Jennings time in this region in that red and green strata were deposited in waters which did not contain marine life. The conditions which brought about this change are very imperfectly understood. The known facts seem to be limited to the following: The waters were unfavorable to marine life, as is indicated by the absence of marine fossils. So far as known, the position of the shore did not change, for there is no evidence of an unconformity by overlap, such as would result from a marine transgression; or of the transfer of coastal-plain accumulations into the sea, such as would result from a marine recession. The volume of sediment was continued while its character changed, this change consisting in an increase in the amount of thoroughly oxidized material and in a decrease in the amount of fresh and unsorted material.

The conditions above cited might have come about as the result of the following causes: The region bordering the coast having been reduced by subaerial erosion to a low-lying plain, over which all coarser river sediments were spread, only the finer sediments reached the sea. At the same time there was increased activity of erosion at a distance from the shore, due either to an uplift which did not affect the coast or to increased precipitation, which swelled the volume of the rivers and resulted in the transportation to the coastal plain of a large bulk of sediment of which only the finer portions reached the sea. The surface from which this material originally came was deeply disintegrated and was attacked rapidly by the strengthened streams. The result would be a large accumulation of coarse material on the coastal plain and a large influx of fresh water and of fine sediment into the sea. As a result either of the amount of this muddy material and fresh water which was poured into the sea or of unknown changes in the sea itself, the marine life of the Devonian was destroyed. The waters which extended over the northern Appalachian region must have been shallow and cut off from the main ocean or they could not have been so profoundly affected.

CARBONIFEROUS SEDIMENTATION.

The change from the Devonian to the Carboniferous sediments in this region is very strongly marked. The contact surface is so sharp as never to be mistaken. Whether or not it is accompanied by an unconformity is a question which can not at present be decided.

POCONO EPOCH.

The beginning of Carboniferous time appears to have been accompanied by a slight submergence and a tilting of the coastal plain toward the west. The red sediments which had been supplied to the sea during late Devonian time failed, either because the deep oxidized residual which had furnished them was exhausted or because transportation to the open sea was prevented by the submergence. At the same time the coarse and cleanly washed quartzose sediments which had been accumulating in the beaches and sand flats of the Devonian coastal plain or in the upper reaches of the rivers were delivered rapidly to the waters of the open sea and were spread as a broad sheet of conglomerate and sand. These beds form the Pocono sandstone. Some of the beaches and lagoons of earlier times were probably then entombed and preserved without destruction in the mass of partly transported and redeposited material. This made the sediments of the Pocono very complex and discordant in bedding. The great and abrupt variations in thickness of the formation find explanation both in previous irregularities in the sea bottom and in local differences in the amount of material at hand, and above all in the varying distance from shore.

Interbedded with the sandstone and conglomerate are beds of fine shale, some of which carry abundant marine fossils. These are probably the most shoreward representatives of the normal marine sediments which form the Waverly group in Ohio and there contain the remains of flourishing marine life.

Pocono time was marked by rapid submergence and the rapid delivery to the sea of the beach accumulations of previously washed and sorted material. The duration of Pocono time was probably not long.

GREENBRIER EPOCH.

The beginning of Greenbrier time was marked by a sudden decrease in the amount of sedimentation. The waters of the Appalachian sea became deeper and clearer and little or no arenaceous sediment was deposited. These waters teemed with marine life, and by the agency of these organisms, aided perhaps by chemical precipitation, beds of limestone were laid down. The argillaceous character of most of the limestone and the presence of interbedded strata of red shale indicate that land was near enough to furnish some detritus. The nature of this sediment shows that the land had a deeply disintegrated surface, and that the shore line was sufficiently embayed or beach bound to prevent the coarser material from reaching the open sea. It was probable that the submergence which brought the deep, clear ocean waters into the region converted the lower courses of the rivers into estuaries in which the coarser part of the land waste was held.

The Loyalhanna ("Siliceous") limestone at the base of the Greenbrier records that stage of the submergence when the last of the pebbly beaches disappeared below the sea and clear marine waters first extended over them. The cross-bedding in this rock was the work of the undertow and tides on the tops and sides of these already submerged beaches. They are a lithologic transition from the Pocono to the Greenbrier, but belong most positively to the age of the latter.

The absence of fossils in these beds is to be explained by the submergence and the accompanying eastward transfer of the shore line having been too rapid for the fauna to accompany it.

Shortly after this first invasion of marine waters from the west, the red and green shales and thin argillaceous limestones of the middle Greenbrier were deposited. It is probable that these deposits record a halt in the subsidence when the ponded Pocono rivers succeeded in clearing their mouths of the marine waters and poured an accumulation of muddy sediment into the sea.

The purer, more thickly bedded limestones which predominate in the upper part of the Greenbrier are the record of a renewed and continued submergence which lasted throughout the remainder of Greenbrier time. Marine conditions then existed for a long period and over a wide area. From time to time muddy sediment reached the sea, but it did not interfere with life, for the limestones and shales are both fossiliferous.

MAUCH CHUNK EPOCH.

The beginning of the Mauch Chunk epoch was marked by the invasion of that part of the sea in which the present Mauch Chunk shales of this area were deposited by a great volume of muddy sediment similar to that which from time to time reached it during the Greenbrier epoch. The clear marine waters and the marine fauna were probably driven away and a great thickness of mud and sand was rapidly deposited. This was occasioned by an uplift of the continent sufficient to quicken erosion and to bring the region under discussion within the zone which could receive muddy sediments, but not enough to deliver coarse unsorted material to the waves. The conditions of Catskill time were repeated. The already deeply weathered and oxidized soil was stripped off and carried to the sea, but on the way the coarser material lagged behind and was accumulated in flood-plain and coastal-plain sediments which were not to be finally deposited until the next epoch.

POTTSVILLE EPOCH.

The beginning of Pottsville time was marked by the change from the deposition of fine weathered sands and clays to that of much coarser and fresh sands and gravels. It was such a change as accompanies a submergence and seaward tilting of an old land surface. The coastal-plain accumulations were rapidly swept into the sea and redeposited with little sorting.

The lowest beds of the Pottsville in this region are much younger than those of the regions to the northeast and southwest. It is thus evident that there was no sedimentation in Maryland during the earliest Pottsville time, or that any such sediments as ever existed have been eroded, or that the oldest Pottsville sediments of these other regions are contemporaneous with part of the Mauch Chunk. This question has been discussed by David White (Twentieth Ann. Rept. U. S. Geol. Survey, part 2, pp. 749–928). The present evidence is inconclusive, but the last explanation is regarded as more probable.

In the Maryland region the beginning of Pottsville time was marked by the deposition of a thin sandstone, following the cessation of the deposition of red sediments and possibly following a still later period of erosion.

The history of Pottsville time is complex, varying much within short intervals, not only from time to time but from place to place. It is a record of the intermittent deposition and migration of coastal- and flood-plain deposits, including coal marshes, with no evidence of incursions of the open sea. The predominant conditions were such that coarse and pebbly sands were deposited.

The detailed discussion of the course of events during this and the succeeding Carboniferous epochs will be found in the author's report on the geology of Garrett County (Maryland Geol. Survey, 1902, pp. 171–181). There are other possible interpretations, such as that given by Stevenson. (See Bull. Geol. Soc. America, vol. 18, 1907, pp. 142–164.)

ALLEGHENY EPOCH.

Allegheny time resembled Pottsville time in that the area of these quadrangles was still within a coastal plain, but differed from it in that the sediments were predominantly finer than during the Pottsville. Marine waters extended into part of this area for a brief time when the Vanport limestone was being laid down, and there were seven episodes of the formation of coal beds.

CONEMAUGH EPOCH.

During Conemaugh time coastal- and flood-plain conditions still prevailed. At least seven coal marshes extended over the entire area, and there were several of less extent. There were short episodes of marine transgression during the formation of the Lower Cambridge, Upper Cambridge, and Ames limestones, all of which occurred during the deposition of the lower half of the Conemaugh formation. With the deposition of the Ames limestone the Appalachian gulf probably ceased forever to be marine, the higher limestones being either of fresh or brackish water or of problematical origin.

MONONGAHELA EPOCH.

Monongahela time was like the later part of Conemaugh time in its general conditions. Finer deposits were made, however, for shales and limestones predominate over sandstones. The Pittsburg coal, the formation of which marks the beginning of Monongahela time, is of wide extent and great regularity. The marsh in which it was formed covered a large area and lasted under very uniform conditions for a long time. The formation of coal beds recurred frequently during this epoch, 10 per cent of the thickness of the formation consisting of coal.

DUNKARD EPOCH.

Dunkard time began with the gentle submergence during which the Waynesburg marsh was covered. The events of this epoch in these quadrangles are not well known because the rocks are not well exposed. It was evidently a time of gentle and continuous submergence and of slow sedimentation in fresh or brackish water.

There is no record preserved, in the local rocks, of the closing portion of the Carboniferous period. Adjoining regions show that sedimentation probably continued in this region until the Appalachian gulf was finally filled. This ended the Paleozoic sedimentary record in this part of the world.

POST-CARBONIFEROUS EROSION.

Widespread and continuous erosion presumably began near the close of Paleozoic time and has continued with no known interruption until the present. Erosion was probably contemporaneous with all the folding which the region has undergone. We do not know the date of either the beginning or the end of the folding, or whether it was slow or rapid, continuous or intermittent, or whether erosion kept pace with it or lagged behind. Consequently the topography of the late Paleozoic or early Mesozoic lands can not be restored.

The earliest record which the physiography of this region reveals is shown in the mature upland topography already described. These features show that the region was long ago worn down by stream action to a condition of far less relief than it now has. This condition represents, in at least the broader sense of that term, a peneplain. Whether the streams of this peneplain had reduced their channels nearly to oceanic base-level, or whether the northern Appalachians consisted of a series of local base-levels, each behind a ridge of resistant rock, and the higher ones at a considerable vertical distance above ocean level, is, in the mind of the writer, an open question. There may also be a question as to whether the crests of the higher ridges represent an older peneplain and the 2500 to 2700-foot upland a later one, or whether the latter represents the oldest peneplain recorded in the region, with the higher hills and ridges as unreduced elevations upon it. The writer admits the possibility of either interpretation but denies the probability of the former.

When this 2500-foot peneplain was well developed—the shale and limestone areas brought to an even surface and the sandstone ridges worn low and cut by gaps—the present drainage lines were established.

The next step in the history of the region resulted in allowing the larger streams to cut quickly from 300 to 500 feet deeper. This may have been brought about by general uplift, by local differential uplift or warping, by climatic changes, or by changes in stream course or grade at a distance from this region and on the rivers draining it. Whatever the cause, the streams trenched their courses quickly to a depth of several hundred feet, then came again to base-level and reduced large areas at the present 1900 to 2100-foot elevation.

This was followed by another stream quickening, whose vertical halt is recorded in surrounding regions by a peneplain at the present 1200-foot elevation. This peneplain is not known to have been cut into the region now under discussion. At the time of its formation the streams of this region had not cut down to its level, or if they had, warping and subsequent erosion have destroyed the evidence.

The subsequent history, so far as local evidence is concerned, is one of continued erosion, retarded here and there by migrating barriers of sandstone and conglomerate ledges across the streams. Behind these barriers local base-levels were formed and local and temporary deposits of clay, sand, and gravel accumulated. Gradually conditions approached those now existing, and probably not for a long time have they differed, over the region as a whole, from those existing at present.

MINERAL RESOURCES.

INTRODUCTION.

The mineral resources of the Accident and Grantsville quadrangles are largely confined to those areas which are underlain by Carboniferous rocks. As these rocks cover more than half of the quadrangles, and as the Carboniferous areas are distributed rather uniformly in the various sections, it is certain that all parts of the region will be benefitted by a development of the mineral industries. All of these industries are as yet in a very youthful stage of development. Coal is now the chief product, and the supply is such that it will probably continue to be the most important product until it is exhausted. Deposits of fire clay have been found which are extremely promising, and it is not unlikely that this and other important clay and cement industries will be developed in the future. The supply of limestone is inexhaustible, but it has as yet been drawn upon only for local use. The rocks of this region contain deposits of iron ore similar to those which in neighboring regions have been of great value in the past, and the time may possibly come when the deposits of this region can be worked in a small way with profit. Some of the sandstones and limestones can be used as building stone and as road metal.

Between the areas of Carboniferous rocks with their rich mineral resources are Devonian areas which, though poorer in mineral resources, contain rocks which by disintegration have formed a rich soil. These regions will be benefitted by the development of the mining regions, because of the market which they will give for agricultural products, while the mining regions will in turn be benefited by being surrounded by rich and prosperous farming regions.

The areal distribution, sequence, and structure of the rocks have already been described in the preceding pages. The valuable minerals contained in these formations will now be described in the order of present importance.

COAL.[a]

GEOGRAPHIC OCCURRENCE.

The coal of the Accident and Grantsville quadrangles is confined to the synclines, or "coal basins," as those which contain beds of coal are called. The synclines of this region are all coal basins. There are four of these coal basins lying partly within these quadrangles. The Georges Creek basin lies in the southeastern part of the Grantsville quadrangle, east of Big Savage Mountain. The most important part of this basin lies to the east of the area here described. The Castleman basin lies in the northwestern part of the Grantsville quadrangle and the southeastern part of the Accident quadrangle, between Meadow and Negro mountains. It is the continuation of the Salisbury basin of Pennsylvania. The lower Youghiogheny basin lies in the northwestern part of the Accident quadrangle, to the west of Winding Ridge and to the north of Dog Ridge. It is the continuation of the Confluence basin of Pennsylvania. The upper Youghiogheny basin lies in greater part to the south of the region here described, but a very small portion of it lies in the extreme southern end of the Accident quadrangle.

STRATIGRAPHIC OCCURRENCE.

The coal beds occur in the Pottsville, Allegheny, Conemaugh, and Monongahela formations, which collectively are called the "Coal Measures."

POTTSVILLE COALS.

The coal beds of the Pottsville formation are of far less importance in this region than those of the overlying formations, or of the Pottsville formation itself farther south. At present no Pottsville coal is mined locally, but further prospecting and different conditions of the market may make some of the beds of commercial importance in the future.

Sharon coal.—This bed, which is the representative of some of the important New River and Pocahontas coals of Virginia and West Virginia, has a far greater areal extent than any other coal in these quadrangles, but is known to be of workable thickness at few if any points. It occurs only a few feet above the base of the formation and is very persistent in its position. It is exposed in the railroad cut about a mile north of Swallow Falls, where its thickness is little more than a foot. A few miles to the west, near the West Virginia line and on the opposite flank of this basin, the same bed has been reported by I. C. White (Bull. U. S. Geol. Survey No. 65, p. 202) as having a thickness of about 3 feet and being quite soft and pure and of the coking type of the New River coals. The bed has not been exposed in the lower Youghiogheny or Castleman basins.

Quakertown coal.—This bed occurs about 140 feet above the Sharon coal and has been exposed at only one place in these quadrangles—in the gorge below Swallow Falls, where it has a thickness of about 18 inches. The only other place in Maryland where it has been seen is in Allegany County, where it is exposed about half a mile below Westernport, on the gravity plane of the Cumberland and Westernport Coal Company.

Section of Quakertown coal near Westernport, Allegany County, Md.

	Feet.
Coal	1
Shale	4
Coal	1½

It is not probable that this bed will ever prove to have any economic value in this region.

Mount Savage coal.—This bed occurs from 120 to 150 feet above the Quakertown coal and from 25 to 75 feet below the top of the formation. It has been seen in all of the basins, but is not at present mined on a commercial scale anywhere in this region. Both the thickness and the quality of the bed vary much within short distances, and it is doubtful if the bed can ever be profitably mined except possibly in connection with the fire clay which is usually associated with it. The following section was measured at the Savage Mountain fire-clay mine near Frostburg, Allegany County, Md.

Section of Mount Savage coal near Frostburg, Md.

	Ft.	in.
Sandstone.		
Shale	1	
Coal	1	2½
Shale		11
Coal	2	
Shale and fire clay	12	

In the average development of this bed it contains about 3 feet of coal with almost 1 foot of shale near the middle. Although the quality of this coal is not good, it is the most promising coal in the Pottsville of this region.

ALLEGHENY COALS.

By far the greater part of the coal of these quadrangles is in the Allegheny formation.

Brookville coal.—This bed occurs only a few feet above the base of the formation. It is very irregular in occurrence, both in this region and in other regions.

Clarion coal.—This bed occurs between 15 and 45 feet above the base of the Allegheny formation and is one of the most persistent of the small beds. It usually contains about 30 inches of coal, with a thin shale about 10 inches above the floor. Frequently the bed thickens locally to 4 feet or more, but is then broken up by shale.

The Clarion coal usually has a characteristic roof of shale with carbonate of iron nodules, which is overlain by a massive sandstone. It has frequently been confused with the Mount Savage coal, but can be readily distinguished from the latter by being associated with iron ore rather than with flint fire clay. The presence of this bed in the Youghiogheny basin has not been definitely established.

Section of Clarion coal on Piney Run, Somerset County, Pa.

	Ft.	in.
Coal	1	11
Shale		¼
Coal	1	2
Shale		8
Coal		8

Split-six coal.—This coal occurs from 60 to 120 feet above the base of the formation and about 50 feet above the Clarion coal. It is not well developed except in portions of the Georges Creek and lower Youghiogheny basins.

Section of Split-six coal 2½ miles north-northwest of Sang Run, Garrett County, Md.

	Ft.	in.
Black shale.		
Coal	1	3
Shale		3
Coal	1	
Shale		1
Coal		11
	3	6

This coal is frequently absent, having been seen at only a few points. Because of this, and of its poor quality, it can not be considered as having any economic value.

Section of Split-six coal at Franklin, Allegany County, Md.

	Ft.	in.
Coal	1	
Shale		11
Coal		11
Shale		1
Coal	1	5
	4	4

Lower (and Middle?) Kittanning coal.—This bed occurs between 90 and 150 feet above the base of the formation, about 80 feet above the Clarion coal, and about 28 feet above the Split-six when that bed is present. It really consists of two coals separated by a band of shale from a few inches to 10 feet in thickness. This bed may be considered as representing either the Lower Kittanning or both the Lower and the Middle Kittanning. When this middle shale is thin, as is the case in a large part of the Potomac Valley, this bed is of great value.

Section of Lower Kittanning coal 3 miles west of Franklin.

	Ft.	in.
Shale roof.		
Coal		0–5
Shale		4
Coal	2	2
Shale		11
Coal	1	
Shale		2
Coal	1	

Section of Lower Kittanning coal on Piney Run, Somerset County, Pa.

	Ft.	in.
Shale		10
Coal	2	6
Bone		8
Shale		8

Section of Lower Kittanning coal 3½ miles east of McHenry, Garrett County, Md.

	Ft.	in.
Coal		7
Shale		4
Coal		2
Shale		1
Coal	2	1
Shale		1
Coal		4

Section of Lower Kittanning coal 3½ miles west of Friendsville, Garrett County, Md.

	Ft.	in.
Coal	1	2
Bone		2
Coal		4
Shale		1
Bone		9
Shale	1	8
Coal		8
Shale		¼
Coal		4
Bone		7
Coal		4
	6	1¼

Where the Split-six is present the Lower Kittanning does not usually have as great a thickness as elsewhere. The following sections are typical of its development under these circumstances.

Section of Lower Kittanning coal near Franklin, Allegany County, Md.

	Ft.	in.
Coal	1	
Bone		6
Coal	1	7
Shale		1
Coal	2	2

Section of Lower Kittanning coal at the White Rock mine, 2½ miles north-northwest of Sang Run, Garrett County, Md.

	Ft.	in.
Coal	2	3
Shale	1	
Coal		6
Shale		1
Coal	1	8

The Lower Kittanning is locally by far the most persistent and valuable bed below the Pittsburg. There are some areas in which it is worthless or perhaps almost absent, but these are few and small. Where it is valueless the trouble is not as much in the absence of coal as in the fact that the shale and bone partings have locally thickened so as to make the expense of mining too great.

Upper Kittanning coal.—This bed occurs from 35 to 65 feet above the top of the Lower Kittanning coal. In most places it is represented by only a few inches of coal or is entirely absent.

Lower Freeport coal.—This bed occurs from 55 to 80 feet above the Upper Kittanning coal and from 100 to 145 feet above the Lower Kittanning coal. It is somewhat variable and uncertain in occurrence.

Section of Lower Freeport coal on old Gorman plane, northwest of Franklin, Allegany County, Md.

	Ft.	in.
Coal		3
Pyrite balls		¼
Coal	1	6

Upper Freeport coal.—This bed occurs from 20 to 60 feet above the Lower Freeport and from 165 to 210 feet above the Lower Kittanning. It is generally present and workable in all of the coal basins of the region.

In the Castleman basin this bed does not outcrop except along the flanks of the fold and has not been opened, but it underlies a large area in the center of the basin. In the bore hole at Jennings Mill it contains 26 inches of clean coal.

Section of Upper Freeport coal at Morrisons, Allegany County, Md.

	Ft.	in.
Black shale		3
Bony coal		4
Bone		7
Coal		6
Bone		2
Coal	2	2
	4	

Section of Upper Freeport coal near old Gorman plane, three-fourths mile northwest of Franklin, Allegany County, Md.

	Ft.	in.
Shale roof.		
Coal	1	11½
Shale		3
Coal		4

In the lower Youghiogheny basin the bed underlies a large area, but has not been much worked because it is so largely shaft coal.

Section of Upper Freeport coal, 1 mile west of Asher Glade, Garrett County, Md.

	Ft.	in.
Coal		4
Shale		2
Coal	2	
Shale		0–2
Coal	1	8
Shale		1
Coal		8
	5	

In the upper Youghiogheny basin this bed underlies several areas, but is of less extent than in the other basins. At W. T. Sine's mine, near Swallow Falls, the coal has the following section:

Section of Upper Freeport coal near Swallow Falls, Garrett County, Md.

	Ft.	in.
Sandstone roof.		
Coal (somewhat bony)	1	0–3
Shale		6
Coal	3	1
	4	8

CONEMAUGH COALS.

The rocks of the Conemaugh formation were formerly known as the "Lower Barren Measures" because they were supposed to contain no workable coal. Later work has shown that in this region at least the Conemaugh contains several beds which are either workable at present or likely to become so in the future. But there is no reason to believe that the coal of the Conemaugh will ever rival that of the Allegheny in importance.

Mahoning coal.—This bed belongs in the Mahoning sandstone, lying from 45 to 60 feet above the Upper Freeport coal. It has not been recognized in the Georges Creek or upper Youghiogheny basins. In the lower Youghiogheny it has been opened for local use at two places.

Section of Mahoning coal at Selbysport (Frazee's mine), Garrett County, Md.

				Ft.	in.
Sandstone, Mahoning (upper part)				2+	
Shale				4	
Coal, Mahoning	Coal		8″	10	8
	Shale	8′			
	Coal		7″		
	Shale		¼″		
	Coal		3″		
	Shale		¼″		
	Coal	1′	1″		
Concealed				5	
Sandstone, Mahoning (lower part)				5+	

Cobert's mine, a mile south of Friendsville, is probably in the same seam, as may also be several small mines in the Castleman basin.

Brush Creek coal.—This bed occurs about 70 feet above the Mahoning coal and from 110 to 135 feet above the Upper Freeport coal. It is extremely constant not only as regards its presence but also its character. It usually contains from 20 to 24 inches of clean coal.

Section of Brush Creek coal on Mill Run, one-fourth mile west of Allegany-Garrett County line.

	Feet.
Fossiliferous shales	1
Black shale with coal streaks	5
Coal (floor not exposed)	1+

A section in the Jennings Mill bore hole shows 1 foot 4 inches of coal, underlain by 3 inches of bone; and a section 1 mile north of Selbysport shows 1 foot 9 inches of coal.

Bakerstown coal.—This bed occurs from 90 to 130 feet above the Brush Creek coal. In the Georges Creek basin it is popularly known as the Three-foot, or less commonly but more correctly as the Four-foot. In the report on the geology of Allegany County, Md., it was called the Barton seam, but it is not the bed to which Stevenson applied the name Barton in the Pennsylvania reports in 1876. In the Potomac basin it is known as the Four-foot. In the Castleman basin it is called the Honeycomb seam.

A section 1 mile southeast of Bittinger, at Peter Lohr's mine, shows 10 inches of bone above 2 feet 3 inches of coal, and a section 1 mile west of Friendsville, at Captain Friend's mine, shows the same thickness of coal.

[a] See Report on the coals of Maryland, by Clark, Martin, Rutledge, et al.: Maryland Geol. Survey, vol. 5, 1905, pp. 219-636; also Maryland mineral industries, 1896-1907: Maryland Geol. Survey, vol. 8, 1908, pp. 97-223.

Section one-half mile north of Franklin (Cumberland-Georges Creek Coal Company's mine).

	Ft.	in.
Bone		11½
Coal	2	11
Shale		½
Coal		4

In all of these basins this coal is of wide extent and great persistence, and has already proved to be of considerable local value.

Grantsville coal.—This bed occurs in the Castleman basin only. Its position is apparently a short distance below the Bakerstown coal, but can not be exactly determined.

Section 1 mile west of Grantsville (Aaron Beachey's mine).

	Ft.	in.
Shale roof.		
Coal		11
Shale		1
Coal	2	
Shale		2
Coal		7
Shale	1	3
Limestone	2	

Section 1 mile northwest of Bevansville (Ridgley's mine).

	Ft.	in.
Shale roof.		
Coal		6
Shale		1
Coal		13
Shale		1
Coal		6
Shaly sandstone	5	
Bony coal		2
Coal		9
Bone		1
Coal	2	1
Shale		2
Coal		6
Bone		4

It can be seen from these sections that the bed is of considerable value, provided it has sufficient area and constancy. Unfortunately these points are in doubt. Three hypotheses concerning its occurrence may be considered:

1. That it is a local development of the Bakerstown.
2. That it is a constant bed, so near the Bakerstown (within 46 feet) at the point where the Jennings Mill bore hole was put down that no record was obtained by the drill, and so far below it (over 60 feet) 1 mile east of Bittinger that it was missed in a section at that point.
3. That it was absent at one or both of the places where the above-mentioned sections were obtained.

The problem must be left at present as an undetermined one. There is no doubt that the bed belongs above the Brush Creek coal, but whether it is a local development of the Bakerstown or belongs as much as 100 feet below it is a question which can not be decided.

This coal was named from the town of Grantsville, near which it is mined.

Maynardier coal.—This bed, which is locally known as the Slate vein, is apparently confined to the Castleman basin and occurs about 40 feet above the Bakerstown coal.

Section at west end of Maynardier Ridge one half mile east of Jennings Mill, Garrett County, Md.

	Ft.	in.
Coal	1	1
Bone		9
Shale		2
Bone	1	
	3	

Section 2¼ miles northeast of Bittinger, Garrett County, Md.

	Ft.	in.
Coal		11
Bone		6
Shale		5
Bone	1	1
	2	11

Wherever this bed has been opened it has proved too impure to mine even for local use, and must be considered as having no commercial value.

This coal was named from its occurrence along the western end of Maynardier Ridge.

Harlem coal.—This bed occurs from 90 to 160 feet above the Bakerstown coal. The interval is about 100 feet in the Georges Creek basin, 160 feet in the Castleman basin, and 90 feet in the lower Youghiogheny basin. This coal has not been exposed in that part of the Georges Creek basin which lies in the Grantsville quadrangle, although there are doubtless many square miles underlain by it. In the northern end of the Georges Creek basin (a mile northwest of Mount Savage, Allegany County, Md.) it contains about 28 inches of coal without partings. In the Castleman basin it varies in thickness from 19 to 24 inches, and is called the Fossil vein. In the lower Youghiogheny basin it varies in thickness from 16 to 20 inches.

Elklick coal.—This bed, which occurs about 35 feet above the Harlem coal, is very irregular and thin in this region. In most places it is entirely absent, and it has never been seen in sufficient thickness to have any commercial value.

Franklin or Little Clarksburg coal.—This bed occurs from 50 to 100 feet above the Elklick coal, 80 to 140 feet above the Harlem coal, and about 150 feet below the Pittsburg coal. In the Georges Creek basin it is known as the Dirty Nine-foot.

In the other basins its section is very different from this, it being represented by one or two beds, each about 15 or 18 inches thick, separated by 20 feet or more of shale.

Section 1 mile northwest of Franklin, Allegany County, Md.

	Ft.	in.
Shale roof.		
Coal		2
Shale		1
Coal		10
Shale	2	3
Coal	2	9

Little Pittsburg coal.—Between the Franklin and Pittsburg coals there are one or two small beds of coal which are variable in position. One of them seems to be everywhere present, and in some places both are. Where only one is present its usual position is 60 to 80 feet below the Pittsburg bed. Where both are present one is about 40 feet and the other about 90 feet below the Pittsburg. The thickness is variable.

Section of Little Pittsburg coal 1 mile east of Barton, Allegany County, Md.

	Ft.	in.
Coal	2	8
Pyrite nodules		¼
Coal		3

Section 1 mile northwest of Friendsville (Rumbaugh's mine).

	Ft.	in.
Coal		6
Shale		2
Coal	1	5
Shale		1
Coal	1	6

In the Castleman basin the thickness seems to be less than 20 inches. In the Georges Creek basin measurements made in Allegany County show a thickness of more than 3 feet.

MONONGAHELA COALS.

The Monongahela formation contains six beds of coal in these quadrangles and the immediately adjoining regions. Five of these beds may be considered workable, while three of them have been mined on a commercial scale at one time or another. However, it is due entirely to the presence of one bed that the Monongahela coals have outranked the others of this region in importance. This is the Pittsburg coal, from which nearly all the coal now being mined in Maryland is taken.

Pittsburg coal.—This bed occurs at the base of the Monongahela formation, 145 or 150 feet above the Franklin coal. It is wholly restricted within these quadrangles, to the Georges Creek and Castleman basins, and almost wholly to the former.

Section of Pittsburg coal at Caledonia No. 1 mine, three-fourths mile west of Barton, Allegany County, Md.

	Ft.	in.
Wild coal	1	
Black shale		11
Top coal	2	
Parting.		
Breast coal	8	
Shale		2
Bottom coal	2	5

Section of Pittsburg coal at Old Potomac mine, 1 mile southeast of Barton.

	Ft.	in.
Top coal	2	6
Parting.		
Breast coal	6	9
Mining ply		4
Coal	1	3
Shale		1½
Coal		3
Shale		1½
Coal	1	4
Shale with pyrite		½
Coal	1	3

Section on Franklin Hill (Excelsior mine).

	Ft.	in.
Wild coal	1	
Shale		11
Top coal	2	4
Breast coal	7	11
Shale		2
Bottom coal	2	5

Section of Pittsburg coal at Scrap mine, Franklin Hill.

	Ft.	in.
Wild coal	1	
Shale		10
Top coal	2	6
Parting.		
Breast coal	8	6
Shale		2½
Bottom coal	3	2

The division of the coal into three members, known as the "top" or "roof" coal, "breast" coal, and "bottom" coal, is a constant and characteristic one. The great variation in the thickness of the bed from the northern to the southern end of the Georges Creek basin is due chiefly to the thickening of the "breast." The "breast" coal is the purest and most valuable of these members and formerly it was the only one mined. But now there is no great difficulty in keeping the "top" and "bottom" coals clean enough to go on the market, and at most openings the full thickness of the bed is mined.

This coal is of exceptional quality, at many mines being very low in ash and sulphur and high in fixed carbon. It is, in fact, a semibituminous coal and is regarded as one of the best steam coals known.

The extent of this coal, as can be seen on the accompanying maps, is not large, and it will probably soon be exhausted. Many mines once abandoned because of the supposed exhaustion of the coal are now being or will be worked again for the coal contained in the roof, floor, and pillars.

Redstone coal.—This bed occurs 20 to 30 feet above the Pittsburg coal. The quality and thickness of the coal are not very well known. The bed is so near to the Pittsburg coal that where that coal has been mined it will be impossible to mine this, no matter how valuable it might otherwise be. For this reason the bed can not be considered to have any great value.

Lower Sewickley coal.—This bed occurs at an interval of about 42 feet above the Redstone coal. It has not been opened within these quadrangles, but is exposed at many points in the immediate vicinity.

Upper Sewickley coal. — This bed, which is locally known as the Tyson or Gas coal, occurs 105 to 120 feet above the Pittsburg coal and about 45 feet above the Lower Sewickley coal. It is locally restricted to the Georges Creek basin, and its area is small.

Section at Caledonia mine, west of Barton, Allegany County, Md.

	Ft.	in.
Coal	2	7
Shale		9½
Coal	1	11¼
Shale		4
Coal		9

This bed, like the Pittsburg coal, thickens from north to south and has its maximum thickness in the lower end of the Georges Creek basin.

Waynesburg coal.—This bed occurs 90 to 120 feet above the Upper Sewickley and 220 to 240 feet above the Pittsburg coal. Its area in this region is small.

Section at Koontz, Allegany County, Md.

	Ft.	in.
Coal	2	3
Bone		4
Coal		6
Bone		7
Coal	1	3
Shale		10
Coal		5

The roof of this bed is the top of the Monongahela formation. The overlying Dunkard formation contains a very little coal in the adjacent region, but there is no evidence that there is any workable coal above the Waynesburg in these quadrangles.

STRUCTURAL OCCURRENCE.

GEORGES CREEK BASIN.

The Georges Creek basin is a deep, broad syncline containing the most complete sequence of the "Coal Measures" in this region. The axis of this syncline lies for the most part east of these quadrangles, and only a small part of the area west of the synclinal axis is within the area here under discussion. As the most valuable coal (the Pittsburg bed) is in the upper part of the "Coal Measures," and consequently lies in the central portion of the basin, the larger part of its area is outside these quadrangles. It is only toward the southern end of the basin, where the eastern edge of the Grantsville quadrangle approaches the synclinal axis, that the quadrangle contains any large areas of Pittsburg coal.

The Conemaugh and Allegheny coals are so overshadowed in importance by the Pittsburg coal that they have not been prospected to any great extent in this basin. Consequently our knowledge of them is far less in this region than it is in the more western basins where the Pittsburg coal is absent and the lower beds are depended upon for local use. The coals of the Allegheny and Conemaugh formations underlie a large area in the part of the basin discussed in this folio, and it is highly probable that when the Pittsburg coal is exhausted the Bakerstown, Upper Freeport, and Lower Kittanning coals will support an important mining industry.

The dip in the part of this basin here under discussion increases from almost nothing in the portion nearest the axis (near Westernport) to about 10° along the western outcrop of the Lower Kittanning coal. The strike averages N. 30° E.

The Allegheny coals can be worked by drift in the southern end of the Georges Creek valley and on many of the tributaries of that stream and of Savage River. In the region north of Barton they can be mined only by shafts near the center of the basin or by slopes from the western outcrop. A far larger proportion of the area of the Conemaugh coals can be reached by drift from the Georges Creek valley.

CASTLEMAN BASIN.

The Castleman basin is a simple shallow syncline with gentle dips and a still gentler northeastward pitch of its axis. The axis of the basin extends in an almost straight line through the eastern end of Grantsville, the forks of Castleman River, and Bittinger.

In the small area of Monongahela coal the mining is entirely by drifts.

The Conemaugh coal beds can be almost entirely mined by drift from the Castleman Valley. The only exception to this is that the Grantsville bed in the very center of the basin would have to be reached by slopes or shallow shafts.

The coal beds of the Allegheny formation are almost entirely shaft coal. They underlie a very large area, but their thickness and quality are very imperfectly known. The bore hole at Jennings Mill, which gives our only section of them in the center of the basin, showed that they were not workable at this immediate point. They should be tested at other points, where they will probably be found to be workable under large portions of the valley. The bore hole at Jennings Mill, which was located very slightly east of the axis of the basin, showed the Upper Freeport at a depth of 193 feet and the Lower Kittanning at a depth of 341 feet. The detailed record of this boring is given on pages 5 and 6 of this folio. These beds can be reached at approximately these depths anywhere along the line of Jennings Brothers Railroad. The deepest part of the basin is somewhat west of the railroad.

UPPER YOUGHIOGHENY BASIN.

The upper Youghiogheny basin is a broad, shallow syncline, which undulates somewhat in its central part. The Monongahela coals and the workable Conemaugh coals are entirely absent from it. The Upper Freeport coal is workable in a few areas, especially along Youghiogheny River below the mouth of Miller Run. It is largely drift coal. The Lower Kittanning coal underlies the larger part of the basin and has been mined to a small extent along the outcrop. It is almost all slope and shaft coal.

LOWER YOUGHIOGHENY BASIN.

The lower Youghiogheny basin is a broad shallow syncline with a low anticline buried in its western portion. The deepest part of the basin is toward the eastern part of its area, the axis passing not far west of Friendsville. It contains no Monongahela coals. The Conemaugh coals, although all present, are not workable.

The Upper Freeport coal is workable by drift from the valleys of Buffalo Run, Laurel Run, Deep Creek, and Mill Run. The larger part of the area of this bed is, however, shaft coal, which can best be reached a short distance up the valley west of Friendsville or along the railroad anywhere between Selbysport and the Pennsylvania line. It can probably be reached anywhere within a depth of 100 feet below the railroad. The quality and thickness in this buried portion have never been tested.

The Lower Kittanning coal is shaft coal in the greater part of the area of the basin. There are small areas around the outcrop which can be mined by drift, but only on a small scale, except in the region southwest of Krug, where the entire area can be reached by drift from the valley of the Youghiogheny. Below Friendsville this coal lies at a depth not exceeding 300 feet below the railroad.

AMOUNT OF COAL.

The following table contains an estimate of the original quantity of coal which existed in these quadrangles before mining began. The figures were obtained by computing separately the tonnage of each bed from its area and the average of all measurements of its thickness.

Area and tonnage of coal in the Accident and Grantsville quadrangles.

	Area.	Amount.
	Sq. miles.	*Short tons.*
Accident quadrangle:		
Youghiogheny basin	114.231	1,003,665,000
Castleman basin	20.599	103,406,000
Grantsville quadrangle:		
Castleman basin	82.784	1,272,828,000
Georges Creek basin	33.865	979,906,000
	251.479	3,359,805,000

HISTORY AND CONDITION OF THE COAL INDUSTRY.

Coal has been mined in the Georges Creek basin since 1830. Until recently only the Pittsburg bed has been mined, but with the approaching exhaustion of this coal, development of the thinner beds is rapidly increasing. The Waynesburg, Upper Sewickley, Bakerstown, Upper Freeport, and Lower Kittanning beds are at present being mined on a commercial scale in the Georges Creek valley. The coal in the Castleman and Lower Youghiogheny basins has been mined only for local use, except in the small areas of Pittsburg coal in the Pennsylvania portion of the Castleman basin.

It is probable that within a few years there will be very extensive developments in the Castleman and Youghiogheny valleys. Development has been retarded in the Castleman basin by lack of means of transportation and by the fact that the Allegheny coals are buried in the central part of the basin. Now that a railroad has been constructed along Castleman River, development of the coal may be expected.

Ownership of the smaller coal beds is principally in the hands of the farmers. Few large tracts have been acquired except in the Georges Creek basin.

CHARACTER OF THE COAL.

Averages of proximate analyses of the coal beds of these quadrangles are given in the following table, which is compiled from the more complete tables of analyses of these coals given in volume 5 of the reports of the Maryland Geological Survey.

These analyses show the variation in character from semibituminous coal in the Georges Creek basin to ordinary bituminous coal in the Castleman and Youghiogheny basins.

under the Homewood sandstone. Its stratigraphic position is shown in the sections of the Pottsville formation on page 5, and in the less complete section on page 11. This bed does not show at the surface as well as it should because its position is usually concealed by talus from the overlying sandstone. Fragments of the flint clay can however, usually be found in the soil. It is usually, though not always, present in the normal stratigraphic position, and could be developed at a great many localities in various parts of these quadrangles. The general location of the belts where it is to be sought is along the edge of the areas of outcrop of the Pottsville formation, not very far from the contact of the Pottsville and Allegheny formations. Their location can thus be found on the accompanying geologic map.

In the mines of the Union Mining Company and the Savage Mountain Fire Brick Works in the northeastern part of Garrett County, not far east of the Grantsville quadrangle, the clay has a thickness of 8 to 14 feet, averaging about 10 feet. It is overlain within a short distance by a coal bed about 3 feet thick, above which is the Homewood sandstone. There are usually two kinds of clay, the soft or plastic and the flint or nonplastic. Both are essential in the manufacture of the bricks. It is necessary that both should be refractory. There is no regularity in the occurrence of the two kinds of clay in relation to each other. In most places the plastic clay is above, but this is not everywhere the case.

Another locality where the same clay was observed is in the tramroad cut at Swallow Falls, where the following section is exposed:

Section of fire clay near Swallow Falls, Garrett County, Md.

	Feet.
Sandstone (Homewood)	50
Shale	6
Flint clay	1–3
Plastic clay	2–3
Coal	3

At no other place has the clay been observed above the coal, as it is here. In this vicinity there is a large area underlain by the clay, which can be easily worked by drift, and the dip is slight. Transportation can be furnished by the narrow-gage road which extends from

Proximate analyses of coals in Georges Creek, Castleman, and lower Youghiogheny basins.

[W. B. D. Penniman and Arthur L. Browne, analysts.]

Basin and coal.	Number of analyses.[a]	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calories.	British thermal units.
Georges Creek basin:								
Split-six	3	1.34	16.78	69.94	11.94	3.93	------	------
Lower Kittanning	8	.67	16.57	70.09	12.67	1.83	7,609	13,599
Lower Freeport	1	.67	18.58	67.18	13.57	5.26	------	------
Upper Freeport	5	.70	17.08	70.37	11.85	1.72	7,707	13,862
Brush Creek	7	1.27	16.79	68.81	13.14	2.23	------	------
Bakerstown	32	.98	16.87	71.26	9.67	2.16	7,783	14,009
Franklin	7	.82	18.56	67.39	13.24	2.76	7,493	13,487
Little Pittsburg	2	3.30	21.67	65.86	9.17	.99	------	------
Pittsburg	7	.70	18.72	73.94	6.64	.99	7,987	14,376
Upper Sewickley	7	.63	20.13	68.99	10.26	1.54	7,774	13,916
Castleman basin:								
Clarion (?)	1	.61	26.94	57.24	14.91	4.69	7,093	12,767
Lower Freeport (?)	2	.70	24.05	66.77	8.48	1.43	7,759	13,966
Grantsville	1	2.23	21.21	63.78	12.78	2.55	7,195	12,951
Bakerstown	5	2.08	21.97	67.15	8.80	2.27	7,706	13,871
Maynardier	1	.73	21.04	60.76	17.57	2.29	6,900	12,420
Lower Youghiogheny basin:								
Lower Kittanning	7	1.94	23.32	60.47	14.27	3.33	7,326	13,187
Lower Freeport	1	2.32	23.39	56.13	18.16	6.64	6,752	12,154
Upper Freeport	3	2.30	25.50	62.36	7.84	1.06	7,653	13,775
Mahoning	2	1.31	22.96	62.74	13.99	4.00	7,358	13,244

[a] If more than one, average is given.

BRICKMAKING MATERIALS.

This region contains a great abundance of valuable clay of various kinds. These resources are entirely undeveloped within these quadrangles, but they promise great possibilities for the future, and are extensively developed in the adjacent region. These materials include fire clays of the highest grade, shales of various kinds, residual clays, and sedimentary clays.

FIRE CLAYS.

Frequently any clay or shale which underlies a bed of coal is spoken of as a fire clay. But there are many clays which, although they have all the external appearance of a fire clay, will not stand a high enough temperature to be used as fire clay. The only satisfactory means of telling whether a clay is a fire clay or not is by testing its fusibility; if it resists fusion it is suitable for the manufacture of fire brick, and is therefore, no matter what its occurrence or appearance, a fire clay. Not all fire clays, nor even all those of this region, underlie coal beds. There are at least two very valuable fire clays now known in this region.

Mount Savage fire clay.—The Mount Savage fire clay occurs at a very constant horizon in the Mercer coal group, near the top of the Pottsville formation and immediately

here to the terminus of the Confluence and Oakland branch of the Baltimore and Ohio Railroad. Power for the plant can be got from Youghiogheny River, and coal for the kilns can be obtained near by. Tests by Heinrich Ries (Maryland Geol. Survey, vol. 4, pp. 449, 450) show that this clay, both plastic and flint, is fully equal in its fire-resisting qualities to that from Savage Mountain.

There are doubtless many other localities in the same stratigraphic position where clay of satisfactory quality could be found by careful prospecting.

Bolivar fire clay.—A deposit of fire clay which is probably the equivalent of the Bolivar fire clay of Pennsylvania outcrops in the north bank of the North Fork of Castleman River about nine-tenths of a mile above the mouth of Tarkill Run. The section is as follows:

Section near Tarkill Run, Garrett County, Md.

	Feet.
Flint clay	3½
Concealed	6
Massive cross-bedded sandstone	7
Concealed	6
Gray shale	4
Coal, shale, and bone	7
Shale	8
Sandstone	5
	46½

The flint clay is in appearance much like that from the Mount Savage bed. It occurs, not in rounded concretionary forms, as the Mount Savage clay frequently does at its outcrop, but in a solid massive ledge. In this ledge the flint showed a thickness of 3½ feet, with both top and bottom concealed. The character of the outcrop was not such as to show whether or not a plastic clay is present in association with the flint.

A sample of this clay was tested by Ries, who says in regard to it (Maryland Geol. Survey, vol. 4, pp. 503–505):

The material is a flint clay which in general appearance is not unlike clays of that character, being hard and dense, and having conchoidal fracture. The chemical analysis of the material is as follows:

Analysis of flint clay from Castleman River, Garrett County, Md.

Silica	51.881
Alumina	36.461
Ferric oxide	1.01
Lime	.98
Magnesia	.10
Alkalies	Trace.
	100.932

Being a flint clay it naturally has practically no plasticity when ground and mixed with water, and consequently its tensile strength is also exceedingly low, showing that it would have to be mixed with a plastic fire clay in making it into fire bricks. The refractoriness of the clay is, however, the most important item, and it was found on testing it that the fusion point of the clay is very nearly that of cone 35 of the Seger series, whose fusion point is about 3326° F. This makes the clay from Castleman River, therefore, one of the most refractory clays found in the United States.

There is a large area in the vicinity in which this clay could be mined, either by drifts or in open pits. The locality could be easily reached by a short spur, having almost no grade, from Jennings Brothers Railroad. Abundant coal, and excellent sites for manufacturing plants are at hand. This clay is worthy of immediate development. It could probably be found at other localities in the Castleman Valley.

SHALE AND BRICK CLAY.

The shales of this region which are suitable for brickmaking have wide geographic and geologic distribution. Lack of facilities for transportation and of local markets has, however, made it unprofitable to work them.

There are probably large areas in the "glade" regions which are underlain by thick and extensive deposits of residual clay, but these too must await more favorable conditions for development.

LIMESTONE.

This region contains extensive deposits of limestone suitable for burning for agricultural and building purposes or for use as a flux. It is also probable that part at least of this limestone is suitable for the manufacture of cement, although it has not yet been tested for this purpose.

The Greenbrier limestone, whose occurrence has been described in the preceding pages, is composed largely of limestone, the most valuable deposits of which occur in the upper member of the formation. This member is about 65 feet thick and consists predominantly of limestone with a few shale partings. Almost the whole thickness can be quarried. This rock has already been opened for agricultural purposes at numerous points, and is of such persistence that it can be worked anywhere except where the covering of soil and rock débris is too thick to be profitably removed. The middle member of the Greenbrier contains a few thin beds of limestone, but they should always be neglected for the overlying beds, which are much thicker and purer. The lower member contains a considerable thickness of limestone which can be quarried and burned, but it is very impure and is far less valuable than the upper member.

The following analyses of samples of Greenbrier limestone from Garrett County, collected by the Maryland Geological Survey, were made by T. Malcolm Price for the Maryland Agricultural Experiment Station and were published in Bulletin No. 66 of that institution:

Analyses of Greenbrier limestone from Garrett County, Md.

	1.	2.	3.	4.	5.	6.
Insoluble	13.69	13.46	8.57	20.95	17.00	4.47
Fe_2O_3 + Al_2O_3	5.44	12.48	2.38	41.10	2.74	2.70
$CaCO_3$	79.16	72.92	88.73	37.35	62.12	93.09
$MgCO_3$	1.21	1.15	.86	.91	15.75	6.38
Total	99.46	99.91	100.54	100.36	99.61	100.28

1. Gerringer & Inglehart's quarry.
2. Offutt's quarry.
3. Crabtree.
4. South of Negro Mountain.
5. Offutt's quarry.
6. Findley's quarry, Piney Run.

Probably any of the rock will furnish a lime that is suitable for agricultural purposes. But when a lime suitable for general and constructive uses is desired care should be taken to select the purer beds in quarrying. The average of the analyses given above indicates a rock far less pure than that generally used for commercial purposes. But some of the analyses show that there are purer bands in the formation, and there is no doubt that if proper care were taken in locating the quarries and in keeping impurities out of the kilns a product could be obtained which would successfully compete with that now shipped from other regions.

The only limestone of this region which can be considered of possible value as a building stone is that of the Greenbrier formation.

The Loyalhanna ("Siliceous") limestone, at the base of the Greenbrier, would possibly make a valuable building stone. It is of a desirable color (light gray or buff), is very durable, and is easily worked. In some parts of the bed are bands of sandy material which would stand out on weathering, but these are not distributed all through the bed. The portions of the bed which do not contain these bands are very uniform in color and texture.

The upper part of the formation contains some layers of massive limestone which would make an attractive and durable building stone. These layers range in color from very light gray to a dark reddish buff. There would be no difficulty in obtaining blocks of considerable size. Some of these layers are well shown in the quarry at Crabtree.

Some of the beds of the Greenbrier limestone will make valuable road metal because they combine high cementing quality with good wearing power. Probably the Loyalhanna ("Siliceous") limestone at the base of the formation will be found the most valuable for this purpose, because of its high wearing power. It has the additional qualification of not being sought for burning to lime.

The limestones of the "Coal Measures" are too much broken up by joints and bedding planes to be considered as building stones, and are too scanty in quantity to be of value for any purpose except for local agricultural lime.

SANDSTONE.

All the building stone that has been quarried in this region has come from the sandstones of the Carboniferous formations and has been used only for rough work, such as foundations, embankments, and bridges. While it is possible that some of the sandstones could be used for a better class of work, it is not likely that such a demand will be made upon it in the immediate future.

IRON ORE.

No iron ore is now mined in this region, and this industry has never been of any great importance. The only place where iron has ever been smelted within the limits of these quadrangles is at Friendsville, where the ruins of a small blast furnace which was built many years ago and has long been out of use still exist. The ore for this furnace was dug from a number of small pits on the western slope of Winding Ridge. It probably consisted of both siderite nodules from the shales of the "Coal Measures," and limonite concretions from the residual soil. The location of the pits is not known. Charcoal was used as a fuel, and Greenbrier limestone as a flux. Probably no attempt was made to supply more than the demands of the local forges.

Small pockets of limonite exist in the Jennings, Catskill, and Mauch Chunk shales, but these could not have been considered workable deposits in any condition of the iron industry.

In the shales between the Clarion coal and the overlying Clarion sandstone there are abundant nodules of siderite, or carbonate of iron, which in some places form a locally continuous stratum that occasionally becomes thick enough to possess possibly some commercial value. Some ore may always be expected at this horizon, and the bed may prove thick enough in places to mine, but it is doubtful if such mining can be done profitably in the present condition of the industry.

There are also small bands of siderite higher in the "Coal Measures," especially in the middle of the Conemaugh and in the Monongahela and Dunkard formations.

WATER RESOURCES.

STREAM SUPPLIES.

Youghiogheny River.—The Youghiogheny and its tributaries drain almost the entire area of the Accident quadrangle. It is a large stream whose capacity is far in excess of any probable demand. The only contamination of the main stream comes from the villages of Oakland, Sang Run, Krug, Friendsville, and Selbysport, and from a few sawmills.

Castleman River.—This stream drains the northwest half of the Grantsville quadrangle. It is a large, uncontaminated stream, but there is no demand for its waters in the agricultural region through which it flows in this quadrangle.

Savage River.—This stream drains the central part of the Grantsville quadrangle. It is a large, relatively pure stream and furnishes the water supply for the towns of Piedmont, W. Va., and Westernport, Md.

Georges Creek.—This stream drains the southeast corner of the Grantsville quadrangle. The main stream and the lower courses of its tributaries are so polluted by sewage and mine water as to be unfit for ordinary uses. The headwaters of the tributaries would furnish good supplies for the many mining villages in the Georges Creek valley.

SPRING WATER.

There are a great many large, pure springs along the belts of outcrop of the Greenbrier limestone. These belts extend (1) along the western foot of Big Savage Mountain; (2) along the eastern front of Meadow Mountain; (3) along the western front of Negro Mountain; (4) along the eastern front of Winding Ridge; (5) through the valleys of Deep Creek and Marsh Run from Thayerville to McHenry, thence westward to Sang Run and along Youghiogheny River for a distance of 2 miles north and south of Sang Run; and (6) along the northern and eastern edges of the Cranesville Valley.

These springs are similar, both in geologic relations and in the properties of their water, to the group of springs from which the celebrated Deer Park spring water is obtained. The Deer Park springs are about 6 miles south of the southern limit of these quadrangles, and are situated along the direct continuation of the line of springs at the western foot of Big Savage Mountain.

ARTESIAN WATER.

The possibility of obtaining artesian water has never been properly tested in this region. It is, however, probable that the synclines that underlie the valleys of Georges Creek, Castleman River, and Youghiogheny River are artesian basins and would yield plenty of good artesian water from various horizons.

Several bore holes made in the coal-bearing portions of the synclines have yielded flows of water. This water came from the "Coal Measures," and was therefore strongly impregnated with sulphur and iron. It is probable that deeper holes would yield better water from the purer porous sandstones which underlie the "Coal Measures." There is, however, no present demand in the region for artesian wells, for the numerous pure streams and springs yield sufficient water for all needs.

September, 1907.

TOPOGRAPHY

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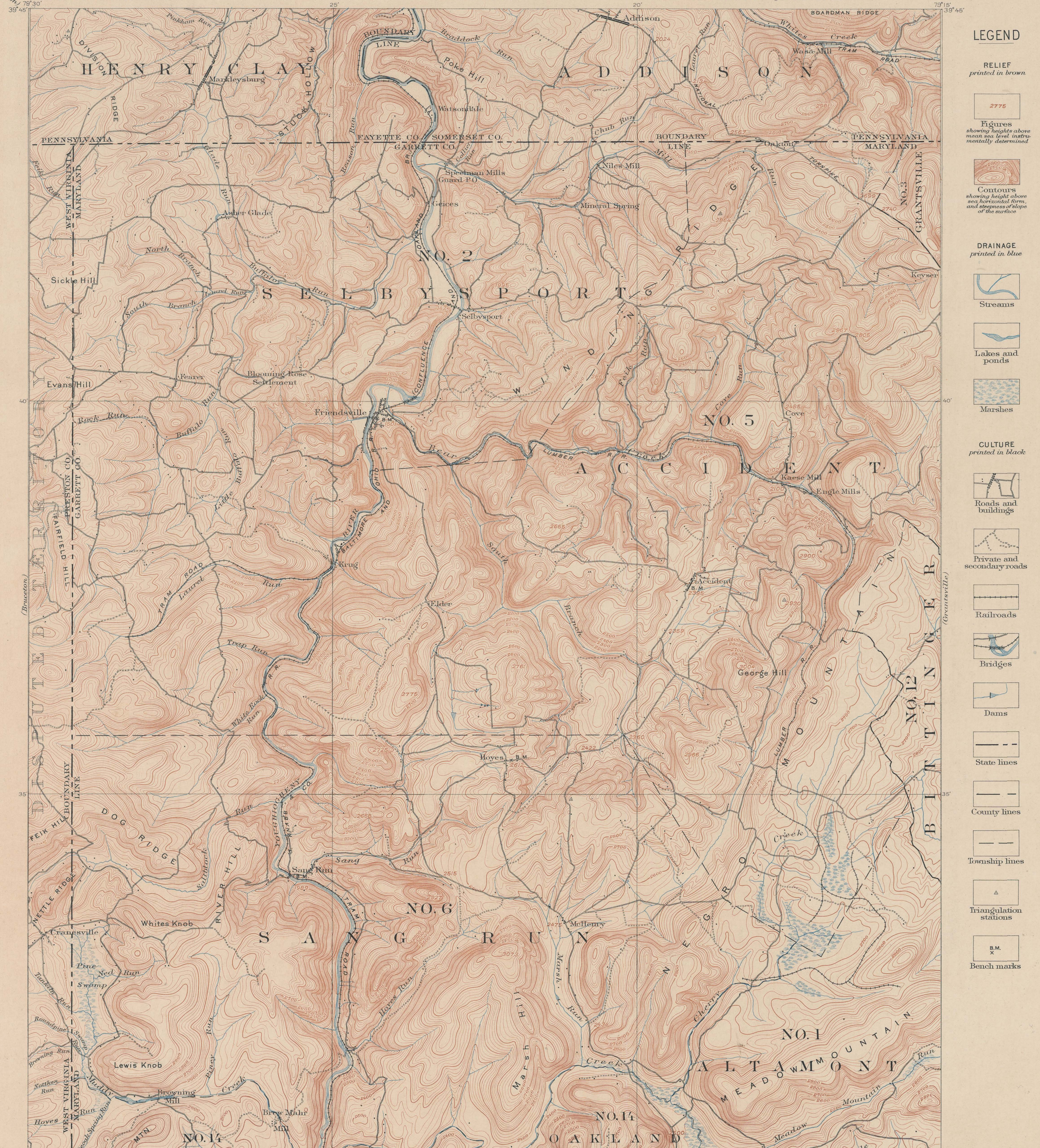
MARYLAND-WEST VIRGINIA-PENNSYLVANIA
ACCIDENT QUADRANGLE



H. M. Wilson, Geographer in charge.
Control by Geo. T. Hawkins and W. Carvel Hall.
Topography by J. H. Jennings.

SURVEYED IN 1898 IN COOPERATION WITH THE STATE OF MARYLAND.

APPROXIMATE MEAN DECLINATION 1908.

Scale 1/62500

Contour interval 20 feet.
Datum is mean sea level.

(St. George)

(Piedmont)

Edition of Oct. 1900, reprinted July 1909, with corrections.

AREAL GEOLOGY

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MARYLAND-WEST VIRGINIA-PENNSYLVANIA
ACCIDENT QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines)

CARBONIFEROUS

Pennsylvanian

- Ccm — Conemaugh formation *(shale, sandstone, and a few limestones, with Bakerstown and several thin coal beds)*
- Ca — Allegheny formation *(shale and sandstone; Upper Freeport coal at top, Lower Kittanning coal below)*
- Cpv — Pottsville formation *(sandstone, conglomerate, and shale, with Mount Savage fire clay and a few thin coal beds)*

Mississippian

- Cmc — Mauch Chunk formation *(red and green shales and sandstone)*
- Cgr — Greenbrier limestone *(limestone with much interbedded shale)*
- Cpo — Pocono sandstone *(sandstone and conglomerate with some shale)*

DEVONIAN

- Dck — Catskill formation *(red and green shale and sandstone)*
- Dj — Jennings formation *(shale and sandstone)*

(St. George 1/125000) (Piedmont 1/125000) (Piedmont 1/125000)

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Surveyed in 1898.

SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1906.

Scale 1/62500

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.
Edition of July 1908.

Geology by G.C. Martin.
Surveyed in 1900-1903.

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MARYLAND-WEST VIRGINIA-PENNSYLVANIA
ACCIDENT QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines)

CARBONIFEROUS

Pennsylvanian

- Ccm (lp, bt) — **Conemaugh formation** *(shale, sandstone, and a few limestones, with Bakerstown and several thin coal beds)*
- Ca (uf, lk) — **Allegheny formation** *(shale and sandstone; Upper Freeport coal at top, Lower Kittanning coal below)*
- Cpv — **Pottsville formation** *(sandstone, conglomerate, and shale, with Mount Savage fire clay and a few thin coal beds)*

Mississippian

- Cmc — **Mauch Chunk formation** *(red and green shales and sandstone)*
- Cgr — **Greenbrier limestone** *(limestone with much interbedded shale)*
- Cpo — **Pocono sandstone** *(sandstone and conglomerate with some shale)*

DEVONIAN

- Dck — **Catskill formation** *(red and green shale and sandstone)*
- Dj — **Jennings formation** *(shale and sandstone)*

Economic and structure data

- 2500 — *Structure contours* *(showing elevation above sea and configuration of the top of the Pottsville formation. Contour interval 100 feet)*
- *Coal outcrops* *(coal of probably workable thickness)*
  - lp, *Little Pittsburg coal*
  - bt, *Bakerstown coal*
  - uf, *Upper Freeport coal*
  - lk, *Lower Kittanning coal*
- LS, *Limestone quarries*
- x *Coal prospects and country banks*

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TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1906.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.
Edition of July 1908.

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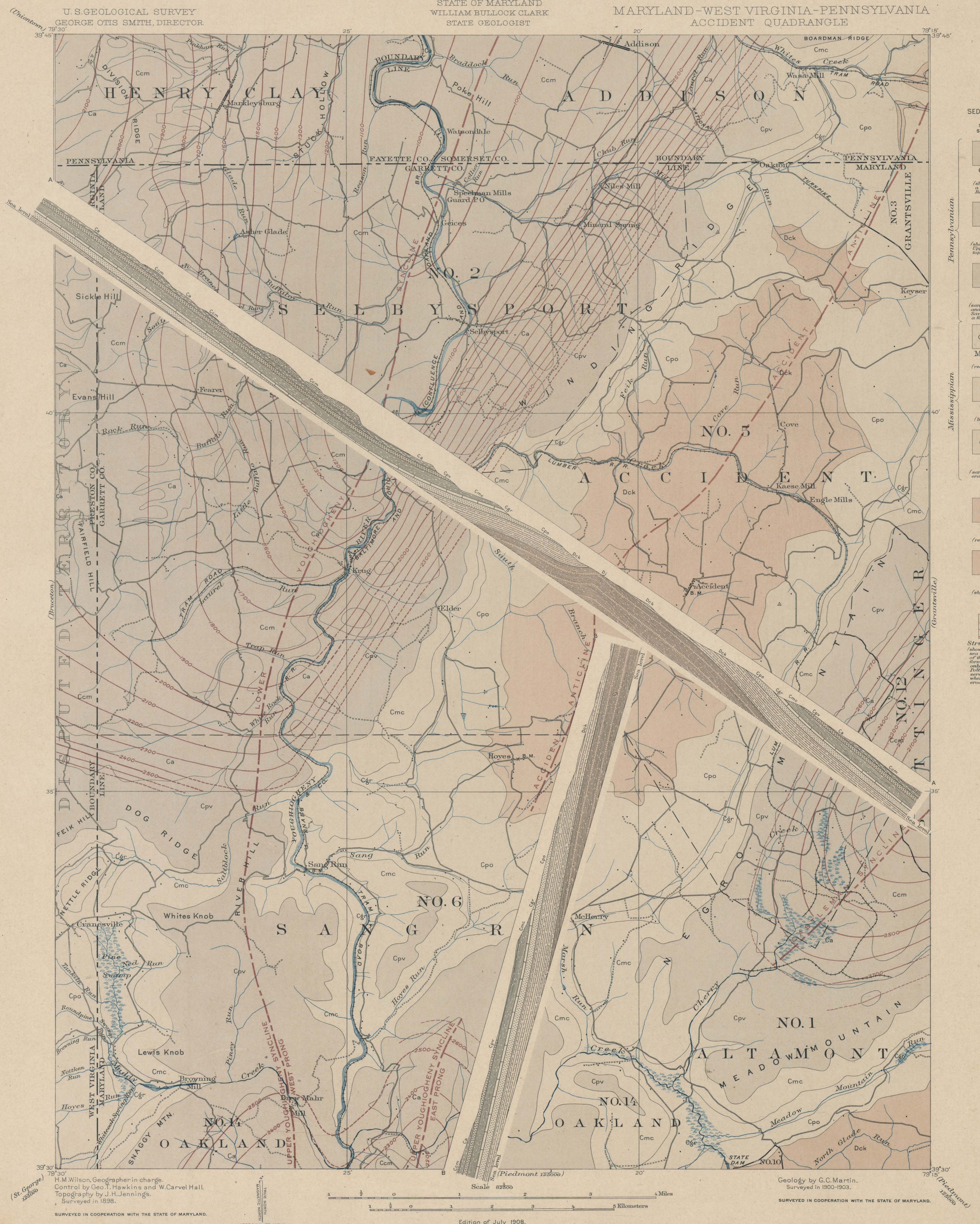
ACCIDENT QUADRANGLE



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APPROXIMATE MEAN DECLINATION 1906.

Scale 1/62500

Edition of July 1908.

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LEGEND

SEDIMENTARY ROCKS

SHEET SYMBOL	SECTION SYMBOL			
Ccm	Ccm	Conemaugh formation (shale, sandstone, and a few limestones, with Bakerstown and several thin coal beds)	Pennsylvanian	CARBONIFEROUS
Ca	Ca	Allegheny formation (shale and sandstone; Upper Freeport coal at top, Lower Kittanning coal below)	Pennsylvanian	CARBONIFEROUS
Cpv	Cpv	Pottsville formation (sandstone, conglomerate, and shale, with Mount Savage fire clay and a few thin coal beds)	Pennsylvanian	CARBONIFEROUS
Cmc	Cmc	Mauch Chunk formation (red and green shales and sandstone)	Mississippian	CARBONIFEROUS
Cgr	Cgr	Greenbrier limestone (limestone with much interbedded shale)	Mississippian	CARBONIFEROUS
Cpo	Cpo	Pocono sandstone (sandstone and conglomerate with some shale)	Mississippian	CARBONIFEROUS
Dck	Dck	Catskill formation (red and green shale and sandstone)		DEVONIAN
Dj	Dj	Jennings formation (shale and sandstone)		DEVONIAN

2500 — *Structure contours* (showing elevation above sea and configuration of the top of the Pottsville formation. Contours shown only in synclines, where Pottsville has been preserved; lines are broken where top of formation is eroded. Contour interval 100 feet.)

TOPOGRAPHY

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Topography by W. Carvel Hall.

SURVEYED IN 1898 IN COOPERATION WITH THE STATE OF MARYLAND

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1903.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

Edition of Mar. 1904, reprinted June 1908.

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(Piedmont $\frac{1}{125000}$)

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Topography by W.Carvel Hall.

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Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

Edition of July 1908.

Geology by G. C. Martin.
Surveyed in 1900-1903.

SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

(Romney $\frac{1}{125000}$)

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines)

CARBONIFEROUS

Pennsylvanian (Possibly Permian at top)

Cd — Dunkard formation *(shale, sandstone, and limestone, with thin coal beds)*

Cm — Monongahela formation *(shale, sandstone, and limestone; Pittsburg coal at the bottom, Waynesburg coal at the top, Sewickley and other coal beds between)*

Ccm — Conemaugh formation *(shale, sandstone, and a few limestones, with Bakerstown and several thin coal beds)*

Ca — Allegheny formation *(shale and sandstone; Upper Freeport coal at top, Lower Kittanning coal below)*

Cpv — Pottsville formation *(sandstone, conglomerate, and shale, with Mount Savage fire clay and a few thin coal beds)*

Mississippian

Cmc — Mauch Chunk formation *(red and green shales and sandstone)*

Cgr — Greenbrier limestone *(limestone with much interbedded shale)*

Cpo — Pocono sandstone *(sandstone and conglomerate with some shale)*

DEVONIAN

Dck — Catskill formation *(red and green shale and sandstone)*

Dj — Jennings formation *(shale and sandstone)*

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LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines)

CARBONIFEROUS

Pennsylvanian (Possibly Permian at top)

- **Cd** — Dunkard formation *(shale, sandstone, and limestone, with thin coal beds)*
- **Cm** (wb, us, pb) — Monongahela formation *(shale, sandstone, and limestone; Pittsburg coal at the bottom, Waynesburg coal at the top, Sewickley and other coal beds between)*
- **Ccm** (bt, gv) — Conemaugh formation *(shale, sandstone, and a few limestones, with Bakerstown and several thin coal beds)*
- **Ca** (uf, lk) — Allegheny formation *(shale and sandstone; Upper Freeport coal at top, Lower Kittanning coal below)*
- **Cpv** — Pottsville formation *(sandstone, conglomerate, and shale, with Mount Savage fire clay and a few thin coal beds)*

Mississippian

- **Cmc** — Mauch Chunk formation *(red and green shales and sandstone)*
- **Cgr** — Greenbrier limestone *(limestone with much interbedded shale)*
- **Cpo** — Pocono sandstone *(sandstone and conglomerate with some shale)*

DEVONIAN

- **Dck** — Catskill formation *(red and green shale and sandstone)*
- **Dj** — Jennings formation *(shale and sandstone)*

Economic and structure data

- 1500 — *Structure contours (showing elevation above sea and configuration of the top of the Pottsville formation. Contour interval 100 feet)*
- *Coal outcrops (coal of probably workable thickness)*
  - wb, *Waynesburg coal*
  - us, *Upper Sewickley coal*
  - pb, *Pittsburg coal*
  - bt, *Bakerstown coal*
  - gv, *Grantsville coal*
  - uf, *Upper Freeport coal*
  - lk, *Lower Kittanning coal*
- ⚒ *Commercial coal mines*
- ⚒LS *Limestone quarries*
- x *Coal prospects and country banks*

(Piedmont 1/125000)

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Topography by W. Carvel Hall.

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TRUE NORTH
MAGNETIC NORTH
4°
APPROXIMATE MEAN DECLINATION 1903.

(Piedmont 1/125000)

Scale 1/62500

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

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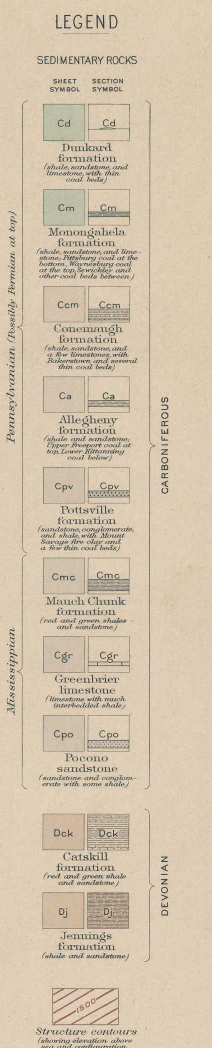

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Topography by W. Carvel Hall.
SURVEYED IN 1898 IN COOPERATION WITH THE STATE OF MARYLAND

Scale $\frac{1}{62500}$

Edition of July 1908.

Geology by G. C. Martin.
Surveyed in 1900-1903.
SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

COLUMNAR SECTIONS

GENERALIZED SECTION FOR THE ACCIDENT AND GRANTSVILLE QUADRANGLES.

SCALE: 1 INCH = 500 FEET.

System.	Series.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.
CARBONIFEROUS	PERMIAN?	Washington formation (of the Dunkard group).	(Cd)		180	Shale with thin sandstones, local fresh-water limestones, and several small coal beds.
	PENNSYLVANIAN	Monongahela formation.	Cm		240–270	Shale with a few sandstone beds, several fresh-water limestones, and six coal beds.
		Conemaugh formation.	Ccm		570–635	Shale and sandstone, the latter in places conglomeratic; several limestones (fresh-water in the upper part of the formation and marine in the lower part) and many thin coal beds.
		Allegheny formation.	Ca		260–350±	Shale and sandstone with several coal beds.
		Pottsville formation.	Cpv		325–375	Sandstone and conglomerate with some shale, coal, and fire clay.
		UNCONFORMITY				
	MISSISSIPPIAN	Mauch Chunk formation.	Cmc		650	Red and green shale with some sandstone.
		Greenbrier limestone.	Cgr		225	Massive limestone at top; red and green shales with thin limestones in middle; calcareous cross-bedded sandstone (Loyalhanna or "Siliceous" limestone) at base.
		Pocono sandstone.	Cpo		450	Sandstone and conglomerate, with some gray shale, especially near base.
DEVONIAN		Catskill formation.	Dck		1200–2200	Red and green shale and sandstone.
		Jennings formation.	Dj		3500±	Olive-green to brownish-red shale and sandstone, with two thin conglomerates; approximately equivalent to the Chemung formation. Olive-green to gray shale alternating with thin fine-grained micaceous sandstones. Probably not exposed at the surface in these quadrangles. Black fissile shale, representative of the Genesee shale. Not exposed in these quadrangles.

DETAILED SECTION OF THE COAL-BEARING ROCKS OF THE ACCIDENT AND GRANTSVILLE QUADRANGLES.

SCALE: 1 INCH = 100 FEET.

Formation.	Names of Members.	Columnar Section.	Thickness in Feet.	Character of Rocks.
WASHINGTON	Washington coal.		3½	Usually not opened or exposed.
	Waynesburg "A" coal.		1½	Thin and not well known.
MONONGAHELA	Waynesburg coal.		2–6	Persistent and important.
	Waynesburg limestone.		5½	Fresh-water fauna.
	Uniontown coal.		1	Generally thin.
	Sewickley sandstone.		15	
	Upper Sewickley coal.		5½	Gas coal; important.
	Lower Sewickley coal.		2½	Sometimes mined.
	Fishpot limestone.		5½	Fresh-water fauna.
	Redstone coal.		3–7	Persistent, but variable and not mined.
	Pittsburg coal.		9–15	Very persistent; most important coal of region.
CONEMAUGH	Little Pittsburg coal.		2–4	Thin and variable.
	Pittsburg limestone (lower).		3	
	Connellsville sandstone.		50	Massive and persistent.
	Franklin coal.		4–9	Persistent but variable. Not often mined.
	Clarksburg limestone.		6–14	Fresh-water fauna; very persistent.
	Morgantown sandstone.		20–50	Massive; locally conglomeratic.
	Elklick coal.		½–2	Thin and variable.
	Ames limestone.		2	Marine fauna; very characteristic.
	Harlem coal.		2	Thin but regular.
	Maynardier coal.		2–3	Restricted to Castleman Valley.
	Saltsburg sandstone.		30	Massive and regular.
	Bakerstown coal.		2–4	Variable in thickness but persistent; mined at many places.
	Grantsville coal.		2–5	Restricted to Castleman Valley.
				Red shale.
	Upper Cambridge limestone.		1	Marine fauna.
	Buffalo sandstone.		10–40	Massive.
	Lower Cambridge limestone.		1–3	Marine fauna.
	Brush Creek coal.		2	Thin but regular and persistent.
	Mahoning sandstone (upper part).		0–50	Massive but variable in thickness.
	Mahoning coal.		2	Usually thin and variable.
	Mahoning sandstone (lower part).		25–50	Massive and persistent.
ALLEGHENY	Upper Freeport coal.		3–5	Very regular and persistent.
	Bolivar fire clay.		4	Flint clay. Limestone occupies this position at some places.
	Roaring Creek sandstone.		20–30	Massive; locally conglomeratic.
	Lower Freeport coal.		1–3	Variable; absent in some places.
	Lower Freeport sandstone.		25	Massive but variable.
	Upper Kittanning coal.		1–3	Variable and of local occurrence.
	Lower and Middle Kittanning coals.		4–6	Persistent and regular.
	Split-six coal.		2–5	Variable.
	Vanport limestone.		3	Marine fauna in places; fresh-water elsewhere.
	Clarion sandstone.		25–70	Very massive; conglomeratic in many places.
	Clarion coal.		2½	Persistent but not valuable.
	Brookville coal.		1–4	Irregular and of local occurrence.
POTTSVILLE	Homewood sandstone.		30–100	Massive and persistent.
	Mount Savage coal.		2–4	Persistent but irregular.
	Mount Savage fire clay.		5–12	Flint and plastic clays.
	Connoquenessing sandstone (upper part).		75	Massive and conglomeratic.
	Quakertown coal.		1	Thin and irregular.
	Connoquenessing sandstone (lower part).		75	Massive and conglomeratic.
	Sharon coal.		1–2	Thin and irregular.

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