O'Harra.
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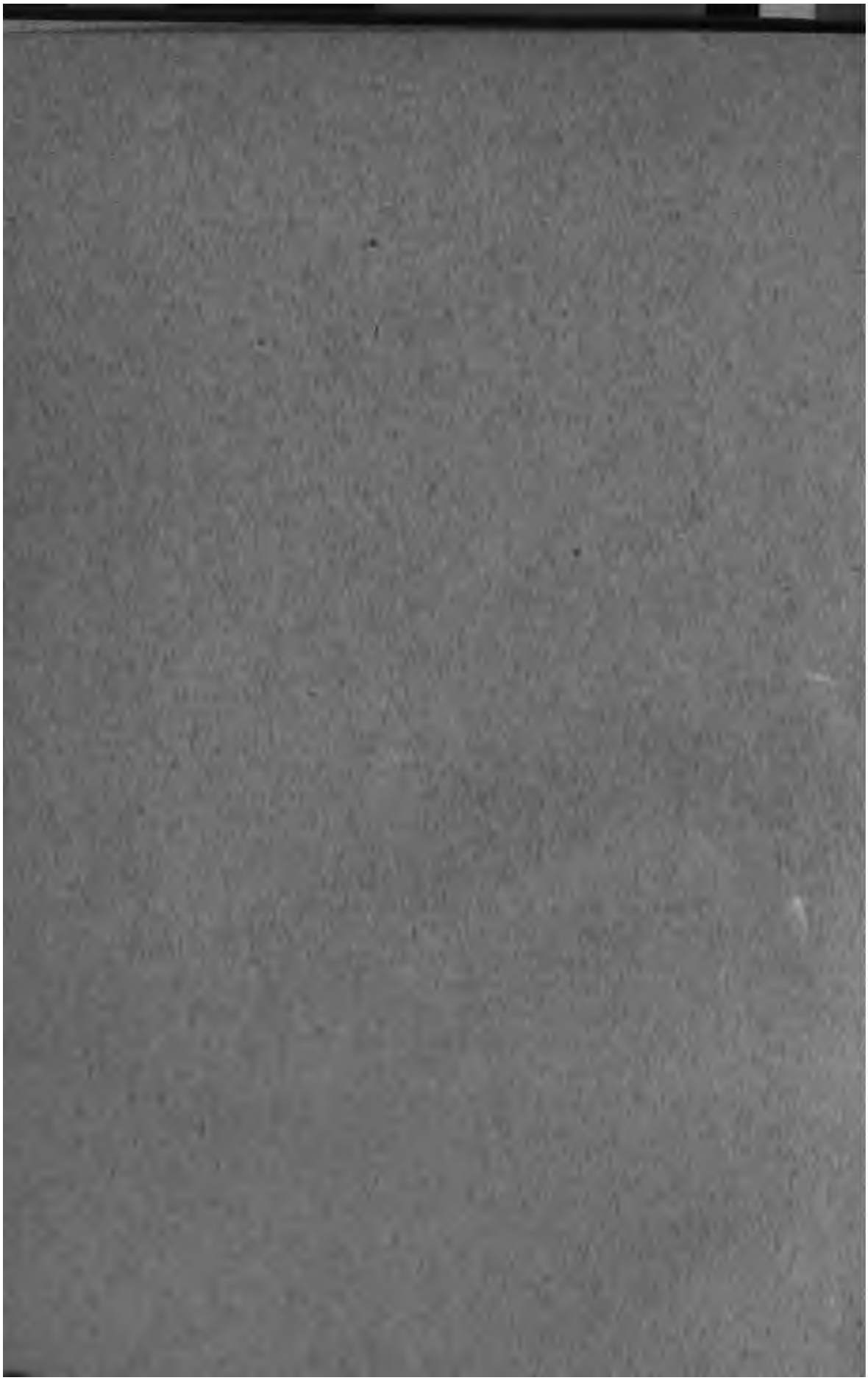

THE GEOLOGY OF ALLEGANY COUNTY

A DISSERTATION

PRESENTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS UNIVERSITY, JUNE, 1898, FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BY

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INTRODUCTORY.

Particular attention is given in the following pages to the stratigraphy, structure and areal distribution of the various formations exposed in Allegany county; the processes and conditions under which the sediments were deposited; and the forces that have operated in bringing about the present attitude of the strata. A brief review of previous work is given, and a bibliography is added. Only such general references to the paleontology, physiography and soils of the region have been made as are necessary to give a clear understanding of the geological features since these branches are more fully discussed in other places.

GEOGRAPHIC AND GEOLOGIC RELATIONS.

The situation and boundaries of Allegany county have been described in earlier pages. Although bounded on the north and west by straight lines whose combined length approximates only 50.8 miles, the entire periphery is about 145 miles, the amount being very much increased by the tortuous channels of the Potomac river and Sideling Hill Creek.

The county contains several mountains of importance. Naming them in order from the east, they are: Town Hill, Green Ridge, Stratford Ridge, Polish Mountain, Warrior Mountain, Tussey Mountain, Martin Mountain, Collier Mountain, Evitts Mountain, Nicholas Mountain, Shriver Ridge Mountain, Wills Mountain, Allegheny Mountain and Dans Mountain. The last two, which may really be

considered as one mountain, and which are alluded to in this paper as the Dans-Allegheny Mountain, form a part of the great Allegheny Front. Tussey Mountain dies out almost immediately after entering the county from Pennsylvania, and Evitts Mountain becomes obliterated nearly as quickly. Other ridges and hills of less geological importance are named on the map.

The drainage of the county is wholly to the south. Among the more important streams entering the Potomac are the following: Sideling Hill Creek, Fifteenmile Creek, Town Creek, Martins Spring Run, Colliers Run, Evitts Creek, Wills Creek, Georges Creek and Stony Run. Among the other streams, lying wholly or partly within Allegany county, whose waters eventually find their way into the Potomac are Flintstone Creek, Murley Branch, Jennings Run, Braddock Run, Moores Run, Jackson Run, Hill Run, Elk Lick Run, Matthew Run, Neffs Run, Winebrenner Run, Staub Run, Wrights Run, Squirrel Neck Run, Koontz Run, Laurel Run, Bartlett Run, Mill Run, Rock Gully Creek, Maple Run, White Sulphur Creek, Piney Ridge Run. Flintstone Creek, Murley Branch and Maple Run flow into Town Creek; Jennings Run and Braddock Run flow into Wills Creek; Rock Gully Creek flows into Evitts Creek; White Sulphur Creek and Piney Ridge Run flow into Fifteenmile Creek; while all of the others named enter Georges Creek.

The area covered by Allegany county forms an integral part of the Appalachian Province, hence an accurate and exhaustive study of the geology of the county can be made only by adequate reference to the conditions governing the complete geologic history of the entire province. The province itself is composed of three genetically related physiographic divisions, the principal features of which have been brought about by geographic conditions that no longer exist.[1] The eastern division is a part of the ancient continent of Appalachia, a land-mass of uncertain area from which most of the sediments of the Appalachian Province were derived. The western limit of this division of the province is now represented by the Blue Ridge.

[1] Willis, Bailey. The Northern Appalachians, Geographic Monographs, vol. i, 1895.

Lying to the west of Appalachia there was a great inland sea in which the sediments from this ancient continent were gradually laid down. The littoral zone of this mediterranean sea having received many thousands of feet of various kinds of sediments, was from time to time affected by powerful organic movements, possibly not yet ceased, the result of which has been to bring the formerly almost horizontal beds into a greatly folded condition. This old littoral zone, now constituting the central physiographic division of the province, corresponds to what is sometimes known as the Greater Appalachian Valley, using that term in its wider sense to include the area between the Blue Ridge and the Alleghany Front. Along the outskirts of the littoral zone the strata were much less influenced by the enormous forces which so disturbed the central and eastern divisions; and, although considerably elevated, they have, as a rule, been left in a more nearly horizontal position. This part which now forms the Alleghany Front and the Alleghany Plateau constitutes the western physiographic division of the Appalachian Province.

Structurally, the area which is covered by the central and western physiographic divisions as above defined, is divided somewhat differently. According to the structure, two divisions are recognized, but the line of separation falls much farther east. In Maryland, the western structural division known as the district of *open* folding is limited on the eastern side by North Mountain, while the western limit extends beyond the western borders of the state. East of North Mountain lies the structural division known as the district of *close* folding. In Maryland it occupies approximately the position of the Hagerstown Valley.

Structurally, then, Allegany county lies wholly within a single district, that of open folding. Physiographically, it includes parts of two divisions, viz., the Greater Appalachian Valley and the Alleghany Plateau. Stratigraphically, it is not referable to any well-defined district or division. The stratigraphic features are, in a sense, much the same as for all of the area west of the great limestone valley. Furthermore, the various structural features, as well as the contacts of the various formations found in the county, extend in many

instances without a break or disappearance for miles beyond the limits of the county. It will thus be seen that the county is not a geological unit and has not been so considered in this paper. However, lying along the Potomac and favorably situated for the display of the structural, physiographic and stratigraphic features of a continuous series of sediments, from the middle Silurian to the late Carboniferous or Permian, rich in easily accessible and well-preserved fossils, and containing also in the western part large deposits of economic importance, the county has for many years been known as a region of peculiar interest, and one deserving careful geologic study.

HISTORICAL REVIEW.

The most prominent physiographic features of Allegany county have long been known. Natural facilities for a careful study of the rocks have always been good, and in addition, especially favorable opportunities have at times been provided by means of the various extensive improvements made for military and commercial purposes. During the middle of the eighteenth century military expeditions to Fort Cumberland and beyond necessitated the construction of a good road from the Atlantic coast to the Ohio valley. George Washington, in a letter to Colonel Bouquet, dated "Camp at Fort Cumberland, 2, August, 1758," says that the first good road for commercial intercourse between the traders of Virginia and Pennsylvania and the Indians along the Ohio was by way of Wills Creek [Cumberland], which place had been selected by intelligent Indians who had been hired to choose the most favorable route of communication. He further states that the Ohio Company in 1753 opened the road at a considerable expense, and that in the following year his own troops greatly repaired it. In 1755 it was widened and completed by General Braddock to near Fort Duquesne. Early in the present century the National Road was surveyed and constructed, the military road being in part utilized for this purpose. Later extensive surveys were made for the Chesapeake and Ohio Canal and for the Baltimore and Ohio Railroad, the latter reaching Cumberland in the year 1842 and

FIG. 1.—TOLL-HOUSE ON THE NATIONAL ROAD.

FIG. 2.—PULP-MILL, NEAR WESTERNPORT.

VIEWS OF ALLEGANY COUNTY.

the former in 1850. These surveys, references to which are given in the bibliography, added much to the general knowledge of the physiography and gave considerable detailed information concerning the character of the rocks and their folded condition, but there appears to have been little attention given to the purely scientific study of the geology of the area.

During the autumn of 1831, Samuel Whyllys Pomeroy traveled through the county and made some hasty observations on the geology along the National Road, particularly in the vicinity of Cumberland and Frostburg (2).

In "Some Notices of the Geology of the Country between Baltimore and the Ohio River, with a Section illustrating the Superposition of the Rocks," by William E. A. Aiken, published in the American Journal of Science, volume xxv, 1834, we have one of the earliest attempts to explain the structure of the mountains and to correlate the various kinds of rocks (3). Unhappily, Mr. Aiken's observations in Allegany county were so meagre that many of the conclusions were necessarily faulty and little definite advance was made.

In the same year, 1834, J. T. Ducatel, State Geologist, and J. H. Alexander, State Topographical Engineer, in a "Report on the Projected Survey of the State of Maryland, pursuant to a resolution of the General Assembly," give general statements concerning the geology of the county (4). Mention is made of the mineral and warm springs near Flintstone, and of the Frostburg coal-field. Much of the information was taken from the collection of reports and letters of the engineers of the Chesapeake and Ohio Canal.

In his "Report of a Geological Reconnaissance made in 1835 from the seat of government by way of Green Bay and the Wisconsin territory on the Coteau du Prairie, an elevated ridge dividing the Missouri from the St. Peters river," G. W. Featherstonhaugh gives considerable geological information concerning Allegany county (8). He traveled under the direction of the United States government and passed through the county while en route westward, evidently entering the county by the National Road. East of Cumberland he

makes little mention of the rocks, but refers to fossils found in the limestone at Flintstone. This limestone he erroneously correlates with the Carboniferous limestone further west. Shriver Ridge is mentioned as being composed of shale and limestone with "*producta*," "*spirifer*" and "*cardia*." The Wills Creek gorge he describes with considerable detail, and gives a sketch of the same. A crude hypothesis for the anticlinal structure of Wills and neighboring mountains is also given. From Cumberland he went to Frostburg, thence down the Georges Creek valley to the Potomac, which he ascended beyond the mouth of Savage river, then returned along the Potomac to Cumberland. He speaks briefly of the Georges Creek coal area and believed that the coal-bearing strata were deposited after the movement which produced the folding to the east.

About this time much interest began to be manifested in the coal, iron, cement, and fire-clay of the coal basin. With the prospect of an opportunity to ship by rail and canal, a greater interest was aroused in the mineral wealth of the county, various mining companies were incorporated, and reports began to appear giving more or less accurate descriptions of the geology of this part of the state. Some of these papers show the result of original work; but not a few were only compilations from the writings of others.

In a report dated October, 1836, to the Georges Creek Coal and Iron Company, one of the earliest companies to develop the mineral resources of the Georges Creek basin, J. H. Alexander and P. T. Tyson give two maps of portions of the Georges Creek area, one columnar section known as the "Dug Hill Section," one structure section and various other details (10). Two months later, Mr. Ducatel, the State Geologist, in his official report to the Governor of Maryland, included a description of the Frostburg coal-field in which the columnar section made for the Georges Creek Coal Company is given. In this report there is also given a carefully prepared hachured map of the entire area on which the various streams, towns and mines are located and named. Frostburg is given on the map as Frost Town, and the coal area is called after it.

During this year, 1836, the State Topographical Engineer, J. H.

Alexander, directed the execution of a chain of triangles with a plane-table survey over a part of the Georges Creek area. The work of this survey was accomplished at individual expense, but the results were generously offered for the use of the state survey.

During the same year, 1836, George W. Hughes made a report to the Maryland Mining Company in which he gives the result of an examination of the coal measures and iron ore deposits belonging to the company (9). The paper includes various analyses and columnar sections.

In this year also, James C. Booth studied the area and published the results in a short paper entitled " Report of the Examination and Survey of the Coal-fields and iron ores belonging to the Barton and New York Coal Company " (7). The next year, 1837, further notes by Mr. Booth, as well as short reports by L. Howell and John Powell were published for the same company.

On February 9, 1837, Professor Philip T. Tyson read before the Maryland Academy of Sciences and Literature a paper entitled " A description of the Frostburg coal formation of Allegany county, Maryland, with an account of its geological position " (12). Later this was published in the Transactions of the Society. With the description of the area one columnar section and two structure sections are given.

In the same year, D. B. Douglas spent three weeks in the coal-field. He made a columnar section and studied the physical and chemical character of the coals (15).

The following year, 1838, Benjamin Silliman made a brief study of the area in the employ of the Maryland Mining Company (16).

During the year 1840, the State Geologist, J. T. Ducatel, made a study of the physical geography, geology and agricultural and mineral resources of Western Maryland (23). The results of his observations were published in the " Annual Report of the Geologist of Maryland, 1840 " (23). This is a paper of 46 pages, 30 pages of which are, however, taken up with a study of the area now included in Garrett county. Mr. Ducatel's report was the first published document of any considerable length which reviewed with reasonable accuracy the

geology of the entire county. It includes the geology and physical geography with remarks on the actual agricultural condition, prospects and resources, as well as information concerning the mineral wealth of the county and the best means of developing it. Two columnar sections of the coal-fields, one structure section along the "Cumberland and National roads," and a topographical map of Allegany and Washington counties on the scale of 1:400,000 are given.

The year 1842 is one of particular interest on account of Sir Charles Lyell's visit to the county. In May of that year he passed through the county by way of the National Road, stopping at Cumberland and Frostburg. In the vicinity of the latter place a number of plants and marine shells were obtained from the coal measures. Among the shells, he mentions *Bellerophon, Euomphalus, Nucula, Loxonema* and *Producta*—seventeen species in all. Of the plants, Bunbury, who described them, gives *Danaeites, Neuropteris, Pecopteris, Lepidodendron, Sigillaria, Stigmaria, Asterophyllites* and *Calamites*—twenty species altogether (30).

In 1844, the classic paper "A Report to the Navy Department of the United States on American coals applicable to steam navigation and other purposes," by Walter R. Johnson was published (27). Coals from several Maryland mines were among those studied.

During the next few years little original investigation was carried on in the county, but this period marks the time of much of the valuable work done by the illustrious brothers, W. B. Rogers, Director of the Geological Survey of Virginia, and H. D. Rogers, State Geologist of Pennsylvania, who published many reports giving valuable information concerning the geology of their respective states, much of which information was extremely helpful in interpreting the geology of Allegany county.

In 1852 reports were published by the Phoenix Mining and Manufacturing Company which included a "topography of the mineral regions" by Professor Forrest Sheppard and a report on the topography and structure of the coal-field by Professor C. U. Shepard (33).

Two years later, 1854, George W. Hughes, President and Engineer of the Hampshire Coal and Iron Company, published a report dealing especially with the lands controlled by his company (34).

VIEW OF NORTH BRANCH OF THE POTOMAC, NEAR KEYSER, W. VA.

In 1855, Robert G. Rankin published a report on the economic value of the semi-bituminous coal of the Cumberland basin (36). This is an excellent paper in which the author gives a description of the basin, analyses, use and origin of the coal and the facilities for transportation.

In 1859 a great advance was made in the historical study of the rocks. Professor James Hall, State Geologist of New York, who was so exhaustively studying the Paleozoic fossils of his own state, made also from time to time large collections from several of the states to the west and south. In September, 1856, he visited Cumberland, made some geological examinations and studied the extensive collection of Mr. Andrews. Later Professor Hall purchased Mr. Andrews' collection and continued his studies upon it. Three years after his visit volume 3 of the Paleontology of the State of New York was published. In this volume sixty-three species are described from Cumberland and vicinity, many of which are figured. Several of the subsequent paleontological reports published under the direction of Professor Hall also contain descriptions and figures of numerous species from the same locality.

The year 1860 marks the appearance of the state geological map by Philip T. Tyson, published in his official report as State Agricultural Chemist (40). This map, which is on the scale of twelve miles to the inch, represents the first serious attempt to arrange in accurate detail the various geological formations in Allegany county. With the map there are three structure sections, one of which crosses the county from west to east near the Maryland-Pennsylvania line.

During the summer of 1868, Professor James T. Hodge of Boston, studied the coal basin and made an extensive survey of the coal properties (47). In his report, published the following year, he gives much attention to property lines, but also discusses the coal region as a whole, including the drainage of the basin, access to the coal-bed, system of mining, area covered by the Big Vein and product of Big-Vein coal to the acre. To the property-owner this has been a most valuable work, but the report is now almost wholly inaccessible.

In 1874, Professor James Hall published his paper on "The

Niagara and Lower Helderberg Groups; their relations and geographical distribution in the United States" (51). In this paper brief but valuable references are made to the relations of the groups as they occur at Cumberland.

In 1878, under the direction of the United States Navy Department, B. F. Sherwood, Theodore Zeller and Henry L. Snyder made careful experiments on various coals, including the Frostburg coal (58). Particular attention was given to the physical structure of the coal, to its action while burning, to its heat-producing power and to the residual ash, clinker and soot.

In 1878, Professor J. J. Stevenson published two articles in the American Journal of Science on the geology of portions of Pennsylvania, Maryland and West Virginia. In one article particular mention is made of the terraces in Garrett and Allegany counties, and in this article the causes of the present physiographic features are discussed (60). The other article deals with the Upper Devonian rocks (61).

The year 1882 was one of particular interest in the development of a correct knowledge of the structural geology of the county. Among the important publications which appeared during this year was a paper by Howard Grant Jones and one by Professor I. C. White. In Mr. Jones' paper a section west of Cumberland was given which was accompanied by a discussion of the correlation of the various rocks (72). Professor White later reviewed the work and rectified some of Mr. Jones' conclusions. Professor White's paper is the first publication showing conclusively the conformity and proper relations of the rock formations as found in the western part of Allegany county (76).

It was during this year also that report TT of the Second Geological Survey of Pennsylvania was published (75). This report is by Professor J. J. Stevenson and deals with the geology of Bedford and Fulton counties, which lie immediately north of Allegany county. In this report frequent reference is made to Allegany county, and much of the general discussion concerning the Pennsylvania counties is directly applicable to it.

In the Transactions of the American Institute of Mining Engineers, vol. xiv, 1886, R. S. Cook gives an account of the manufacture of fire-brick at Mt. Savage, which included a discussion of the occurrence and composition of the clay and a description of the methods of manufacture (90).

During the years 1883-4-5 considerable topographical mapping was done in Western Maryland and adjacent portions of West Virginia by the United States Geological Survey. The topographic party in the early part of the work was in charge of Mr. S. H. Bodfish. Later, Mr. Bodfish's health having failed, Mr. W. T. Griswold took charge of the party and remained in charge during the following two field seasons (86). During the year 1886 much of this work was examined, reviewed and prepared for publication by Mr. Merrill Hackett (87). Of the sheets surveyed at this time which include portions of Allegany county, only those covering the Piedmont and the Romney quadrangles have been published.

In the year 1897, topographic work was resumed in Allegany county by the United States Geological Survey in connection with the Maryland Geological Survey, since which time the survey of the county has been completed.

In volume 34 of the American Journal of Science, 1887, Professor J. J. Stevenson discusses the lower Carboniferous rocks of Pennsylvania, Maryland and the Virginias, and mentions various Allegany county localities (95).

In the same journal and in the same year, Professor I. C. White discusses the probable causes which have brought about the deposition of rounded boulders at high altitudes on the eastern side of the Alleghanies and makes particular mention of the vicinity of Cumberland (96).

In the 42d Annual Report of the New York State Museum, 1889, Professor John M. Clarke discusses "The Hercynian Question," in connection with which he gives important notes on some of the formations in the region about Cumberland (101).

During the year 1891, Bulletin No. 65 of the United States Geological Survey was published. This is by Professor I. C. White on

"The Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio and West Virginia" (113). In this bulletin reference is made to the Coal Measures of Maryland, and the map which accompanies the bulletin includes the Cumberland-Georges Creek district.

It was in May of this year, 1891, that the students in the Geological Department of the Johns Hopkins University visited Allegany county under the direction of the late Professor George H. Williams for the purpose of studying Appalachian geology. The results of their study are given in volume xi, number 94, of the University Circulars for that year (114).

In 1893, in the Maryland World's Fair Book, entitled "Maryland, its Resources, Industries and Institutions," a general summary of the geology of the state was published by Professors George H. Williams and William B. Clark of the Johns Hopkins University, in which the geology of Western Maryland is discussed at considerable length (144). With this publication there is a geological map of the state in which the areal distribution of the various formations and the structure of the rocks of Allegany county are represented in much greater detail and accuracy than on any previous map.

In 1894, Mr. Howard Shriver, of Cumberland, published a short paper containing a catalogue of fossils found in the vicinity of Cumberland (150).

In the Fourteenth Annual Report of the United States Geological Survey, published during the same year, 1894, Joseph D. Weeks, under the title of "The Potomac and Roaring Creek Coal Fields," describes at some length the Cumberland-Georges Creek district, and gives a columnar section of the same (151).

During the years 1894 and 1895, H. O. Hofman and C. D. Demond describe, in the Transactions of the American Institute of Mining Engineers, extensive experiments which were carried on by them for the purpose of determining the refractiveness of fire-clays (148). Various experiments were made with the Mt. Savage fire-clay, and in the paper a number of analyses are given.

In 1896, the Piedmont Folio, No. 28 of the Geologic Atlas of the United States, was published by the United States Geological Survey

(159). The geological work was done by Messrs. N. H. Darton and Joseph Taff under the direction of Mr. Bailey Willis, and was begun in the autumn of 1894. The quadrangle covered by this folio includes a small area in the southwestern part of Allegany county, and the geology of the entire quadrangle is very similar to that of this county. Several of the formational names used in the folio have been adopted by the Maryland Geological Survey, and much of the discussion concerning the various geological features is directly applicable to Allegany county.

In the early part of the year 1896, the Maryland Geological Survey was organized, and at the opening of the field season began work in various parts of the state. Since then three volumes have been published by the survey under the direction of Professor William B. Clark, State Geologist. In volume I a general preliminary discussion of the various geological features of the state is given, including much new and valuable information concerning the stratigraphic, physiographic, economic and structural features of Allegany county.

Volume II includes a description of the various building stones and of the geologic maps of the state, with particular mention of Allegany county.

Volume III treats especially of the highways of the state, their present conditions and the material at hand in each of the counties for road-construction.

BIBLIOGRAPHY.

CONTAINING REFERENCES TO THE GEOLOGY AND ECONOMIC RESOURCES OF ALLEGANY COUNTY.

1824.

1. Shriver, James. An Account of the Examination and Surveys, with Remarks and Documents relative to the Chesapeake and Ohio and Lake Erie Canals. Baltimore, 1824. 116 pp., map.

1832.

2. Pomeroy, Sam. Whyllys. Remarks on the Coal Region between Cumberland and Pittsburg, and on the Topography, Scenery,

etc., of that portion of the Alleghany Mts. [Letter written Nov., 1831.]

Amer. Jour. Sci., vol. xxi, 1832, pp. 342-347.

1834.

3. AIKEN, WILLIAM E. A. Some of the notices of the Geology of the Country between Baltimore and the Ohio River, with a section illustrating the superposition of the rocks.

Amer. Jour. Sci., vol. xxvi, 1834, pp. 219-232, plate.

4. DUCATEL, J. T., and ALEXANDER, J. H. Report on the Projected Survey of the State of Maryland, pursuant to a resolution of the General Assembly. 8vo. 39 pp. Annapolis, 1834. Map.

Md. House of Delegates, Dec. Sess., 1833 (Annapolis, 1834).

Another edition, Annapolis, 1834, 8vo., 58 pp. and map.

Another edition, Annapolis, 1834, 8vo., 43 pp. and folded table.

5. MERCER, CHAS. FENTON. Report of the Hon. Charles Fenton Mercer [on the Chesapeake and Ohio Canal].

House Misc. Doc., 23rd Cong., 1st Sess., Doc. 414. Washington, 1834, 378 pp.

1836.

6. ANON. Charter, etc., of the Georges Creek Coal and Iron Company, containing a detailed account of the Geology, &c., of this locality. Baltimore, 1836.

7. BOOTH, JAS. C. Report of the Examination and Survey of the Coal Lands, etc., belonging to the Boston Purchase, near Cumberland, in the State of Maryland. New York, D. Fanshaw, 1836.

8. FEATHERSTONHAUGH, G. W. Report of a Geological Reconnaissance made in 1835 from the seat of government by way of Green Bay and the Wisconsin Territory on the Coteau du Prairie, an elevated ridge dividing the Missouri from the St. Peters River. 169 pp. 4 plates. Washington, 1836.

9. HUGHES, GEORGE W. Report of an Examination of the Coal Measures, including the Iron-ore deposits, belonging to the Maryland Mining Company, in Allegany County, &c., &c. 1836.

1837.

10. DUCATEL, J. T., and ALEXANDER, J. H. Report on the new Map of Maryland, 1836. 8vo. 104 pp. and 5 maps. [Annapolis, 1837.]

Md. House of Delegates, Sess. Dec., 1836.

Another edition, 117 pp.

11. ELDREDGE, N. T. Report of the Special Agent sent to examine the Mines of the Company. Sm. 8vo. 13 pp. New York, 1837.

12. TYSON, PHILIP T. A description of the Frostburg Coal Formation of Allegany County, Maryland, with an account of its geological position.

Trans. Md. Acad. Sci. and Lit., 1837, pp. 92-98, plate.

1838.

13. ANON. Report upon the Surveys for the Extension of the Baltimore and Ohio railroad from its present termination near Harper's Ferry, on the Potomac, to Wheeling and Pittsburg on the Ohio river. 8vo. 138 pp.

14. ANON. Charter of the Carroll White Sulphur Spring Company, in Allegany County, Maryland, with a scientific Report upon the situation, properties, composition, etc., of the springs. 1838.

15. DOUGLAS, D. B. Report on the Coal and Iron Formation of Frostburg and Upper Potomac in the States of Maryland and Virginia. Brooklyn (?), 1838, with map.

16. SILLIMAN, B. Extracts from a report made to the Maryland Mining Company, 1838.

1839.

17. ERICKSON, CAPTAIN. Report of Captain Erickson, Civil Engineer, London, showing the cost of the coal of the *Maryland Mining Company* per ton, delivered at the several cities of Washington, Baltimore, Philadelphia and New York. 1839.

18. SHEPPARD, F. Report to the Potomac and Allegany Coal and Iron Manufacturing Company. 1839.

19. SILLIMAN, B. Extract from a report made to the Maryland and New York Coal and Iron Company. 1839.

20. WELD, HENRY THOMAS. A Report made by Henry Thomas Weld, Esq., of the Maryland and New York Iron and Coal Company's Land, &c.

1840.

21. ALEXANDER, J. H. Report on the Manufacture of Iron, addressed to the Governor of Maryland by J. H. Alexander. Printed by order of the Senate. Annapolis, 1840. 8vo. 369 pp., 3 plates.

22. ANON. Charters of the Union Potomac Company and the Union Company, with a description of their Coal and Iron Mines, &c. 1840.

1841.

23. DUCATEL, J. T. Annual Report of the Geologist of Maryland, 1840. 8vo. 46 pp. [Annapolis, 1840.] Map and sections.

Another edition, 8vo., 59 pp. and 3 plates; also Md. House of Delegates, Dec. Sess., 1840, n. d., 8vo., 43 pp., 3 plates.

24. ROGERS, HENRY D. An Inquiry into the Origin of the Appalachian Coal Strata—Bituminous and Anthracitic.

Trans. Assoc. Amer. Geol. and Nat., 1842, pp. 433-474.

25. ROGERS, W. B. and H. D. On the Physical Structure of the Appalachian Chain as Exemplifying the Laws which have Regulated the Elevation of Great Mountain Chains.

Repts. Amer. Assoc. Geol. and Nat., 1842, pp. 474-531.
(Absts.) British Assoc. Repts., 1842, Pt. II, pp. 40-42.
Proc. Assoc. Amer. Geol. and Nat., 1840-42, pp. 70-71.
Amer. Jour. Sci., vol. xliii, 1842, pp. 177-178; vol. xliv, 1843, pp. 359-362.

1843.

26. SILLIMAN, BENJ. Lecture VII. Coal, its Origin and Organic Remains. Pittsburg, 1843.

1844.

27. JOHNSON, W. R. A Report to the Navy Department of the United States on American Coals applicable to steam navigation and to other purposes.

Exec. Doc. House, 28th Cong., 1st Sess., vol. vi, 1844, No. 276, pp. 1-607.
Sen. Doc. No. 386, 28th Cong., 1st Sess., vol. vi, June 6, 1844, 607 pp.

1845.

28. LONSDALE, W.

Appendix Quart. Jour. Geol. Soc. London, vol. i, 1845, pp. 427-429. (See Lyell, Chas.)

29. LYELL, CHAS. Travels in North America, with Geological Observations on the United States, Canada and Nova Scotia. 2 vols. 12 mo. New York, 1845.

Another edition. 2 vols. 12mo. London, 1845.
Second English edition. London, 1855.
German edition, translated by E. T. Wolff, Halle, 1846.

1846.

30. BUNBURY, C. J. F. On some remarkable Fossil Ferns from Frostburg, Md., collected by Mr. Lyell. (Read Dec. 3, 1845.)

Quart. Jour. Geol. Soc., London, vol. ii, 1846, pp. 82-91, 2 plates.
(Abst.) Amer. Jour. Sci., 2nd ser., vol. ii, 1846, pp. 427-428.

1848.

31. TAYLOR, R. C. Statistics of Coal. The geographical and geological distribution of Mineral Combustibles or Fossil Fuel. 8vo. 745 pp. Philadelphia, 1848.

1850.

32. JOHNSON, W. R. The Coal Trade of British America with Researches on the Character and Practical Values of American and Foreign Coals. 1850. 8vo. 179 pp.

1852.

33. ANON. Documents relating to the Phoenix Mining and Manufacturing Company's Cumberland Coal and Iron. Comprising extracts from various official reports made under direction of Government officers and others. New York, 1852. 52 pp. and map.

1854.

34. HIGGINS, JAMES. The fourth Annual Report of James Higgins, M. D., State Agricultural Chemist, to the House of Delegates of the State of Maryland. 8vo. 92 pp. Baltimore, 1854.
Also Md. House of Delegates, Jan. Sess., 1853.

35. HUGHES, GEO. W. Report of Coal. Geo. W. Hughes, President and Engineer of the Hampshire Coal and Iron Company of Virginia and Maryland. 35 pp. with map. New York, 1854.

1855.

36. RANKIN, ROBERT G. A Report on the economic value of the semi-bituminous coal of the Cumberland coal basin. New York, 1855. 71 pp. and 2 plates.

1856.

37. LESLEY, J. P. Manual of Coal and its Topography, or Geology of the Appalachian Region of the United States of America. Philadelphia, Lippincott, 1856.

38. PHILLIPS, G. JENKINS. Prospectus of the Balcarras Coal and Iron Company, Allegany county, Maryland. New York, 1856. 15 pp. with plate.

1858.

39. ROGERS, H. D. The Geology of Pennsylvania. 2 vols. (vol. ii in two parts) and maps. 4to. Philadelphia, 1858.

1860.

40. TYSON, P. T. First Report of Philip T. Tyson, State Agricultural Chemist, to the House of Delegates of Maryland, January, 1860. 8vo. 145 pp. Annapolis, 1860. Maps.
Md. Sen. Doc. [E].
Md. House Doc. [C].

1861.

41. HALL, JAMES. Paleontology. Vol. iii, Part I. Containing Descriptions and Figures of the Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. 1855-1859. Geological Survey of New York, Albany, 1861.

1862.

42. TYSON, PHILIP T. Second Report of Philip T. Tyson, State Agricultural Chemist, to the House of Delegates of Maryland, Jan., 1862. 8vo. 92 pp. Annapolis, 1862.
Md. Sen. Doc. [F].

1866.

43. DADDOW, S. H., and BANNON, BENJ. Coal, Iron and Oil; or the Practical American Miner. 8vo. 808 pp. Maps, sections, illustrations. B. Bannon, Pottsville, Pa., 1866.

1867.

44. ANON. Reports on the Iron Interests of the Cumberland Coal and Iron Company. New York, 1867. 14 pp.

45. HALL, JAMES. Paleontology, Vol. iv, part I. Containing Descriptions and Figures of the Fossil Brachiopoda of the Upper Helderberg, Hamilton and Chemung Groups, 1862-1866. Geological Survey of New York, Albany, 1867. 4to. 427 pp., 63 plates.

1869.

46. ANON. Cumberland Bituminous Coal.
Eng. and Min. Jour., vol. viii, 1869, p. 153.

47. HODGE, JAS. T. Report of the Coal Properties of the Cumberland Coal Basin in Maryland, from surveys and examinations made during the summer of 1868. New York, 1869. 65 pp.

1871.

48. TYSON, P. T. Section of Cumberland Coal Basin.
Proc. Amer. Phil. Soc., vol. xi, 1871, pp. 9-13.

1872.

49. STEPHENS, THOMAS. Mining Summary. Maryland.
Eng. and Min. Jour., vol. xiv, 1872, p. 411.

1873.

50. MACFARLANE, JAMES. The Coal Regions of America, their Topography, Geology and Development. New York, 1873.

1874.

51. HALL, JAS. The Niagara and Lower Helderberg Groups; their relations and geographical distribution in the United States.
Proc. Amer. Assoc. Adv. Sci., vol. xxiii, 1874, pp. 321-335.
27th Rept. N. Y. State Museum, Albany, 1874, pp. 117-131.

52. MERRILL, WM. E. Extension of the Chesapeake and Ohio Canal to the Ohio River. Including Reports by J. S. Sedgwick, Totten, Poussin, Lesley and Latrobe.
House Doc. No. 208, 43rd Cong., 1st Sess., 59 pp.

1875.

53. ANON. The Maryland Coal Company's Cumberland Coal.
Eng. and Min. Jour., vol. xix, 1875, p. 1.

1876.

54. FONTAINE, WM. M. The Conglomerate Series of West Virginia.
Amer. Jour. Sci., 3rd ser., vol. xi, 1876, pp. 276-284, 374-384.

1877.

55. ANON. Assessed Valuation of Coal and Mining Corporations in Allegany County, Maryland.
Eng. and Min. Jour., vol. xxiii, 1877, p. 242.

56. SCHOOT, CHAS. A. Tables, Distributions and Variations of the Atmospheric Temperature in the United States.
Smithsonian Contrib. Knowledge, vol. xxi, 1876, 360 pp., 9 diagrams, 2 plates, 3 charts.

1878.

57. COOK, GEORGE H. Report on the Clay Deposits of Woodbridge, South Amboy, and other places in New Jersey, etc. 8vo. Geol. Survey of New Jersey, 1878. Pp. 300, 341, 351.

58. SHERWOOD, B. F., ZELLER, THEO., SNYDER, HENRY L. Report on the two kinds of Coal submitted by the Chesapeake and Ohio Railroad agency. Washington, 1878. 30 pp.

59. LOWDERMILK, WILL H. History of Cumberland [etc.], with maps and illustrations, by Will H. Lowdermilk. 8vo. Washington, D. C., 1878.

60. STEVENSON, JOHN J. On the Surface Geology of Southwest Pennsylvania, and adjoining portions of Maryland and West Virginia.

Amer. Jour. Sci., 3rd ser., vol. xv, 1878, pp. 245-250.

61. ———— The Upper Devonian Rocks of Southwest Pennsylvania.

Amer. Jour. Sci., 3rd ser., vol. xv, 1878, pp. 423-430.

1879.

62. ANON. Review of the Coal Trade of 1878.

Eng. and Min. Jour., vol. xxvii, 1879, pp. 1-10.

63. CAIN, PETER. Second Annual Report of Peter Cain, Inspector of Mines. Annapolis, 1878. 8vo. 16 pp.

64. FRAZER, PERSIFOR, JR. Classification of Coals. (Read May 1877.)

Trans. Amer. Inst. Min. Eng., vol. vi, 1879, pp. 430-451.

65. MCCREATH, ANDREW A. Second Report of Progress in the Laboratory of the Survey at Harrisburg.

Rept. 2nd Geol. Survey, Pa. MM, Harrisburg, 1879.

1880.

66. BROWN, THOMAS. The Maryland Union Coal Company.

Eng. and Min. Jour., vol. xxx, 1880, p. 3.

67. DANA, J. D. Manual of Geology. 3rd edit.

68. FONTAINE, WM. M., and WHITE, I. C. The Permian or Upper Carboniferous Flora of West Virginia and S. W. Pennsylvania.

Rept. 2nd Geol. Survey Pa. PP, Harrisburg, 1880, 143 pp. and 38 plates.

69. RIORDAN, O. Second Annual Report of Owen Riordan, Inspector of Mines for Allegany and Garrett Counties. For year ending Dec., 1879. 8vo. 31 pp.

Md. House and Sen. Doc., 1880 [J].

70. STEVENSON, J. J. Surface Geology of Southwest Pennsylvania and adjacent portions of West Virginia and Maryland. (Read April, 1879).

Proc. Amer. Phil. Soc., vol. xviii, 1879, pp. 289-316.

1881.

71. BROWN, T. Second Annual Report of T. Brown, Inspector of Mines for Allegany and Garrett counties. 8vo. 40 pp.
Md. House and Senate Doc., 1881 [F].

1882.

72. JONES, HOWARD GRANT. Notes on the Cumberland or Potomac Coal Basin. (Read Sept. 11, 1880.)
Proc. Amer. Phil. Soc., vol. xix, 1882, pp. 11-110.

73. LESLEY, J. P. (The Cumberland or Potomac Coal Basin.) Remarks on the paper by Mr. Jones.
Proc. Amer. Phil. Soc., Phila., vol. xix, 1882, p. 110.

74. SCHARF, J. T. History of Western Maryland, being a history of Frederick, Montgomery, Carroll, Washington, Allegany and Garrett Counties from the earliest period to the present day. 2 vols. 4to. Philadelphia, 1882.

75. STEVENSON, J. J. The Geology of Bedford and Fulton Counties, Pennsylvania.
2nd Geol. Survey Pa., Rept. T2. Harrisburg, 1882, 8vo., 382 pp., two maps.

76. WHITE, I. C. Notes on the Geology of West Virginia. A Rectification of the Sections made by Mr. Howard Grant Jones, M. S. (Read June 17, 1881.)
Proc. Amer. Phil. Soc., vol. xix, 1882, pp. 438-446.

1883.

77. SMOCK, J. C. The Useful Minerals of the United States.
Mineral Resources U. S. Washington, 1883, pp. 664, 690-693.

78. WILBUR, F. A. Clay.
Mineral Resources U. S., 1882. Washington, 1883, pp. 465-475.

1884.

79. BROWN, T. Report of T. Brown, Inspector of Mines for Allegany and Garrett Counties. Annapolis, 1884. 64 pp.
Md. House and Senate Doc., 1884 [D].

80. ROGERS, WILLIAM BARTON. A Reprint of Annual Reports and other papers, on the Geology of the Virginias.
Sm. 8vo. Appleton, 1884.

81. SMOCK, J. G. Geologico-geographical Distribution of the Iron Ores of the Eastern United States.
Eng. and Min. Jour., vol. xxxvii, New York, 1884, pp. 217-218, 230-232.
Trans. Inst. Min. Eng., vol. xii, 1884, pp. 130-144.

82. SWANK, JAMES M. History of the Manufacture of Iron in all Ages. Philadelphia, 1884.

83. WEEKS, JOSEPH D. Report on the Manufacture of Coke.
Tenth Census, vol. x. Washington, 1884.

1885.

84. ANON. General Mining News—Maryland.
Eng. and Min. Jour., vol. xl, 1885, p. 294.

85. ARMSTRONG, S. C. (Compiler). Coal.
Mineral Resources U. S., 1883-84. Washington, 1885.

86. GANNETT, HENRY. Administrative Reports. Topographic work in Maryland.
5th Ann. Report. U. S. Geol. Survey, 1883-1884. Washington, 1885, pp. 7-8.

87. ———— Administrative Reports. Topographic work in Maryland.
6th Ann. Report U. S. Geol. Survey, 1884-1885. Washington, 1885, p. 8.

88. SWAIN, GEO. F. Report on the water power of the Middle Atlantic Watershed.
Tenth Census, vol. xvi. Washington, 1885, pp. 513-660.

1886.

89. ASHBURNER, CHAS. A. Coal.
Mineral Resources U. S., 1885. Washington, 1886, pp. 33-34.

90. COOK, R. S. The Manufacture of Fire-brick at Mount Savage, Maryland.
Trans. Amer. Inst. Min. Eng., vol. xiv, 1886, pp. 698-706.

91. LESLEY, J. P. Annual Report of the Geological Survey of Pennsylvania for 1885. 8vo. Harrisburg, 1886. Pp. 227-249.

92. PEALE, A. C. Lists and analyses of the mineral Springs of the U. S.
Bull. U. S. Geol. Survey, No. 32, 1886, pp. 51-53.
House Misc. Doc., 49th Cong., 2nd Sess., vol. viii, No. 164.

93. PUMPELLY, R. (Editor). Mines and Metallurgical Establishments East of the 100th Meridian.
Tenth Census, vol. xv, Mining Industries of the U. S. Washington, 1886, pp. 3-36.

1887.

94. ASHBURNER, CHAS. A. Coal.
Mineral Resources U. S., 1886. Washington, 1887, pp. 224-279.

95. STEVENSON, JOHN J. Notes on the Lower Carboniferous groups along the easterly side of the Appalachian area in Pennsylvania and the Virginias.

Amer. Jour. Sci., 3rd ser., vol. xxxiv, 1887, pp. 37-44.

96. WHITE, I. C. Rounded Boulders at High Altitudes along some Appalachian Rivers.

Amer. Jour. Sci., 3rd ser., vol. xxxiv, 1887, pp. 374-381.

1888.

97. ASHBURNER, CHAS. A. Coal.

Mineral Resources U. S., 1887. Washington, 1888, pp. 169, 171, 177, 263-270, 337.

98. DAY, D. T. Useful Minerals of the United States.

Mineral Resources U. S., 1887. Washington, 1888, pp. 739-742.

99. HALL, JAMES, and CLARKE, J. M. Paleontology, vol. vii. Texts and Plates containing descriptions of the Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. Geological Survey of New York, Albany, 1888.

100. SWANK, JAS. M. The Iron and Steel Industries of the United States in 1887 and 1888.

Mineral Resources U. S., 1887. Washington, 1888.

1889.

101. CLARKE, J. M. The Hercynian Question.

42nd Ann. Rept. N. Y. State Museum, pp. 408-437. Albany, 1889.

102. MERRILL, G. P. The Collection of Building and Ornamental Stones in the U. S. National Museum.

Smithsonian Rept., 1886, pt. II, 1889.

103. MILLER, S. A. North American Geology and Paleontology for the use of Amateurs, Students and Scientists. 8vo. 664 pp. Cincinnati, 1890.

104. SCHUCHERT, CHAS. A List of Fossils Occurring in the Oriskany Sandstone of Maryland, New York and Ontario.

8th Ann. Rept. N. Y. State Geol. Albany, 1899, pp. 50-54.

42nd Ann. Rept. N. Y. State Museum. Albany, 1889, pp. 396-400.

105. WARD, LESTER F. The Geographical Distribution of Fossil Plants.

8th Ann. Rept. U. S. Geol. Survey, 1886-87. Washington, 1889, part II, pp. 663-960, maps.

1890.

106. ASHBURNER, CHAS. A. Coal.
Mineral Resources U. S., 1888. Washington, 1890.

107. MACFARLANE, J. R. An American Geological Railway Guide. 2nd edit. 8vo. 426 pp. Appleton, 1890.

108. SCHARF, J. T. Report of the Commissioner of Land Office. Report from Jan. 1st, 1888, to Jan. 1st, 1890, ... with a series of carefully prepared articles on Maryland's resources. . . . 1890.
Md. House of Delegates, Dec. Sess., 1890, 8vo., 148 pp.

1891.

109. JONES, JOHN H. (Spec. Agt.). Census Bulletins of the Coal Industry in 1889.
Eng. and Min. Jour., vol. li, 1891, p. 238.

110. KEYES, CHARLES ROLLIN. Paleozoic fossils of Maryland.
Johns Hopkins Univ. Cir. No. 94, vol. xi, 1891, pp. 28-29.

111. KINNECUT, L. P., and ROGERS, J. F. Fire-clay from Mount Savage, Allegany Co., Md.
Jour. Anal. and Appl. Chem., vol. v, 1891, p. 542.

112. WATKINS, J. ELFRETH. The Development of the American Rail and Track as illustrated by the Collection in the U. S. National Museum.
Report of the U. S. Nat. Mus. for 1889, p. 671. Washington, 1891.

113. WHITE, ISRAEL C. Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio and West Virginia.
Bull. U. S. Geol. Survey, No. 65, 1891.
House Misc. Doc., 51st Cong., 2nd Sess., vol. xiii, No. 136.

114. WILLIAMS, G. H. The Geological Excursions by University students across the Appalachians in May, 1891.
Johns Hopkins Univ. Cir. No. 94, vol. xi, 1891, pp. 25-27.

115. WILLIAMS, H. S. Correlation Papers—Devonian and Carboniferous.
Bull. U. S. Geol. Survey, No. 80, 1891.
House Misc. Doc., 52nd Cong., 1st Sess., vol. xix, No. 24.

1892.

116. ANON. Fire-Brick Industry.
The Iron Belt, Roanoke, Va., vol. iii, Nov. 1892, pp. 4-5.

117. Babb, Cyrus C. The Hydrography of the Potomac Basin.
Amer. Soc. Civ. Eng., vol. xxvii, 1892, pp. 21-33.

118. Clark, Wm. B. The Surface Configuration of Maryland.
Monthly Rept. Md. State Weather Service, vol. ii, 1892, pp. 85-89.

119. Jones, J. H. Coal.
House Misc. Doc., 52nd Cong., 1st Sess., vol. i, pt. I, No. 340.
Eleventh Census, Rept. on Mineral Industries, 1892, pp. 345-422.

120. Lesley, J. P. A Summary description of the Geology of Pennsylvania. 3 vols. Harrisburg, 1892.

121. Parker, E. W. Coal.
Mineral Resources U. S., 1889-90. Washington, 1892.

122. Peale, A. C. Mineral Waters.
Mineral Resources U. S., 1889-90. Washington, 1892.

123. Scharf, J. Thomas. The Natural Resources and advantages of Maryland, being a complete description of all of the counties of the State and City of Baltimore. Annapolis, 1892.

124. Williams, G. H. The University and its Natural Environment.
Johns Hopkins Univ. Cir. No. 96, vol. xi, 1892, pp. 54-56.

1893.

125. Clark, Wm. Bullock. The Available Water Power of Maryland.
Monthly Rept. Md. State Weather Service, vol. iii, 1893, pp. 7-9.

126. ———— Physical Features [of Maryland].
Maryland, its Resources, Industries and Institutions. Pp. 11-54. Baltimore, 1893.

127. ———— The Leading Features of Maryland Climate.
Monthly Rept. Md. State Weather Service, vol. iii, 1893, pp. 1-6.

128. Gannett, Henry. The Average Elevation of the United States.
13th Ann. Rept. U. S. Geol. Survey, 1891-2, pt. II. Washington, 1893, pp. 283-289.

129. Hill, R. T. Clay Materials of the United States.
Mineral Resources U. S., 1891. Washington, 1893.

130. Howard, A. B. First Annual Report of the Bureau of Industrial Statistics of Maryland. Annapolis, 1893.

131. KEYSER, W. Iron.
Maryland, its Resources, Industries and Institutions, pp. 100-112. Baltimore, 1893.

132. PARKER, E. W. Coal.
Mineral Resources U. S., 1891. Washington, 1893.

133. ——— Coal.
Mineral Resources U. S., 1892. Washington, 1893.

134. PEALE, A. C. Mineral Waters.
Mineral Resources U. S., 1891. Washington, 1893.

135. ——— Mineral Waters.
Mineral Resources U. S., 1892. Washington, 1893.

136. SCHUMANN, C. H. The Manufacture of Bricks.
Cassier's Magazine, vol. iv, 1893, pp. 403-47.

137. SPENCER, S. B. Natural and Artificial Cements.
Mineral Resources U. S., 1891. Washington, 1893.

138. STEVENSON, J. J. Origin of Pennsylvania Anthracite.
Bull. Geol. Soc. Amer., vol. v, 1893, pp. 39-70, pl. II.

139. WHITNEY, MILTON. The Soils of Maryland.
Md. Agri. Exper. Sta., Bull. No. 21. College Park, 1893, 58 pp., map.

140. ——— Agriculture and Live Stock [of Maryland].
Maryland, its Resources, Industries and Institutions. Baltimore, 1893, pp. 152-217.

141. ——— Soils of Maryland.
Monthly Rept. Md. State Weather Service, vol. iii, 1893, pp. 15-22, map.

142. WILLIAMS, G. H. [The Appalachian Region and the Itinerary from Washington, D. C., to Cumberland, Maryland.]
Geological Guidebook of the Rocky Mt. Excursion, Comte Rendu de la 5me Ses. Congrès Geolog. Internat. Washington, 1893, pp. 268-279.
House Misc. Doc., 53rd Cong., 2nd Sess., vol. xiii, No. 107, pp. 268-279.

143. ——— Mines and Minerals [of Maryland].
Maryland, its Resources, Industries and Institutions. Baltimore, 1893, pp. 89-153.

144. WILLIAMS, G. H., and CLARK, W. B. Geology [of Maryland].
Maryland, its Resources, Industries and Institutions. Baltimore, 1893, pp. 55-89.

145. WILLIS, BAILEY. The Mechanics of Appalachian Structure.
13th Ann. Rept. U. S. Geol. Survey, 1891-92, pt. II. Washington, 1893, pp. 211-281, plates and maps.

1894.

146. CLARK, WM. BULLOCK. The Climatology and Physical Features of Maryland.

1st Biennial Rept. Md. State Weather Service, 1894.

147. GANNETT, HENRY. Results of Primary Triangulation.

Bull. U. S. Geol. Survey, No. 122, 1894, pp. 64-65.

House Misc. Doc., 53rd Cong., 1st Sess., vol. ix, No. 78.

148. HOFMAN, H. O., and DEMOND, C. D. Some Experiments for Determining the Refractiveness of Fire-clays.

Trans. Amer. Inst. Min. Eng., vol. xxiv, 1894, pp. 42-66. See also 1895.

149. PARKER, E. W. Coal.

Mineral Resources U. S., 1893. Washington, 1894.

150. SHRIVER, HOWARD. Catalogue of Fossils Found at Cumberland, Md. (n. d.) 4 pp.

151. WEEKS, JOSEPH D. The Potomac and Roaring Creek Coalfields in West Virginia.

14th Ann. Rept. U. S. Geol. Survey, 1892-93, pt. II. Washington, 1894, pp. 567-590.

1895.

152. BAIRD, G. W. Experiment to Determine the Economic Vaporization of George's Creek Cumberland Coal, Under Conditions of Actual Practice on Board the Dolphin in port.

Jour. Amer. Soc. Naval Eng., vol. vii, 1895, pp. 329-331.

153. DANA, J. D. Manual of Geology. 4th edit. 8vo. New York, Blakeman, Taylor & Co., 1895.

154. HOFMAN, H. O. Further Experiments for Determining the Fusibility of Fire-clays.

Trans. Amer. Inst. Min. Eng., vol. xxv, 1895, pp. 3-17. See 1894.

155. KEMP, JAMES. The Ore Deposits of the United States. 8vo. 343 pp. New York, 1895.

156. NEWELL, F. H. Report of Progress of the Division of Hydrography, 1893-94.

Bull. U. S. Geol. Survey, No. 131, 1895.

House Misc. Doc., 54th Cong., 1st Sess., vol. —, No. 318.

157. PARKER, E. W. Coal.

16th Ann. Rept. U. S. Geol. Survey, 1894-95, pt. IV. Washington, 1895.

158. RIES, HEINRICH. Technology of the Clay Industry.

16th Ann. Rept. U. S. Geol. Survey, 1894-95, pt. IV. Washington, 1895, pp. 523-575.

1896.

159. DARTON, N. H., and TAFF, JOSEPH. Piedmont Folio, Explanatory sheets.
U. S. Geol. Survey, Geol. Atlas, folio 28. Washington, 1896.

160. PARKER, E. W. Coal.
17th Ann. Rept. U. S. Geol. Surv., 1895, pt. III. Washington, 1896.

161. WHITNEY, MILTON. Texture of some Important Soil Formations.
U. S. Dept. Agri., Div. Agri. Soils, Bull. No. 5. Washington, 1896. Illustrated, 23 pp., 35 plates.

162. WILLIS, BAILEY. The Northern Appalachians.
The Physiography of the United States.
Geographic Monographs, I. American Book Co., 169 pp., 1896.

1897.

163. CLARK, WILLIAM BULLOCK. Historical Sketch embracing an Account of the Progress of Investigation Concerning the Physical Features and Natural Resources of Maryland.
Md. Geol. Surv., vol. i, pt. II, pp. 43-138. Baltimore, 1897.

164. ——— Outline of Present Knowledge of the Physical Features of Maryland embracing an Account of the Physiography, Geology and Mineral Resources.
Ibid., pt. III, pp. 139-228.

165. MATHEWS, EDWARD B. Bibliography and Cartography of Maryland, including Publications relating to the Physiography, Geology and Mineral Resources.
Ibid., pt. IV, pp. 229-401.

166. NICOLLS, WILLIAM JASPER. The Story of American Coals. 8vo. 405 pp. Philadelphia, 1897.

167. PARKER, E. W. Coal.
18th Ann. Rept. U. S. Geol. Surv., 1896, pt. V. Washington, 1897.

1898.

168. BAUER, L. A. Report on the Survey of the Boundary-line between Allegany and Garrett Counties. 8vo. 48 pp. Baltimore, 1898.

169. CLARK, WM. BULLOCK. Administrative Report containing an Account of the Operations of the Survey during 1896 and 1897.
Md. Geol. Surv., vol. i, pt. I, pp. 25-43.

170. MATHEWS, EDWARD B. An Account of the Character and Distribution of Maryland Building Stones, etc.
Md. Geol. Surv., vol. i, pt. II, pp. 125-241.

171. ———— The Maps and Map-makers of Maryland.
Md. Geol. Surv., vol. i, pt. III, pp. 337-488.

172. NICOLLS, WILLIAM JASPER. Above Ground and Bolow in the George's Creek Coal Region. (Published for the Consolidation Coal Company.) Sm. 8vo. 32 pp. Baltimore, 1898.

173. PARKER, E. W. Coal.
19th Ann. Rept. U. S. Geol. Survey, 1897-98, pt. VI.

174. WHITE, I. C. The Pittsburg Coal Bed.
Amer. Geol., vol. xxi, pp. 49-60, 1898.

1899.

175. ABBE, CLEVELAND, JR. A General Report on the Physiography of Maryland.
Md. Weather Service, vol. i, pt. II, pp. 39-216.

176. CLARK, WILLIAM BULLOCK. The Relations of Maryland Topography, Climate and Geology to Highway Construction.
Md. Geol. Surv., vol. iii, pt. II, pp. 47-106.

177. NEWELL, F. H., AND OTHERS. Report of progress of stream measurements for the calendar year 1897, including papers by Dwight Porter, J. B. Lippincott and other hydrographers.
19th Ann. Rept. U. S. Geol. Survey, 1897-98, pt. IV. Washington, 1899.

STRATIGRAPHY AND AREAL DISTRIBUTION.

With the exception of some scattering Pleistocene deposits, all of the geological formations exposed in Allegany county are of Paleozoic age. The Pleistocene deposits are too poorly defined to receive satisfactory mapping, but the areal distribution of the Paleozoic formations is indicated on the geological map in the Physical Atlas accompanying this report, while their lithological features are shown on the columnar sections.

The stratigraphic relations of the several geological formations, all of which are herein described, are shown in the following table:

TABLE OF ALLEGANY COUNTY FORMATIONS.

Cenozoic.	
Pleistocene	Alluvial, etc.
Paleozoic.	
Permian	Dunkard.
Carboniferous	Monongahela,
	Conemaugh,
	Allegheny,
	Pottsville,
	Mauch Chunk,
	Greenbrier,
	Pocono.
Devonian	Hampshire,
	Jennings,
	Romney,
	Oriskany,
	Helderberg.
Silurian	Salina,
	Niagara,
	Clinton,
	Tuscarora,
	Juniata.

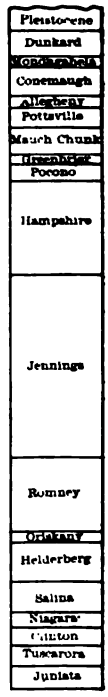

FIG. 4.

THE SILURIAN.

THE JUNIATA FORMATION.

The Juniata formation, known farther north as the Lower or Red Medina or Levant Red Sandstone, (IV b) receives its name from the Juniata river, Pennsylvania, along which it is typically developed. It includes the oldest rocks that appear at the surface in Allegany county and outcrops in only one locality. This outcrop is in the gorge just northwest of Cumberland where Wills Creek cuts through Wills Mountain.

The formation is made up of dull red sandstones and shales interbedded without any regularity of succession. The sandstones are hard, fine-grained, quartzitic near the top, cross-bedded and micaceous. Some of the beds exposed are more than one foot in thickness, but most of them are less than six inches. A few of the beds contain small rounded or flattened pellets of brittle yellowish-green

VIEW FROM DANS ROCK, LOOKING ACROSS THE POTOMAC VALLEY.

or reddish clay, the largest of which are usually less than one-half inch in diameter.

The shale beds vary from less than one inch to six feet or more in thickness. In general, they are considerably thicker than the sandstones, and the total thickness of shale in the exposure is much greater than the total thickness of sandstone. The shales, like the sandstones, are almost always distinctly micaceous and weather readily.

The depth to which Wills Creek has cut into the formation is 530 feet. However, 140 feet of this, computed according to the horizontal distance and supposed average dip, is concealed by the heavy talus derived from the overlying Tuscarora quartzite. Along the Baltimore and Ohio Railroad on the north side of Wills Creek the upper 370 feet is well shown, there being in all of this not more than twenty feet hidden. Here all of the remainder of the Juniata is concealed, but 140 feet below, on the opposite side of the creek, along the Cumberland and Pennsylvania Railroad, an additional exposure of thirty feet may be seen. With the exception of the 140 feet concealed, the measurements were all made with a steel tape.

Notwithstanding the good exposure of much of the formation, the various strata of shales and sandstones are more or less inclined to grade into each other, so that no satisfactory detailed section can be given. The top of the formation is considered as beginning with the highest distinct red shale bed, which is six inches thick where best shown. This may be seen in the small excavation at the spring on the north side of Wills Creek near the east end of the Narrows, a few feet above the Baltimore and Ohio Railroad track. Here the red shale bands quickly become of little importance, and the whiteness of the sandstone gradually but rapidly increases, the Juniata formation thus being separated from the Tuscarora by a transition zone of only a few feet in thickness.[1]

THE TUSCARORA FORMATION.

The Tuscarora formation, perhaps nearly identical with the White Medina of the Pennsylvania and New York surveys, receives its

[1] For a discussion of contacts and transition zones, see Lesley, J. P., A Summary Description of the Geology of Pennsylvania, in three volumes. Vol. i, pp. 627 to 629, Harrisburg, 1892.

name from Tuscarora Mountain, Pennsylvania, where the formation is most typically developed. It is brought to the surface in five places in the county, viz., in Wills Mountain, where, lying conformably upon the Juniata, it gives rise to the higher portions of that mountain; in Evitts Mountain and in Tussey Mountain, of which it makes up almost the entire exposed surfaces; and in two small areas along the Baltimore and Ohio Railroad near Potomac Station, southeast of the southern end of Wills Mountain. The smaller of these last areas has been excavated about twenty feet in order to give a suitable grade for the railroad track. The larger area has a perpendicular exposure of more than one hundred feet above the railroad and extends to the southwest as a well-marked low ridge for a distance of nearly five hundred yards.

The formation is made up of snow-white to light gray quartzite, frequently cross-bedded and consisting usually of medium-coarse quartz grains in a very hard siliceous matrix. In some of the beds scattering quartz pebbles are found, but these are never abundant, and usually are not larger than wheat grains. Yellowish-green, hard clay pebbles of various sizes are sometimes found, but they are not common.

With the exception of casts of *Arthrophycus harlani*, no forms of positive organic origin have been found in the Tuscarora of this county. Even *Arthrophycus harlani* is not abundant in any of the Allegany county exposures, although the faces of some of the upper beds along Wills Creek in the Narrows are pretty well covered by the casts. Casts of Arthrophycus are also shown, and possibly to a better advantage in the outcrops along the Baltimore and Ohio Railroad near Potomac Station. This plant form was found in greater abundance in the upper beds, the lower beds apparently being nearly destitute of them.

In general, the rocks are highly indurated and massive, and do not weather readily. In the Narrows and in Rocky Gap on Evitts Mountain, heavy talus slopes conceal the lower faces of the cliffs, while the overhanging walls of white rock give to these gorges a very rugged appearance. To some extent the same is true of the gap in Tusseys

Mountain, but this gap is so near the point where the mountain pitches beneath the surface that the walls of the gorge are very low.

The total thickness of the formation is shown only in the Wills Creek gorge in Wills Mountain. Here the thickness is 287 feet, a good measurement having been obtained by means of a line dropped from the top of the Narrows to the Tuscarora-Juniata contact at a point near the Baltimore and Ohio Railroad yard limits.

THE CLINTON FORMATION.

The Clinton formation is identical with the Clinton rocks of the New York section, the name being first used by the New York survey on account of the excellent development of the rocks in that state in the vicinity of Clinton. This formation lies conformably upon the Tuscarora quartzite and immediately surrounds the areas covered by the Tuscarora formation.

The largest area flanks Wills Mountain on either side, and continuing south-southeast beyond Cresap, encloses the smaller Tuscarora areas on the Potomac where that river makes a strong bend to the southeast. Another area lies to the northeast of Cumberland where, coming in from Pennsylvania, it flanks the southern end of Evitts Mountain. A third area lies further east and holds the same relation to Tussey Mountain northwest of Flintstone that the second area holds to Evitts Mountain.

The Clinton is composed essentially of thin reddish and greenish-yellow shales, while sandstone beds, some of which are of considerable thickness, occur in it, and a few thin beds of limestone appear in the upper part. Two important beds of iron ore are also found in it. In the lower part, where light colored shales predominate, the several transition sandstones present are more or less quartzitic, but are of no very great thickness. These lower sandstones are best seen on the south side of Wills Creek at the east end of the Narrows.

Near the top of the formation there is a light gray massive sandstone generally about ten feet thick. This is well shown along the Baltimore and Ohio Railroad about forty rods west of Brady, where the thickness is a little less than ten feet, and where the sandstone is

overlain by a six-inch bed of hematitic iron ore, known as the upper Clinton iron ore. A sandstone which apparently corresponds to the above-mentioned sandstone was seen on the National Road northeast of Cumberland, a little west of the Sixmile House, one hundred yards west of the junction of the Johnston Road with the National Road.

The limestones of the formation are seldom six inches in thickness, and are much inclined to occur in layers about two inches thick, interbedded with shale bands of similar thickness. The limestones are almost always highly fossiliferous.

The shales occupy most of the lower part of the formation, besides a considerable space in the middle and upper portions. These also frequently contain fossils. In color, they are usually a yellowish green or olive where freshly broken, but the flat exposed surfaces frequently have a marked scarlet color. Near the bottom of the formation the shales have more of a dull grayish brown appearance and are less fossiliferous.

The lower Clinton iron ore includes two beds separated, where best seen, by six feet of greenish calcareous shale. The thickness of the lower bed averages about four and one-half feet and is 160 feet above the bottom of the formation, as shown on the Baltimore and Ohio Railroad southeast of Cresap between the two small Tuscarora exposures. The other bed, six feet higher, not fully exposed, shows a thickness of eight feet where observed southeast of Cresap, and is ten feet thick at Cumberland, north of the cement mill, where it is cut through by Wills Creek. All of the iron ore beds are fossiliferous, the upper bed of the lower ore being sometimes excessively filled with the various Clinton fossils.

The following partial section was measured on the Baltimore and Ohio Railroad southeast of Cresap:

	Feet.
Red iron ore band. (Not exposed to the top)	8
Calcareous greenish shale	6
Red iron ore band	4½
Fine brownish red and green arenaceous shale with several thin but compact sandstones or quartzites near the bottom,	160
Clinton-Tuscarora contact	
Total amount exposed	178½

Along the south side of Wills Creek, at the east end of the Narrows, the full thickness of the Clinton shows the following section:

	Feet.
Shales and fossiliferous limestone, mostly concealed	33
Reddish shale with a few thin limestone bands (more or less concealed and perhaps containing the upper Clinton iron ore near the top)	29
Fossiliferous gray shale and blue limestone, with five and one-half feet of shaly sandstone near the bottom	28
Concealed	57
Reddish olive fossiliferous shale	24
Concealed	238
Fossiliferous iron ore (Lower Clinton ore)	10
Rusty olive shale	17
Fossiliferous olive-colored shale	85
Rusty shale at top. Uneven bands of gray sandstone at bottom interstratified with olive shales	36
Olive-colored shales with thin beds of brownish gray quartzite,	27
Clinton-Tuscarora contact	
Total thickness of Clinton	584

THE NIAGARA FORMATION.

The Niagara formation, the name of which is derived from Niagara Falls, New York, where excellent exposures of these rocks have given opportunity for their careful study, lies conformably on the Clinton and, surrounding the outcrops of that formation, occupies areas closely related to them in size, in shape, and in geographical distribution.

The westernmost area lies as a narrow belt around the base of Wills Mountain and extends southward to the Potomac river near Potomac Station. The second area lies as a sharp loop around the southern end of Evitts Mountain with a narrow projection southward along its pitching anticline, while the third area is similarly situated about Tussey Mountain.

In Allegany county the Niagara is pretty much concealed, the areas about Evitts and Tussey mountains affording no satisfactory exposures, while the Wills Mountain area shows only one complete section. This is on the Potomac river just west of the cement-mill near Potomac Station. The formation is made up almost wholly of thin limestones with shale partings. The shale partings become of

considerable thickness in the upper portions where they predominate over the limestones. In the lower portions the limestones predominate and the partings are very thin. A few thin sandstones are found near the top interbedded with the shales and limestones.

The thickness of the formation as measured along the south side of Wills Creek in Cumberland is 260 feet. The rocks are, however, mostly concealed and the upper and lower limits of the formation cannot be accurately determined. In the Potomac Station section the formation was found to be 317 feet thick, but owing to the considerable folding here the measurement may not be exact. The true thickness certainly approximates 300 feet, and this may with propriety be considered as the thickness for the county. The section as measured by R. B. Rowe along the Baltimore and Ohio Railroad near Potomac Station is as follows:

	Feet.
Niagara-Salina contact	
Black shales with layers of sandstone and an occasional layer of limestone	22
Mostly dark blue limestone with shale partings. Very fossiliferous at top, less fossiliferous near the bottom. Some folding, but the measurement is believed to be fairly accurate	225
Dark blue limestone with thin shale partings. So much folded that the thickness can be only estimated	70
Niagara-Clinton contact	
Total thickness of formation	317

THE SALINA FORMATION.

The Salina formation receives its name from Salina, New York, where it is typically developed. The rocks of this formation follow those of the Niagara conformity and are distributed about Wills Mountain, Evitts Mountain and Tussey Mountain in much the same manner as the two preceding formations. Along the eastern base of Wills Mountain the Salina has been cut through by the meanderings of the Potomac, thus throwing portions of the outcrop on the West Virginia side.

The formation is composed of sandstones, shales and limestones. The sandstones predominate near the bottom and the limestones in the upper portions, while the shales are rather abundant throughout

FIG. 1.—CHARACTERISTIC EXPOSURE OF CLINTON SANDSTONE.

FIG. 2.—HARD STRATA IN HELDERBERG FORMATION, DEVIL'S BACKBONE.

GEOLOGICAL SECTIONS IN ALLEGANY COUNTY.

the formation. Cement rock of importance is found in the lower part. The location of the four cement beds of commercial value is given in the section below.

The rocks of this formation are not well exposed except along Wills Creek in Cumberland, along the Potomac river near Potomac Station, and along Flintstone Creek at Flintstone. Much of the Wills Creek section can be made out only with difficulty, but the Potomac section is well shown. West of the cement mill in Cumberland the red sandstone beds at the bottom of the formation can be readily seen, as can also considerable portions of the shales and limestones, including the cement series. Immediately north of Flintstone, along Flintstone Creek, various lower beds are fairly well exposed. Around Evitts Mountain the rocks are almost wholly concealed. The Potomac section, the best exposed section of Salina in the county, measures as follows:[1]

	Feet.
Salina-Helderberg contact	
Gray papery shales, dark drab magnesian limestone, dark blue limestone and yellowish and green sandstones in various relations to each other and all thin bedded. Fossils (Ostracods) are present, especially near the bottom	450
"Fourth" cement rock. A twelve-inch band of limestone is found about five feet from the bottom	17
Bluish gray shaly rock with some thin arenaceous and calcareous beds	19½
"Third" cement rock	12½
Light greenish, fossiliferous shales with some calcareous and arenaceous layers	54
"Second" cement rock	15
Massive fossiliferous limestones alternating with thin cement layers	15
"First" cement rock	6
Bluish green shale with three and one-half feet of darker shale at the top. Fossiliferous	15
Greenish gray sandstone	3½
Light brown disintegrated rock, probably limestone originally	8
Greenish gray massive sandstone	7
Bright yellow sandstone	½
Thinly bedded greenish gray sandstone	2½
Dark, fine-grained shale	13½
Salina-Niagara contact	
Total thickness of Salina	639

[1] Section of R. B. Rowe.

The Devonian.

THE HELDERBERG FORMATION.

The Helderberg formation, so called from its typical locality, the Helderberg Mountains of New York, is considered by some geologists as the lowest Devonian formation, while others regard it as the highest Silurian formation. It follows the Salina of the Silurian with perfect conformity and, like all of the preceding formations, is exposed only in the central and west-central portions of the county. The easternmost and largest area, shaped like a much constricted letter W, lies to the east, west and south of Tussey Mountain, and by its prominent double bifurcation makes up a large part of Warrior Mountain and Martin Mountain. On the state line east of Tussey Mountain the Helderberg belt is less than one-half mile wide, while the width of the corresponding outcrop on the western side is considerably greater. Southward, owing to the pitching of the Tussey Mountain anticline, these bands gradually approach each other until, at a point near Rush, the two coalesce. Within less than one mile southward the area again becomes bifurcated, but this time, owing to the synclinal nature of the fold, the projecting parts are separated by the Oriskany formation, which immediately follows the Helderberg. Of the two southern Helderberg projections, the one furthest east is the more extensive, and includes within it Flakes Knob, the highest point in the county east of the Alleghany Front. This part of the area narrows southward, but caps Warrior Mountain to within almost a mile of where the mountain ceases to be a distinct topographic feature. The projection lying further west is much narrower than the one to the east, but continues almost as far south and acts as a capping for Collier Mountain.

The next area of Helderberg lies further west and flanks the outcrop of Salina around Evitts Mountain in much the same way that the first area does the Salina around Tussey Mountain. The bifurcation at the north caused by the Evitts Mountain anticline is quite like that produced by the Tussey Mountain anticline. The formation continues southward in one long, continually narrowing band to within one and one-half miles of the Potomac, where the Helderberg

ending in a sharp point passes beneath the Oriskany to appear again at the roadside by the canal, where the Potomac has cut entirely through the overlying Oriskany and into the Helderberg for a distance of fully a hundred feet. The eastern part of this area forms much of the crest and western slope of Nicholas Mountain, while the contact line along the western side is clearly marked by a row of hills extending from the state line southward. This row of hills reaches almost as far south as does the Helderberg outcrop, but finally coalesces with Nicholas Mountain.

East of Wills Mountain a belt of Helderberg averaging less than one-half mile in width comes into the county from the north, and extending southward along the western slope of Shriver Ridge, passes through the western part of Cumberland and across the Potomac into West Virginia. The Potomac in its very perceptible eastward bend nearly three miles above Cumberland, and again in the more prominent eastward bend about six miles above Cumberland, has carved out two small portions of this belt from the West Virginia area. These patches are mostly concealed, but their contact with the Salina is fairly well shown. Northward the Helderberg-Salina contact is largely concealed, but the limestone quarries which occur in the lower part of the Helderberg along the western base of Shriver Ridge afford a convenient means of judging the approximate western outcrop of the Helderberg. Shriver Ridge marks the eastern limit, as the contact lies on its western slope a short distance below the top.

West of Wills Mountain there is a band of Helderberg corresponding in position to the eastern belt, but by reason of the perpendicular attitude of the strata, this belt is considerably narrower than the one on the eastern side. Following closely the general direction of Wills Mountain, it crosses the Potomac river at Potomac Station. Along the belt north of the National Road the Helderberg-Salina contact is usually not well shown, but the Helderberg-Oriskany contact is prominent, the latter being represented by the steep ridges to the north and south of Corriganville. South of the National Road neither contact is well shown, although slight topographic features usually indicate their positions with reasonable accuracy.

Another Helderberg area of considerable extent is exposed south of Rawlings. This forms the body of the steep isolated ridge known as Fort Hill, which extends southward along the Potomac for a distance of about four miles.

In addition to the above-mentioned areas, two very slight exposures may be seen along the West Virginia Central Railroad on the north and south sides of Monster Rock near Keyser, West Virginia. They are of little importance except in so far as they are of value in helping to work out the structure in that part of the county.

Lithologically, the Helderberg is pre-eminently a limestone formation. Argillaceous materials occur as impurities in some of the beds, but these are not important, and sandstones are almost wholly lacking. Thin bands of chert, which are white or yellowish-white in color, occur sparingly throughout the upper part of the formation. Most of the limestone in the upper part is heavily bedded, and much of it is highly fossiliferous. The lower part of the Helderberg is a dark blue thin-bedded limestone which in breaking gives a decided ring. This corresponds to the Tentaculite limestone of New York, which in Maryland is over 400 feet thick. In the field the contact between the Salina and the Tentaculite limestone is very marked because of the different weathering qualities of the two rocks. The Salina rock weathers into soil very completely, while the Tentaculite limestone leaves innumerable small, thin, dark blue slabs upon the surface.

In Western Maryland the Tentaculite limestone is mapped as a part of the Helderberg formation. This is done because the lithological break between it and the Salina is very marked and can be followed in the field, as shown above, while there is no lithological break between the Tentaculite and Lower Pentamerus subformations, and the division for mapping purposes cannot be made here. Professor James Hall of the New York survey always insisted that the Tentaculite should be considered as a portion of the Helderberg, while Professor James D. Dana considered it as a portion of the Waterlime (Salina) formation. Since Professor Hall's death, even the geologists of the New York survey have been inclined towards Dana's view. The Tentaculite limestone of Western Maryland has

not only a greater thickness but also a more abundant fauna than that of the New York region.

This fauna, as will be shown in the more complete systematic reports, belongs to the Silurian and Devonian. It is too premature, at least, to assign all of the Helderberg of Maryland to either the Devonian or Silurian systems.

The thickness of the formation is nearly eight hundred feet. The two partial sections given below are believed to represent the full thickness as well as a duplication of some of the middle beds as indicated. The Potomac section extends from the bottom of the formation to and includes a few inches of the coralline ledge. The thirty-six foot massive *Stromatopora* bed of the Devil's Backbone section is believed to come in immediately above this, the other beds of the section continuing upward in the order named to the top of the formation.

The Devil's Backbone section, measured along the Huntingdon and Broadtop Railroad east of Wills Creek is as follows:

	Feet.
Helderberg-Oriskany contact	
Concealed	42
Light gray fossiliferous limestone with numerous layers, a very light-colored chert	22
Light gray massive fossiliferous limestone. Breaks into rectangular blocks	16
Shaly limestone	1½
Bluish gray limestone, breaking into shaly fragments. Weathering indicates much argillaceous material	18
Massive *Stromatopora* beds	36
Shaly limestone, somewhat nodular	10
Light gray massive limestone with upper part containing layers of light-colored chert	45
Thinly bedded limestone, the weathered surface covered with small bryozoans	16
Dark blue massive limestone, very hard and difficult to break...Upper part filled with *Pentamerus galeatus*	36
Fine shaly fossiliferous limestone	16
Massive dark blue fossiliferous limestone	40
Slightly argillaceous, thinly bedded, fossiliferous limestone.	14
Gray arenaceous fossiliferous limestone with layers of cherty material	16
Concealed to bottom of formation	
Total thickness of exposure at this place	328½

The measurements made at Potomac Station are as follows:

	Feet.
Upper beds concealed. Very massive light gray limestone with a few feet of nodular limestone near the top. Coralline layer near the top	95
Mostly concealed, but sufficiently exposed to show that the beds are generally made up of thin grayish limestones. Some massive beds are present	240
Generally thin-bedded, dark blue limestone, but with some heavy beds. Fossiliferous	148
Thinly bedded, dark blue fossiliferous limestones with occasional papery shales	92
Helderberg-Salina contact	——
Total thickness of exposed Helderberg	575

THE ORISKANY FORMATION.

The Oriskany formation receives its name from Oriskany Falls, New York, at which place it is well shown. In middle and western Allegany county the Oriskany, although thin compared with most of the other Paleozoic formations, on account of its zigzag course and usually more or less inclined position, covers a not insignificant part of the surface. To speak definitely, the Oriskany-Romney contact is more than one hundred miles in length, being considerably greater than that of any other contact line in the county. Coming in across the Maryland-Pennsylvania state line near Flintstone and going southward, the Oriskany constitutes the eastern slope of Warrior Mountain. Returning northward near Big Spring Run, it forms much of the western slope of Warrior Mountain. It enters quite largely into the structure of Martin Mountain and completely covers the central and southern portions of Collier Mountain, including the two projections near the Potomac. It also constitutes the western slope of the northern part of Martin Mountain continuing beyond the state line. Branching south of the state line, one part returns southward and forms much of the eastern slope of Nicholas Mountain. It continues to the Potomac, but turning northward once more it helps to form the line of hills that flank Nicholas Mountain on the west, then again passes beyond the state line.

A little further to the west a narrow strip along Shriver Ridge cuts across the county in a northeast-southwest direction through

Cumberland. West of Wills Mountain a still narrower strip comes in from the north, runs approximately parallel with considerable portions of Wills Creek and Braddock Run, then bending to the east takes a more nearly north and south direction and passes across the Potomac near Potomac Station. Another area extends from Rawlings, southwestward through Keyser, West Virginia. Geologically, the outcrop is not discontinuous between these points, but a small part of it has been cut off from the county by a bend in the Potomac river north of Monster Rock. A very small area is also found near the bend of the river east of Monster Rock, a short distance from Keyser, West Virginia, but this is greatly obscured by the comparatively recent river deposits.

In addition to the above-mentioned areas, there are two others well shown east and northeast of Oldtown, besides one or more obscure patches in the bed of a ravine west of Corriganville. The smaller of the Oldtown areas covers less than half a square mile and outcrops immediately north of the Potomac and just west of the mouth of the South Branch. The other area forms Stratford Ridge, lying just west of the lower course of Town Creek. These last two areas are minor extensions or spurs of the much higher ridge south of the Potomac in West Virginia.

The Oriskany formation in Allegany county consists of two well-marked lithological divisions which grade into each other. The lower part, resting conformably upon the Helderberg, is a blue-black chert in nodules and layers, separated by thin beds of dark gray arenaceous shale. This is the "chert lintel" of the Piedmont folio.[1] The upper part of the formation is a greenish gray, bluish gray, brownish gray or white sandstone, which is often calcareous.

The chert in an unweathered condition is in hard, deep blue-black masses and shows a great tendency to break into small-sized nodular or angular blocks with smooth conchoidal fractures. The unweathered surfaces have at times a pearly white appearance and the weathered specimens are almost invariably light colored. Specimens in which weathering has been carried on to an extreme degree usually

[1] Geologic Atlas of U. S. Piedmont Folio, No. 28.

show a yellowish brown color and are more or less arenaceous and spongy. The Helderberg-Oriskany contact line can often be easily followed by these chert fragments even if all other traces of the contact are gone. So numerous are the fragments in many places that in some well-cultivated fields they lie sufficiently close together to almost completely hide the surface of the ground. This is particularly noticeable in some of the fields near the tops of Warrior Mountain, Martin Mountain and Nicholas Mountain. In the vicinity of Flakes Knob on Warrior Mountain the chert beds have been worn entirely through, and on the top of this highest point the underlying limestone is exposed. Surrounding this high knoll is a heavy talus of the chert blocks. Near the top of Martin Mountain on the National Road a good exposure shows the chert weathered to spongy blocks sufficiently soft to be easily cut with a knife. The same thing may be observed in other places, although usually it is not so well shown. West of Wills Mountain on the Georges Creek and Cumberland Railroad and on the Eckhart branch of the Cumberland and Pennsylvania Railroad the same alteration has taken place, but some of the beds here show a more or less bright-colored banded structure. This is apparently due to a rearrangement of the ferruginous contents, thus leaving some portions with a peculiar bluish gray color, while other portions show yellowish, brownish or reddish parallel bands. No outcrop in the northern part of the county shows the full thickness of the chert, but the outcrop at the Devil's Backbone compared with outcrops near Keyser, West Virginia, and near North Branch seems to indicate pretty conclusively that these beds thicken rapidly southward.

The upper portion, or sandstone member, of the Oriskany when wholly unweathered is usually hard and compact, and is at times rather inclined to resemble a very arenaceous limestone. The texture is sometimes fine, but the rock is more often coarse-grained, and in the upper part of the formation one or more bands of conglomerate are always present. In the exposures near Keyser, West Virginia, the lower part of the formation is shaly, while the middle and upper portions apparently contain a greater percentage of coarse material

FIG. 1.—FOLD IN ORISKANY SANDSTONE, NEAR MOUTH OF SOUTH BRANCH OF THE POTOMAC.

FIG. 2.—ORISKANY EXPOSURE, MONSTER ROCK, NEAR KEYSER, W. VA.

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than elsewhere. Generally fossils are extremely abundant, occurring in irregular bands varying in thickness from one or two inches to several feet. The sandstone easily losing its calcareous cement, weathers readily to a very friable, dirty-buff, porous rock, in which condition large blocks can be easily shattered by a single blow of the hammer. In many places protected from denudation, the rock has completely disintegrated, leaving beds of dirty brownish-yellow sand. In this loose sand, under favorable conditions, well-preserved fossils may be procured. Pockets are frequently found in the less weathered rocks in which fossils free from the matrix are also beautifully preserved. It is to these pockets that many collectors owe their finest cabinet specimens.

Excellent exposures of the Oriskany are frequent, but the full thickness is not often shown. The thickness as measured on the south side of Monster Rock near Keyser, West Virginia, is three hundred feet, and at 21st Bridge, three hundred and forty feet; on the Williams Road, two and one-half miles east of Cumberland, only one hundred and fifty-five feet are exposed. On the eastern slope of Warrior Mountain no good measurement could be obtained, but apparently the thickness there where best shown is less than at Cumberland. The following section was obtained along the West Virginia Central Railroad at the base of Monster Rock, opposite Keyser, West Virginia:

	Feet.
Oriskany-Romney contact	
Fine-grained fossiliferous conglomerate	12
Coarse sandstone with few fossils	6
Fine-grained fossiliferous conglomerate	4
Coarse but slightly shaly sandstone	4½
Coarse-grained fossiliferous sandstone	8
Fossiliferous conglomerate	1
Coarse fossiliferous sandstone	3½
Very fossiliferous coarse conglomerate	½
Coarse-grained fossiliferous sandstone	12
Fossiliferous sandstone, mostly coarse-grained	156
Coarse shaly, almost non-fossiliferous, sandstone	25½
Black nodular chert	67
Concealed	
Total thickness measured	300

On the Williams Road, two and one-half miles east of Cumberland, the Oriskany section is as follows:

	Feet.
Oriskany-Romney contact	
Coarse sandstone, almost black and non-fossiliferous	2
Much-decomposed yellowish sandstone with many fossils	16
Concealed	6
Slightly fossiliferous conglomerate, the individual particles being of characteristic wheat-grain size	4
Concealed	7½
Very fossiliferous conglomerate	⅔
Concealed	2
Blue calcareous fossiliferous sandstone	1⅓
Coarse, much-weathered, fossiliferous sandstone	2½
Concealed	14½
Very coarse fossiliferous brown sandstone	3
Fossiliferous conglomerate much like the wheat-grain conglomerate above	1
Brown fossiliferous sandstone	29
Concealed	42
Sandstone and concealed, mostly concealed	30
Concealed	
Total thickness measured	156

The Oriskany-Helderberg contact is not shown here, and there is at least 90 feet of chert still to add to the thickness.

In the well-weathered Williams Road exposure the conglomerate bands are easily distinguished from the intervening finer material, but in the Monster Rock section, where the present face of the rock has been exposed only a few years, the lines of separation are much less clearly marked. This indistinctness, which is one of appearance rather than reality, is largely due to the bluish-gray color of many of the pebbles, as well as to the calcareous cement which is present in the conglomerate bands and in the finer sandy portions.

In general, the individual pebbles of the conglomerate are fairly well rounded, usually of approximate wheat-grain size, and seldom larger than peas. In many places the rocks are densely crowded with fossils. This is particularly true of the formation in the vicinity of Cumberland, the locality from which Professor Hall has described so many forms. Frequently the conglomerate bands partake of this fossiliferous nature, but the fossils are usually more abundant in the

finer portions. In Warrior Mountain the exposures are usually not good, and where exposed the fossils are less abundant, the sandstone there being less calcareous and highly compact.

The Oriskany sandstone, although playing an important part in the composition of the mountains of Allegany county, owes much of its prestige, especially in the more calcareous areas, to the protection of the less easily disintegrating Oriskany chert beds.

THE ROMNEY FORMATION.

The Romney formation, corresponding in the main with the Marcellus and Hamilton formations further north, takes its name from Romney, West Virginia, where it is extensively developed. The passage from the Oriskany to the Romney is particularly abrupt, a distinct lithologic difference existing within a space of two inches. This contact is admirably shown on the Williams Road near the church two and one-half miles east of Cumberland, as well as on the north and south sides of Monster Rock along the West Virginia Central Railroad. It is also seen to good advantage on the Baltimore and Ohio Railroad one-fourth of a mile south of Rawlings, and on the same railroad about two miles northeast of Keyser, West Virginia. In various places along the east side of Warrior Mountain the contact is disclosed, but the opportunities for studying it are not so good here as elsewhere.

Next to the Jennings the Romney is the most widely distributed formation in the county. The largest area lies along the Potomac river in the vicinity of Oldtown. It includes the valleys of Big Spring Run and Saw Mill Run and much of the lower course of Town Creek and sends a narrow belt northward along the eastern side of Warrior Mountain beyond the state line into Pennsylvania. Further west along either side of the southern end of Martin Mountain there are small, elongated Romney areas which coincide approximately with the narrow valleys of Collier Run and Martin Spring Run. In the Evitts Creek valley a belt of considerable width comes into the county from Pennsylvania and passing southward is divided by a large Jennings area, the two Romney bands thus formed passing along

down on the higher slopes of the valley and continuing southward help to cover the Maryland projection west of the southern end of Nicholas Mountain. At the foot of Alleghany Front another area is shown which, like several of the succeeding formations, stretches as a somewhat narrow belt entirely across the county. Near Rawlings a prominent offshoot projects from this belt across the Potomac into West Virginia. On the eastern side of Monster Rock a slight, synclinal fold has preserved a very small area, but this is almost wholly concealed.

In general the formation is an argillaceous fissile shale, intensely black and papery near the base, but more often of a drab color above, the upper part weathering into fine angular fragments. Owing to a lack of hard material, the formation is prominent in the valleys, where it forms low ridges or rounded hills.

The sandstones and sandy shales of the formation are comparatively unimportant. However, on the Williams Road two and one-half miles east of Cumberland near the middle of the formation, there is a bed of brownish-gray sandstone weathering readily into irregular rhombs or lozenges, the whole being fifty feet thick. Thin irregular streaks of sandy shale are shown at various horizons below the middle of the formation on the Baltimore and Ohio Railroad in the cut immediately north of 21st Bridge on the West Virginia Central Railroad. Northeast of Cumberland, between Shriver Ridge and Evitts Creek, there is a series of well-defined parallel ridges which apparently owe their preservation largely to shaly sandstone. In the Town Creek valley east and west of Saw Mill Run the various Romney ridges there appear to be quite free from sandstone. Most of these ridges show to good advantage the characteristic weathering of the upper shales. On the ridge west of Saw Mill Run two miles northwest of Oldtown, the exposed shales have completely broken up into fine irregularly angular, almost cubical blocks of various sizes usually considerably smaller than walnuts. These small fragments at this place are in such extreme abundance that they lie upon the surface of the ridge just within the angle of rest and in beds so deep and so frequently subject to gravitational movement that vegetation is limited almost wholly to stunted pines.

The intensely black shales at the bottom are very carbonaceous but do not contain coal seams. However, along Collier Run, where the lower beds can be easily reached, as well as along the road near the Warm Spring iron bridge one mile south of Flintstone, the shales have been fruitlessly worked with the idea that they might prove to be coal-bearing.

About one hundred and fifty feet from the bottom of the formation there are several bluish-gray fossiliferous limestone bands. These are apparently never absent, although in the well-exposed Williams Road section none of them can be seen. This is perhaps due to the effect of weathering, as certain evidences indicate their probable presence. These bands are individually rarely three feet, usually less than one foot thick, but the total thickness in the best exposed sections is more than twenty feet. They are shown to good advantage in the West Virginia Central Railroad cut at 21st Bridge, one mile northeast of Keyser, West Virginia. They are found less clearly shown on the county road along the lower course of Martin Spring Branch east of the Oriskany fork at the south end of Martin Mountain, where a little of the limestone has been burned for fertilizing purposes. In various other places more or less limestone is shown but the exposures are not of sufficient importance to demand special mention.

One of the upper beds, about six inches thick, known as the Nautilus Ledge, shows great persistence, having been found at several widely separated localities. Another bed, usually from two to two and one-half feet thick, is honeycombed with concretionary nodules. These nodules, which are from one-half inch to four inches in diameter and generally more or less ferruginous, gradually weather free from their matrix and may be found in many localities scattered about in considerable numbers over the ground.

Iron-ore pockets have been found in various localities along the eastern base of Warrior Mountain near the bottom of the Romney formation. Iron ore may also be seen between and slightly to the west of the two Oriskany outcrops northeast of Oldtown. There are indications of the ore elsewhere, but in no case can the exact horizon

be definitely located, nor can the full thickness at any place be learned. It is evidently very near or at the bottom of the Romney, and the theory has been advanced [1] that its presence indicated a possible local unconformity between the Oriskany and the Romney formations.

THE JENNINGS FORMATION.

The Jennings formation, closely related to the Chemung and Portage of the Pennsylvania and the New York Geological Surveys, is so called from its typical development in Jennings Gap and along Jennings Branch, Virginia. It follows the Romney with perfect conformity and has a considerably greater areal distribution than any other formation in the county. It occurs in four large areas. Farthest east is the much dissected strip east of Town Hill running from the state line southward beyond the Potomac river. A long irregularly shaped area west of Green Ridge extends entirely across the county; it is scarcely more than a mile in width in the southern part, but in the northern part, on the state line, it is about seven miles wide. Polish Mountain lies in the northwestern part of this area. In the lower part of the Evitts Creek valley and in the big bend of the Potomac immediately south, there are two good-sized areas which for our purpose here may be considered as one. There is also a strip nearly a mile wide and about twenty-five miles long stretching northeast-southwest across the widest part of the county on the eastern slope of Alleghany Front.

The deposits of this formation are almost wholly arenaceous. In the lower and middle parts the thin layers of sandy shales and quartzose sandstones are interbedded with no regularity of sequence or of thickness. In the upper part heavy quartzitic sandstones predominate, but even here the sandy shales are in considerable abundance. In connection with the heavy quartzitic beds there are several more or less important beds of conglomerate, some of which are fossiliferous. Fossils also occur in the sandstones at various horizons, the fossiliferous beds being densely crowded, usually sharply defined

[1] Darton, N. H. Notes on the Stratigraphy of a portion of Central Appalachian Virginia, Amer. Geol., vol. x, July, 1892, p. 16.

and seldom more than a few inches in thickness. The lower shales of the Jennings are thin and black, somewhat resembling those at the base of the Romney formation. The upper part of the Jennings is lithologically indefinite. The paleontological evidence indicates that the formation extends about six hundred and fifty feet above the heaviest conglomerate. This conglomerate is prominent in many parts of the county and from its situation so near the top of the formation can be used advantageously as a guide in tracing the upper contact. This conglomerate in Jennings Run is thirty-five feet thick, the lower six feet of which is flaggy and contains only scattered pebbles. The remainder is massive and is highly charged with flattened or rounded white quartz pebbles of various sizes up to one inch or more in diameter. This conglomerate is apparently continuous over the county. It is well marked by a line of hills along the eastern slope of Alleghany Front and near the southern end of this line of hills four and one-half feet of the bed is shown. Whether or not this represents the entire thickness at this point could not be learned. At various intermediate points the conglomerate does not show, but this is thought to be due not so much to its thinness as to more complete concealment. Remnants of the same conglomerate are seen along the top of Polish Mountain. It is not well shown on Green Ridge, although there is abundant evidence of its presence, but along the eastern flank of Town Hill it appears to be of considerable thickness. Along the Little Orleans-Oronoko Road near the western end of the big bend of the Potomac about three miles west of Little Orleans the abundance of loose conglomerate boulders indicates a considerable thickness there. The individual pebbles are quite large, equaling the largest found in Jennings Run. Above this big conglomerate, as well as below it, there are thinner conglomerates which, although they may be of very varying thickness, are nevertheless generally present. They are usually greatly iron-stained, but when not so they much resemble some of the Carboniferous conglomerates. However, to one accustomed to observing them, the more flattened nature of the pebbles and the very characteristically smooth fracture across both matrix and pebbles at once distinguish the Jennings from the Carboniferous conglomerates.

The thickness of the formation appears to vary within rather wide limits. Along Jennings Run it is thought to be between thirty-five hundred and four thousand feet, although no good measurement could be made. Along the Potomac near the mouth of Town Creek it is approximately five thousand feet.

THE HAMPSHIRE FORMATION.

The Hampshire formation, approximately equivalent to the Catskill of the North, receives its name from Hampshire county, West Virginia, where it is extensively developed. In Allegany county these rocks are exposed in three areas as follows: First, in the eastern part where Sideling Hill Creek and the Potomac river have carved out small portions of the wide belt which underlies Sideling Hill further east. Since these several small patches are closely related structurally, they may here be considered together as one area. Second, a belt nearly three miles wide which runs northeast-southwest across the county forming the base of Town Hill. Third, a strip averaging perhaps one-half a mile in width which lies along the eastern face of Alleghany Front and stretches entirely across the county. The patches included under the first area are largely concealed by their own detritus. The rocks in the second area are well exposed only along the Potomac river and in the gap of Fifteenmile Creek. In the western area the rocks are shown to good advantage along Jennings Run. They are shown to less advantage along Braddock Run, and in the Potomac gorge they are largely concealed.

In composition the Hampshire is an extensive monotonous series of cross-bedded, flaggy and massive sandstones and fine-grained very fissile sandy and argillaceous shales. The shales are usually bright red or brownish red, although some gray and green or even yellowish shales are seen. These latter colors occur more frequently near the top of the formation, and this is particularly noticeable just outside of the county immediately east of the mouth of Sideling Hill Creek. The sandstone beds near the bottom are heavy, being in several instances more than twenty feet in thickness. The shales and sandstones frequently merge gradually into each other, both laterally and

vertically, and are interbedded without any constant order of succession.

The thickness of the Hampshire along Jennings Run is nineteen hundred feet. Along the Potomac river in the Town Hill syncline a measurement of nineteen hundred twenty-five feet was obtained. The Jennings Run measurement is believed to be quite accurate and the measurement in the Town Hill syncline approximately so.

The Carboniferous.

THE POCONO FORMATION.

The Pocono formation, named from Pocono Plateau, Pennsylvania, where it is well developed, is the basal member of the Carboniferous and lies conformably upon the Hampshire formation of the Devonian. Of these rocks there are only three narrow areas shown in the county. One occupies a position along the eastern slope of Alleghany Front, capping a line of knobs which extend across the county. The other two, separated by the Fifteenmile Creek gorge, form the crest of Town Hill.

Little study of the formation could be made on Town Hill, but it is known to consist largely of a very massive conglomerate in which the milky quartz pebbles are pretty well rounded. The size of the pebbles varies much, ranging up to three-fourths of an inch in diameter or even larger. In the western part of the county the lithological character of the formation is very different. The entire thickness is shown, although to poor advantage, on the Cumberland and Pennsylvania Railroad in the first tunnel east of Eckhart, where the thickness is two hundred and fifty-eight feet. In the Potomac gorge between Westernport and Keyser, West Virginia, there is an exposure of only thirty feet, but this may represent the entire thickness of the formation at that point. It has been so considered in the Piedmont folio.[1]

In the Cumberland and Pennsylvania Railroad section the bottom of the formation extends sixty feet east of the east end of the tunnel,

[1] Geologic Atlas of the United States, Piedmont Folio, Washington, 1896.

while the top extends ninety feet west of the west end. The lower part of the formation here is a coarse, cross-bedded, grayish-green, micaceous sandstone. About one hundred feet above the bottom there is a four- or five-foot band of grayish, impure, friable sandstone frequently showing a prominent bluish coating. Scattering pebbles of various sizes up to two inches in longest direction are present. These are angular, subangular or well-rounded and of clear or smoky quartz, but seldom milky as in the conglomerate of the same formation on Town Hill. At various horizons above this there are thin bands of fine conglomerate, the pebbles of which are inclined to be of the nature of milky quartz. Near the middle of the section there is a space of nearly thirty feet which is largely taken up with shales, some of which bear slight traces of plant remains. The upper part of the section shows mostly grayish-green or reddish-green micaceous, flaggy sandstones with some interbedded grayish, greenish, yellowish or reddish shales.

In the Potomac gorge section the formation is made up of gray, cross-bedded sandstone with only a few widely scattered pebbles.

THE GREENBRIER FORMATION.

The Greenbrier formation, so-called from Greenbrier county, West Virginia, lies conformably upon the Pocono and outcrops in Allegany county only in a single narrow band extending high up along the eastern face of the Alleghany Front from the Maryland-Pennsylvania state line southward through the county, cutting across the Potomac river almost midway between Westernport, Maryland, and Keyser, West Virginia.

The formation consists mainly of limestone strata. Sandstones and arenaceous limestones are most prominently developed in the lower part. Shales preponderate near the middle while the upper part is mostly composed of highly fossiliferous and more nearly pure limestones. Many of the lower arenaceous beds show a peculiar banding on the weathered surfaces apparently as if they were highly cross-bedded.

The formation is well shown in only one place in the county, viz.,

at the mouth of Stony Run below the water-tank on the West Virginia Central Railroad, two miles southeast of Westernport. Even here some of the beds are hidden. In the only other places in the county where one might hope to get good sections, viz., along Braddock Run and along Jennings Run, the formation is largely concealed by soil and by talus from the heavy Pottsville sandstones and conglomerates above. As a result no measurements can be made in the northern part of the county, but judging from measurements in various places outside of the state, it seems quite certain that the formation grows continually thinner northward from Stony Run.[1] Much interest is attached to this formation because it is in great measure the Appalachian representative of the great Carboniferous limestones of the Central Mississippi states.

At the mouth of Stony Run the following section was made:

	Feet.	Inches.
Greenbrier-Mauch Chunk contact		
Heavy dark bluish gray fossiliferous limestone.....	4	6
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
Massive bluish fossiliferous limestone	7	
Concealed 10		
Massive bluish fossiliferous limestone	1	6
Massive bluish, highly fossiliferous limestone, weathers very irregularly	3	6
Thinly bedded fossiliferous limestone with thin bands of olive-green fossiliferous shale 10		10
Concealed	9	
Reddish brown, much disintegrated sandstone		9
Concealed 20		
Heavy, pinkish green, mottled, slightly fossiliferous limestone	2	6
Concealed 11		
Red sandy shale with thin green layers near top and bottom	3	
Greenish red shaly arenaceous limestone	1	
Concealed	3	
Red sandy shale with a few thin shaly defined green argillaceous bands 32		

[1] Lesley, J. P. A Summary Description of the Geology of Pennsylvania in Three Volumes, vol. iii, part i, page 1791, Harrisburg, 1895. See also the Geologic Atlas of the United States, Piedmont and Franklin Folios.

	Feet.	Inches.
Concealed	6	
Red shaly sandstone	1	6
Massive sandstone in streaks or layers of pink, green and white	6	
Red arenaceous shale	10	
Red shaly sandstone	9	
Calcareous, pinkish gray sandstone	2	6
Concealed	7	
Shaly sandstone	1	6
Mostly concealed, some shaly sandstone showing	20	
Very arenaceous pinkish green limestone	26	
Concealed	5	
Bluish arenaceous limestone	7	
Concealed	8	

Below this comes a coarse grayish sandstone which is considered as marking the top of the Pocono, thus giving for the total thickness of the Greenbrier at this place two hundred and twenty-seven feet.

THE MAUCH CHUNK FORMATION.

The Mauch Chunk formation, which is very similar to the Canaan formation of the Piedmont quadrangle, receives its name from Mauch Chunk, Pennsylvania, where the formation is well shown. Like the preceding formation, it is exposed in Allegany county only along the eastern face of the Alleghany Front. This formation, together with the underlying Greenbrier, lies obscurely in the depressions extending in a line across the county between the heavy crest of Alleghany Front and the Pocono knobs a little lower down on the eastern face.

The Mauch Chunk is composed chiefly of red arenaceous and argillaceous shales, the argillaceous shales being a bright red and particularly prominent in the lower part. A little above the middle of the formation there lies in one almost continuous body about one hundred feet of soft, flaggy, fine-grained, reddish-green to brownish-red sandstone. The sandstones are very generally micaceous, as are also many of the middle and upper shales.

Between the Mauch Chunk and the Greenbrier there is a greenish brecciated sandstone which near the mouth of Stony Run is four feet thick. At the top of the Mauch Chunk there is also a four-foot transition band of highly brecciated reddish arenaceous limestones above

FIG. 1.—EXPOSURE OF JENNINGS SANDSTONE, CORRIGANVILLE.

FIG. 2.—EXPOSURE OF POTTSVILLE SANDSTONE, WESTERNPORT.

GEOLOGICAL SECTIONS IN ALLEGANY COUNTY.

which lie the lower flags of the succeeding Pottsville formation. This brecciated limestone can be seen to best advantage on the Cumberland and Pennsylvania Railroad one hundred twenty rods east of Barrelville. It is apparently continuous southward, since a similar brecciated limestone at the same horizon may be seen outcropping on the Keyser-Piedmont wagon road on the West Virginia side of the Potomac about one and one-half miles below Piedmont.

The total thickness of the formation in the Potomac gorge east of Westernport is about eight hundred feet. Along Jennings Run, twenty-five miles to the northeast, the space occupied by the Mauch Chunk and Greenbrier combined is approximately nine hundred and thirty feet or about one hundred feet less than the combined thickness of the two formations in the Potomac gorge.

THE POTTSVILLE FORMATION.

The Pottsville formation, which is approximately equivalent to the Blackwater formation of the Piedmont quadrangle, receives its name from Pottsville, Pennsylvania, near which place it is extensively developed. It is this formation which, at its easternmost outcrop in the county, makes the bold crest of Alleghany Front, and dipping westward passes beneath the surface and forms the massive floor of the Cumberland-Georges Creek coal district. It is to this formation more than to any other that is due the preservation of the present area of the coal-field. By its resistance to erosion it has governed the position of Alleghany Front, and although its eastern edge is greatly notched by Jennings Run, by Braddock Run and by the Potomac river, the latter having, indeed, cut into the formation westward across the synclinal axis, the formation nevertheless retains its full thickness throughout almost all of the area in Allegany county west of the easternmost Pottsville outcrop. The formation is slightly cut into by Georges Creek near the southern end of the coal basin, but passes beneath the creek bed a few yards north of the Cumberland and Pennsylvania car-shops in the northern suburbs of Westernport.

Messrs. N. H. Darton and Joseph A. Taff, in their general de-

scription of the Blackwater formation with which the Pottsville so closely agrees, mention the following important characteristics of the area in the northeastern part of the Piedmont quadrangle: "In the vicinity of Piedmont the uppermost and lowest sandstone beds are conglomeritic and are one hundred and ten and thirty feet thick respectively, while the medial sandstone is fine-grained and only fourteen feet thick."[1] The triple character of the formation can be readily made out by means of the many extensive outcrops of sandstone and conglomerate ledges; nevertheless there is no really good exposure of the whole formation found in the county, the softer strata being very largely concealed. Furthermore this, like most of the other Carboniferous formations, shows exceedingly rapid changes within short distances, so that a measurement in one locality, even if favorable conditions prevail, will but poorly suffice, so far as details are concerned, for an area only a short distance away.

It is perhaps for this reason alone that such wide discrepancy is observed in the details of all published sections made near the Potomac in the southern part of the Georges Creek basin. The following section, constructed from measurements made at various places, is believed to represent with reasonable accuracy the general character of the Pottsville formation in that vicinity:

	Feet.	Inches.
Pottsville-Allegheny contact		
Massive sandstone	20	
Coal, frequently impure or accompanied by black or gray shales [Westernport or "Two-foot" coal]	2	
Shale and heavy sandstone	85	
Shale with coal streaks	30	
Flaggy sandstone and shale	12	
Coal	1	6
Impure fire-clay	8	
Flaggy sandstone	14	
Coal [Bloomington or "Railroad" coal]	1	6
Shale	2	
Shale, flaggy sandstone and concealed	80	
Coal and coaly shale	3	
Black, yellow and gray arenaceous shales	7	
Greenish flaggy sandstone	30	
Pottsville-Mauch Chunk contact		
Total thickness of Pottsville	296	

[1] Geologic Atlas of the United States, Piedmont Folio, Washington, 1896.

No good measurement of the Pottsville can be obtained in the northern part of Allegany county, but the following section has been measured a little north of the state line near Wellersburg, Somerset county, Pennsylvania, in the gap of Gladdens Run through Little Allegheny Mountain:[1]

	Feet.	Inches.
Massive sandstone	75	
Mount Savage coal	4	
Mount Savage fire-clay	7	6
Conglomerate sandstone	125	
Dark, shaly sandstone	10	
Shale	1	
Coal and shale		8
Impure fire-clay	10	
Dark shales with iron ore	20	
Massive sandstone	35	
Total thickness	288	2

Along the Baltimore and Ohio Railroad west of Piedmont, West Virginia, is a coal seam popularly known as the Railroad Seam, which has been named the Bloomington coal, and near the top of the formation is a two-foot seam named the Westernport coal.

THE ALLEGHENY FORMATION.

The Allegheny formation, identical with the Allegheny river series of Pennsylvania, immediately follows the Pottsville, and like it, underlies most of the Georges Creek basin. It outcrops on the eastern side of the basin high up on the western slope of Dans and Little Allegheny mountains. In a similar manner its western edge shows along the eastern slope of Savage Mountain, but of this last outcrop Allegany county includes only a small portion near the Maryland-Pennsylvania line. The entire thickness of the formation is shown in the southern part of the basin on the hillsides along the Potomac but northward the formation disappears beneath the bed of Georges Creek one mile below Barton.

The formation consists mainly of irregularly interbedded shales and sandstones with several coal seams of greater or less importance.

[1] White, I. C. Stratigraphy of the Bituminous Coal Fields of Pennsylvania, Ohio and West Virginia, U. S. G. S. Bull. No. 65, p. 186, Washington, 1891.

At the base is the poorly exposed Bluebaugh seam which has been opened at Warrior Run. About 35 feet above this is the Parker seam shown in various parts of the coal basin and supposed to be the equivalent of the Clarion coal of Pennsylvania. About the center of the formation is the Davis or Six-foot coal, the most important of all the coals in this formation. It is supposed to be the equivalent of the Lower Kittanning of Pennsylvania. About 30 feet beneath it streaks of coal may usually be found which together compose the unworked Split-six. At the top of the formation is the Thomas or Three-foot seam.

Most of the sandstones are thinly bedded and disintegrate easily, so that the face of the outcrop is generally hidden by a gently sloping cover of loose shale and soil delimited by the more massive Pottsville sandstone below and the heavy Mahoning sandstone above.

The following section was measured near the Franklin gravity plane a short distance from the mouth of Savage river:

	Feet.
Sandstone, apparently the Mahoning	
Concealed	25
Sandy ferruginous shale	60
Sandstones and concealed	50
Sandstone, flaggy near top	60
Shale	6
Coal [Davis or "Six-foot"]	6
Concealed	30
Flaggy and shaly sandstone	61
Coal [Parker]	1
Shale	19
Conglomeritic sandstone of Pottsville	—
Total thickness of Allegheny formation	318

A more detailed section was obtained as follows near Franklin village on Georges Creek.

	Feet.
Massive sandstone, apparently the Mahoning	
Greenish shaly sandstone. A coal vein near the top [Thomas]	55
Massive sandstone	24
Ferruginous shale, showing spheroidal weathering	3
Fine black and brown shales	8
Grayish green, slightly nodular shale	10
Fine grayish green shale	4
Arenaceous shale	9
Greenish sandstone and shale	26

	Feet.
Shaly sandstone	6
Fine shale and concealed	9
Shaly sandstone	13½
Concealed	30
Coal [Davis]	6
Sandstone, shale and concealed	7
Flaggy sandstone	16
Massive sandstone	4
Shale	2
Coal ["Split-six"]	3
Concealed	90
Total thickness of Allegheny formation	325½

Professor I. C. White, in Bulletin 65 of the United States Geological Survey, gives the following measurements for the vicinity of Westernport:

		Feet.	Inches.
Coal, Upper Freeport [Thomas]	Coal	2	
	Shale and bone	1	
	Coal	2	5
Concealed		10	
Shale, bluish		10	
Coal, Lower Freeport		2	
Fire-clay		2	
Concealed		10	
Sandstone, hard		2	
Sandstone, shaly		5	
Shales, sandstones and concealed		55	
Coal, Upper Kittanning	Bituminous slate	5	
	Coal	2	7
Dark shales and concealed		10	
Massive sandstone, gray		50	
Shales, drab		5	
Coal, Upper Kittanning [Davis]	Coal, slaty	1	
	Coal, bony	8	
	Coal, good	1	4
	Slate, hard		½
	Coal, good	2	6 5 6½
Fire-clay, sandy		3	
Shales, with nodular iron ore		2	
Fire-clay, impure		4	
Flaggy sandstone		20	
Concealed		25	
Fire-clay, sandy		10	
Flaggy sandstone and sandy shales		25	
Concealed and sandy shales		40	
Total		307	6½

In the northern part of the coal basin the thickness cannot be learned, nor is there a good exposure anywhere along the lines of outcrop on the eastern and western borders of the basin.

Near the mouth of Georges Creek, as seen beneath Mr. Merrill's mine, there is a coal seam almost thirty feet below the "six-foot." The section obtained at Mr. Merrill's mine for this part of the formation is as follows:

	Feet.
Coal [Davis]	
Shale	9
Sandstone and shale	11
Shale	4
Shaly sandstone	1
Shale	4
Coal ["Split-six"]	3

THE CONEMAUGH FORMATION.

The Conemaugh formation, so-called from Conemaugh river, Pa., follows the Allegheny in regular order and lies within the area outlined by that formation. In the northern part of the basin the Allegheny has been cut deeply by Jennings Run and its tributaries, while at the southern end Georges Creek has made a long incision into it, the bifurcation extending northward to within one mile of Barton.

The Conemaugh, formerly called the "Barren Measures," is largely a shale formation. A sandstone, sometimes rather massive, is generally found near the bottom. This is apparently equivalent to the Mahoning sandstone of Pennsylvania. A second sandstone occasionally quite massive, is found twenty or thirty feet below the top. The latter sandstone is generally not less than twenty feet thick and is sometimes conglomeritic, especially in the lower parts. Two hundred yards east of the Hofman mine opening an exposure above and below the railroad switch gives a thickness of thirty-eight feet with neither the top nor bottom shown. A few rods east of Eckhart on the National Road near the Cumberland and Pennsylvania Railroad, thirty feet of the sandstone is exposed, but here also the top and bottom are concealed. Likewise, immediately east of the long railroad bridge near Detmold Run, fourteen feet is exposed, and in

the village of Miller, east of Lonaconing, twenty-five feet is shown, but in each case the top and bottom are hidden. This sandstone is flaggy near the top and, like most of the other Coal Measures sandstones, is highly charged with iron, contains much mica and is highly cross-bedded.

A sandstone which is frequently conglomeritic is found a little below the middle of the formation. Thirty-six feet of this conglomeritic sandstone is shown to good advantage at Barton on the hillside south of the Potomac tramway.

The shales are chiefly argillaceous, and the coals, of which there are several, are usually impure; one coal seam of some importance known as the "Four-foot" or Barton coal is approximately 250 feet above the bottom of the formation. Irregular beds of iron ore are frequent and two or three limestones are present. A limestone bed, perhaps the thickest limestone of the formation, is poorly exposed on the Potomac gravity plane about 235 feet below the top of the formation. It is bluish-black in color, slightly fossiliferous and six feet thick. It measures as follows:

	Feet.	Inches.
Massive limestone	1	6
Shaly limestone		6
Massive limestone		8
Shaly limestone		4
Massive limestone	3	

Another limestone was found in a ravine at the roadside one mile west of Mount Savage. This is apparently about one hundred feet higher than the limestone at the Potomac Plane. The measurement of the entire exposure here is as follows:

	Feet.	Inches.
Concealed		
Black shale		10
Very coaly shale		3
Black, somewhat coaly shale	1	8
Impure coal	2	8
Black shale with very thin coal streaks		4
Coaly shale	1	1
Coal, apparently all good	2	4
Shale, dark above, gray in lower part	1	5
Clay		7
Massive, bluish gray, argillaceous limestone	2	1

	Feet.	Inches.
Massive light gray argillaceous brecciated limestone.....	1	9
Very argillaceous limestone	4	6
Soft weathered shale		4
Iron-ore band		4
Black coaly shale	2	
Concealed		

Thirty feet below this section there is a thin highly ripple-marked sandstone exposed in the road-bed two hundred yards west of the coal outcrop.

For a complete section of the entire formation no more detailed section can be given than that published by Professor P. T. Tyson[1] many years ago, as obtained from measurements made on the eastern side of Dug Hill near Lonaconing, the hill having received this name on account of the excavations made especially for these measurements on Laurel Run and on Mill Run. It is not easy to decide just which stratum of Professor Tyson's section coincides with the lower limit of the Conemaugh, but the section as given below is believed to have its lowest measurement within a few feet of the contact. Although on account of the variability of the strata the measurements may seem to have been taken more in detail than necessary and less attention given to recording the degree of purity of the various coal seams and iron-ore bands than may be desirable for economic purposes, nevertheless the section will perhaps always remain an important one for this division of the Coal Measures at Lonaconing. In the absence of good exposures elsewhere it has in the past been largely depended upon as a guide for other parts of the coal basin.

The section is as follows:

	Feet.	Inches.
"Big Vein" coal [from Dug Hill measurements].....		
Shale with iron ore at the top.....	12	
Fire-clay	3	
Limestone	1	6
Shale	15	6
Sandstone, fine-grained	29	
Shale	27	6

[1] Proc. Amer. Philos. Soc. xi, 1871, pp. 9-13.

FIG. 1.—THE "RAILROAD SEAM" NEAR PIEDMONT, W. VA.

FIG. 2.—VIEW OF "BIG VEIN" COAL, IN OCEAN MINE, NO. 3.

GEOLOGICAL SECTIONS IN ALLEGANY COUNTY.

	Feet.	Inches.
Coal	2	6
Shale	4	
Shale with iron ore at the top	16	8
Shale, ferruginous	1	
Coal	3	9
Shale	1	
Coal	1	
Shale, with three bands of iron ore	2	6
Fire-clay with iron ore	3	
Shale		6
Coal	1	
Shale with iron ore		7
Fire-clay with iron ore nodules	2	
Shale		6
Coal	1	6
Shale	2	6
Fire-clay with two bands of iron ore	5	6
Sandstone	1	6
Shale with four bands of iron ore	6	6
Shale with two bands of iron ore nodules	6	6
Iron ore		7
Shale with iron ore	4	3
Coal		6
Shale with iron ore		6
Coal	1	6
Shale	2	
Coaly shale	2	3
Shale with iron ore	2	2
Coal	2	1
Shale		6
Fire-clay with iron ore	2	8
Shale with iron ore	4	10
Shale, ferruginous	2	6
Iron ore	1	6
Coal		3
Shaly sandstone	2	
Shale	4	6
Coal	2	6
Limestone	3	
Fire-clay	3	6
Coal		8
Shale	1	6
Shale, ferruginous	1	6
Shale	1	
Coal	1	3
Shale	1	3
Coal	1	6
Shale	1	6

	Feet.	Inches.
Coal	1	6
Shale, brown	2	8
Shale, arenaceous and nodular	5	
Shaly sandstone	8	
Shale	4	6
Coal	1	6
Fire-clay	7	4
Shale, ferruginous	5	
Shale with nodules	7	
Shale, ferruginous	2	
Shale	1	
Sandstone	39	
Shale	15	
Fire-clay with iron ore	3	
Limestone	6	
Fire-clay with iron ore	2	
Shale	10	
Sandstone [from measurements on Laurel Run]	44	
Coal		8
Shale		10
Limestone	2	2
Sandstone	23	6
Shale	6	
Hard black band	6	
Shale, very ferruginous	6	
Shale [from measurements on Mill Run]	4	6
Coal, shaly, hard, good	5	8
Fire-clay, sandy	4	
Ore in shaly fire-clay	6	
Limestone	6	
Sandstone	33	
Shale	9	6
Fossiliferous ferruginous shale	11	
Total thickness of strata now considered as Conemaugh,	495	6

An excellent section recently obtained by Professor Charles S. Prosser of the Maryland Geological Survey gives the thickness of the Conemaugh on Phœnix Hill two miles below Barton as approximately 630 feet. This section is as follows:

	Feet.	Inches.
"Big Vein" coal		
Black shales with thin layers of sandstone	41	6
Concealed in part	93	6
Thin-bedded sandstone with coal streak at base	10	
Black clay shales	4	6

			Feet.	Inches.
Coal	2½ in.			
Black clay shale	1½			
Coal	7			
Black clay shale	2 ft. 0			
Coal	11			
Black clay shale	7	The Franklin or so-called		
Coal	3	"Dirty Nine-foot"	10	4
Black clay shale	5			
Coal	5			
Black clay shale	2 4			
Coal	2 6			
Fire-clay and shales			24	
Brownish sandstone			2	6
Concealed			23	
Coal				3
Concealed			15	
Drab to yellowish shales			16	6
Coal				9
Sandy shales with iron nodules			14	9
Mostly concealed			38	
Shales			17	6
Bituminous shale			1	6
Shales with limestone concretions			21	
Concealed			25	
Shales and sandstone			28	9
Brownish gray compact sandstone			1	
Concealed, probably containing Barton or "Four-Foot" coal			37	6
Yellowish gray shales			2	
Coal				4
Shales and thin-bedded sandstones			28	6
Thin-bedded sandstones and shales			6	
Impure fire-clay and shales			10	
Yellowish sandy shales			20	
Bluish to yellowish shales			23	
Massive sandstone			12	
Concealed			20	
Coal			1	9
Fire-clay			2	6
Yellowish shales with iron nodules			15	6
Massive sandstone			1	
Concealed			20	3
Olive to yellowish shales			11	6
Concealed, with sandstone blocks			8	9
Massive sandstone			3	9
Concealed and sandy shales			21	
Conemaugh-Allegheny contact				

Total thickness of Conemaugh.....630+

THE MONONGAHELA FORMATION.

The Monongahela formation received its name from the Monongahela river, along which stream it is well developed. The floor of the "Big Vein" coal distinctly marks the base of the formation, while its upper limits in the few small areas where the full thickness still remains is marked by the roof of the Koontz (Waynesburg) coal.

The formation has been much dissected by erosion and, retaining only a minor proportion of its former distribution, is broken into many distinct areas. The most extensive of these lies around and largely to the south of Frostburg. Its northern end lies upon and helps to make the high transverse divide which separates the drainage of Jennings and Braddock runs from that of Georges Creek, and has thus survived the cutting that has so seriously affected the northern and southern portions of the basin. This area is very irregular in outline. It extends southward to Lonaconing, and one narrow area reaches northward to within almost half a mile of Mount Savage. Three of its prominent westerly projections extend across the county line into Garrett county. An oval area of small extent lies upon the county line about one and one-half miles southwest of Frostburg as an outlier of the above-mentioned larger area from which it has been cut off by the branches of Winebrenner Run, a tributary of Georges Creek. North of Frostburg and west of the Cumberland and Pennsylvania Railroad there is an area of considerable size which is separated from the larger area to the south by the headwaters of Jennings Run. A rapidly disappearing remnant of Monongahela, covering perhaps twenty acres, caps a prominent hill north-northwest of Mount Savage, one-half mile south of the state line. The area is oval in shape and the greatest thickness above the "Big Vein" is less than seventy-five feet.

In the southern part of the basin east of Georges Creek there are several isolated areas. The largest of these, lying southeast of Lonaconing, covers less than three square miles and retains the full thickness of the formation. None of the others reach an area of two square miles and none show the full thickness. Several areas lie west of Georges Creek south of Koontz Run, but only one of these,

the small one west of Moscow, is wholly within Allegany county. That just west of Lonaconing is one of the largest and retains the full thickness of the formation.

The Monongahela formation is composed almost wholly of easily disintegrating materials. Only rarely do the sandstones become sufficiently thick and massive to form noticeable topographic features, although in Washington Hollow near Eckhart and on the hillsides east of the village of Miller many loose sandstone boulders were found which are quite massive and conglomeritic. The surface of the hillsides covered by the Monongahela is smooth and gently sloping. The characteristic topographic feature commonly known as the "bench," which is so frequently seen above the Big Vein, is due generally to the relatively easy weathering properties of the coal and to the hardness of the heavy underlying sandstone.

Near the top of Westernport Hill above the Franklin tramroad is a micaceous sandstone about twenty-five feet thick. This is near the middle of the formation and apparently varies greatly in character. Other thinner sandstones are interbedded among the shales, but their exact location is generally not easy to determine.

The shales of the Monongahela are arenaceous and argillaceous and vary in color from a light gray through green and brown to an intense black. Iron-ore bands are not infrequent, and in the lower part of the formation they are sometimes of considerable thickness.

The number of persistent limestones is not definitely known. Some of those which in places show good exposures are evidently so lenticular in character that they can seldom be safely correlated with those in distant areas. In the mine shaft sunk by the Borden Mining Company three miles south of Frostburg, two limestones were found about forty and fifty feet above the "Big Vein" coal. In the Consolidation Coal Company's pumping shaft not far distant two limestones were also found, one thirty-three feet above the "Big Vein," while the other was more than two hundred feet above. An additional limestone bed is exposed near by but a few feet above the mouth of the shaft. One mile north of Frostburg along the upper railroad track near the New York mine, loose boulders of a massive

limestone are shown which indicate a stratum not more than fifty feet above the "Big Vein" coal. Likewise, in the vicinity of the Koontz mine, a variable limestone is found about forty feet above the "Big Vein," and one-half mile west of Vale Summit in a ravine on the west side of the Georges Creek and Cumberland Railroad a limestone is found at about the same horizon. Near the new furnace, one-half mile west of the New Detmold mine, a three and one-half foot bed is shown one hundred and five feet above the "Big Vein," while near the top of Westernport Hill loose limestone boulders indicate a bed there occupying about the same position.

The limestones frequently appear brecciated on weathered surfaces, are usually slightly fossiliferous and are almost invariably dark in color when fresh.

Owing to the detritus which covers the well-weathered hillsides in the northern and in the southern ends of the basin, good sections of the Monongahela can be obtained only near the central part. Measurements made by Professor Tyson near Lonaconing, and by the Consolidation Coal Company at their pumping shaft, include all of the strata now considered as Monongahela, and since the Borden Mine shaft has passed through the lower half of the formation, we have three good measurements in as many different places. The measurements obtained at Borden Shaft are as follows:

	Feet.	Inches.
Top of shaft		
Hard gray sandstone	6	6½
Shale	12	6
Coal [Tyson]	3	4
Shale	8	5½
Sandstone	2	4
Shale and sandstone	5	2
Sandstone	1	
Shale	7	
Limestone	2	
Shale	2	9
Limestone and shale	7	8
Shale	8	9½
Coal and shale [Redstone]	8	3
Fire-clay	1	4½
Black shale	18	2½
Sandstone		4

	Feet.	Inches.
Shale	2	7
Elkgarden or "Big Vein" coal	12	6¼
Total thickness exposed	110	9¾

In the Consolidation Coal Company's shaft, which is situated about two miles south of Frostburg, the measurements are:

	Feet.	Inches.
Top of shaft		
Unconsolidated surface material	8	5
Limestone with boulders	5	7
Siliceous fire-clay	3	11
Sandstone		10
Shale	4	10
Sandstone	1	8
Shale	20	
Coal		5
Shale	5	8
Sandstone	14	2
Shale	38	
Coal		10
Shale [Tyson]	3	
Coal	1	8
Shale	16	
Sandstone	4	
Shale	25	
Sandstone	1	
Coal	2	6
Shale	18	
Sandstone		10
Shale	9	6
Limestone	5	6
Shale	7	8
Coal and shale [Redstone]	7	4
Shale	18	9
Sandstone	1	2
Coal and shale	3	7
Elkgarden or "Big Vein" coal	9	6
Total thickness exposed	239	4

Professor Tyson's measurements are as follows:

	Feet.	Inches.
Shale above		
Coal	6	
Limestone with shale	12	
Fire-clay	13	9
Concealed	3	9

	Feet.	Inches.
Shale with iron nodules	27	3
Shale	27	9
Fine-grained sandstone	3	6
Shale	2	6
Coal with two inches of shale	4	3
Fire-clay	10	
Coal	3	6
Fire-clay	3	
Coarse shaly, micaceous sandstone	51	
Shale	42	6
Coal	4	6
Shale	2	
Coal	1	
Shale	4	9
Coal		10
Shale	1	3
Shaly sandstone	1	
Ferruginous shale	4	8
Elkgarden or "Big Vein" coal	14	
Total thickness of Monongahela at Lonaconing	238	9

THE PERMIAN.

THE DUNKARD FORMATION.

Several of the highest hills near the central part of the coal basin are capped by strata which are equivalent to the Dunkard series of Pennsylvania. The largest of these areas, on which Frostburg is situated, caps the irregularly shaped divide which separates the headwaters of Georges Creek, Braddock Run and Jennings Run. An area of considerable size lies to the north of Lonaconing and another lies to the west. Both extend into Garrett county. A much smaller area lies to the south. A dumbbell-shaped area lies west of Ocean and a small oval patch lies north of Upper Ocean. A fair-sized area lies also between Ocean and Vale Summit.

Stratigraphically the Dunkard formation conformably follows and includes everything above the Monongahela. The higher slopes of the hills on which the formation lies are in every case well rounded and show almost no natural outcrops. Shales and limestones are known to be prominent, sandstones are present but apparently not

important, and coal-beds, although shown in some places, seem to be of little consequence. The shales have a dull reddish-green color, but were seen only where considerably weathered. The lowest limestone observed is exposed in the Cumberland and Pennsylvania Railroad cut near the Consolidation Coal Company's pumping shaft two miles south of Frostburg. This is composed of an upper dark massive fossiliferous layer twenty-eight inches thick and a lower, somewhat shaly bluish-gray stratum forty-three inches thick. About 300 feet above this, on the hill east of the pumping shaft, there is an abandoned limestone quarry in which the partially exposed limestone containing small scattering fossils seems to have a thickness of about six feet. Fifteen feet higher there is another thinner limestone as indicated by loose blocks on the surface. A very argillaceous limestone seven and one-half feet thick is exposed about 250 yards north of the Frostburg tunnel. This seems to be several feet above the bottom of the Dunkard formation and possibly lies at the same horizon as the one seen in the railroad cut near the pumping shaft.

But little can be said of the coal seams in the Dunkard formation, and so far as known none are more than twelve inches thick. One bed having this thickness is exposed a few feet above the limestone north of the Frostburg tunnel. Others were seen at this place, but they were of much less thickness. Near the pumping shaft two coal seams are known to lie more than 300 feet above the bottom of the formation, but their thickness could not be learned.

No detailed section of the formation can be given, but its greatest thickness is about four hundred feet.

The Permian character of these strata has been maintained by some, and they are classified as Permian in Volume One of The Maryland Geological Survey in conformity with the results obtained by Professors Fontaine and White in their study of similar strata in Pennsylvania and West Virginia. Their work in the higher strata there has shown a gradual decrease and final disappearance of coal, a great change in plant life and important changes in physical conditions. Lithologically, in Maryland, the Dunkard appears but little different from the higher Coal Measures except in the lesser importance of its

coal seams and possibly in the greater abundance of its limestones. The fossils thus far found in the formation are not numerous and have not yet been described. All of those collected have been confined wholly to minute forms found in the limestones. The plant form *Pecopteris elliptica* described by Bunbury, is thought to have come from the Dunkard formation, but this is not certain.[1]

The Pleistocene.

THE ALLUVIAL AND OTHER LATE DEPOSITS.

Well-rounded boulders and coarse gravels of quartzite and conglomerate are found in the western part of the county scattered loosely upon the hillsides, extending at Cumberland as much as 300 feet above the Potomac river, or a little more than 900 feet above tide. At Piedmont, West Virginia, where the river bed is 300 feet higher, similar boulders have been found as much as 1060 feet above sea-level. These and other deposits of like nature have been described and discussed by Professors J. J. Stevenson and I. C. White, both of whom consider them of glacial or post-glacial age.[2]

At a considerably lower level in several places along the Potomac river deposits of clay, coarse gravels and boulders are found which sometimes show coarse stratification. This is particularly noticeable in the vicinity of Cumberland and in some of the Baltimore and Ohio and West Virginia Central Railroad cuts between Cumberland and Westernport, as well as along the Baltimore and Ohio Railroad near the eastern part of the county between Paw Paw, West Virginia, and the mouth of Sideling Hill Creek. The gravels and boulders are usually well-rounded and polished and consist for the most part of fragments of Paleozoic materials such as are found in

[1] Fontaine, Wm. M., and White, I. C. The Permian, or Upper Carboniferous, Flora of West Virginia and S. W. Pennsylvania. Second Geological Survey of Pennsylvania, Report PP, p. iii, Harrisburg, 1880.

[2] Stevenson, John J. On the Surface Geology of Southwest Pennsylvania and adjoining portions of Maryland and West Virginia. A. J. S., vol. xv, 1878, pp. 245-250.

White, I. C. Rounded Boulders at high altitudes along some Appalachian Rivers. A. J. S., vol. xxxiv, 1887, pp. 374-381.

the immediate vicinity. Near the railroad tunnel just north of Paw Paw the stratification may be seen to excellent advantage, the deposits there extending upwards as much as sixty feet above the bed of the Potomac river. Some of the materials found here have evidently been carried a considerable distance, since among them are chert fragments, evidently from the Helderberg formation, the nearest outcrop of which is more than ten miles distant. Distinct stratification may also be seen in a few favorable places between Cumberland and Westernport.

It may be of interest to describe in this connection a fossiliferous limestone-chert breccia found by the author between Cumberland and Westernport. Professor I. C. White has described an apparently similar deposit along Patterson Creek in West Virginia, but does not mention the presence of fossils.[1] The two deposits possibly have the same origin. The breccia is made up of small angular, slightly water-worn, frequently flattened fragments of chert and limestone, evidently derived from the Helderberg formation on which it is found. The cementing material is lime. It is hard but vesicular and forms no little portion of the entire mass.

As yet only a small collection of this breccia has been examined, but among the fossils thus far found the following have been identified by Professor H. A. Pilsbry:

Pupa (Bifidaria) armifera, Say.
Zenitoides minusculus, Binn.
Strobilops, probably *virgo*, Pils. or *affinis*, Pils.
Helicina occulta, Say.
Helicodiscus lineatus, Say.
Polygyra hirsuta.
Polygyra albocabris, Say (?).
Polygyra, species undetermined.

The breccia is apparently of quite recent origin, and there is some reason for believing that it may be forming at the present time. Professor Pilsbry says that *Helicina occulta* is one of the most abun-

[1] White, I. C. Rounded Boulders at high altitudes along some Appalachian rivers A. J. S., 3d series, vol. xxxiv, 1887, pp. 374-381.

dant and characteristic fossils of the Iowa loess and is now almost extinct, being confined to a few very restricted though widely separated areas, and that it has not hitherto been known to occur in Maryland, either recent or fossil. The other species have been previously recognized as living in Maryland.

STRUCTURE.

THE ORLEANS ANTICLINE.

The Orleans anticline, known in Pennsylvania as the Whip Cove anticline, enters Allegany county from the north near the point where Sideling Hill Creek crosses the state line. It may be considered as including the area covered by the Jennings formation east of Town Hill. The several small patches of Hampshire that have been carved out by the meanderings of the Potomac river and Sideling Hill Creek along the eastern side may also be considered with this anticline, although the easternmost parts of the areas might perhaps be more conveniently considered with the Sideling Hill syncline outside of the county.

The exact position of the main anticlinal axis on the state line is concealed, but it is apparently east of Sideling Hill Creek and the Second Geological Survey of Pennsylvania from data collected in that state has so indicated it. West of the creek the dip was observed in various places in the bottom of the ravine which runs nearly parallel with the state line. Two hundred yards west of the creek there is a very perceptible anticline, although the exact position of the axis is concealed. The west limb of this anticline dips quite regularly 27° to 28° W. East of the axis the dip is complicated. At a point one hundred yards west of the creek the dip is 38° E. This rapidly decreases eastward to almost zero, then as rapidly increases again to 50° E., which in turn quickly decreases to zero, this last measurement having been obtained in the bed of Sideling Hill Creek. East of the creek along the state line the rocks are concealed.

The anticline running nearly parallel with Town Hill extends entirely across the county, including the two larger West Virginia areas

that have been carved out by the sinuosities of the Potomac river. In general the fold is composite, as is indicated by the presence of various small anticlines situated near where the main axis evidently lies.

On the National Road, about one mile south of the state line, the various attitudes of the strata are well shown and three anticlines are there disclosed. The evidence seems to indicate that the main axis crosses the National Road about one mile west of Sideling Hill Creek. At this point there is a very perceptible anticline, the west limb dipping 43° W., the east limb dipping 14° E. This last dip changes within one-half mile east to 21° W., and this a little further east is followed by an anticline, the eastern limb of which dips 52° E. At the edge of the county, where the road crosses the creek near the Hampshire-Jennings contact, the dip is 36° E. West of the main anticlinal axis as located, the dip rapidly swings around from 43° W. through zero to 46° E., but one-half mile west there is another anticline with the west limb dipping 4° W. Continuing westward the dip is slight until the Jennings-Hampshire contact four miles west is reached, near which place there is a small anticline with east and west limbs dipping 60° E. and 41° W. respectively. This is followed by strata dipping more and more gently westward.

Southward from the National Road the anticline turns a little more to the east, passing only a few rods west of the great bend in Sideling Hill Creek, where the east limb dips 48° E. and the west limb 61° to 85° W. Continuing southward the axis crosses Fifteenmile Creek three-fourths of a mile west of Little Orleans, the village which suggested the name here used in describing the anticline. Where the axis crosses the creek the east limb of the anticline dips 14° E., the west limb 50° W. The dip of the east limb gradually increases eastward until at the mouth of the creek the dip is 90°. On the Potomac river, one-fourth mile north of Little Orleans, a dip of 54° W. is shortly followed to the east by a dip of 78° W. Beyond this, eastward, the dip passes somewhat rapidly through zero to 57° E., near which attitude the strata remain until within two hundred yards of the mouth of Sideling Hill Creek. Here there is a small syncline

with west limb dipping 44° E. and east limb dipping 53° W. At the mouth of the creek the dip is 34° W. On Fifteenmile Creek, west of the main anticlinal axis, the strata dip on an average about 40° W. until near the Jennings-Hampshire contact, where there is a syncline with east and west limbs dipping 40° W. and 38° E. respectively.

South of Fifteenmile Creek the axis extends in a more southerly direction and cuts across the West Virginia projection about one mile west of Doe Gully tunnel on the Baltimore and Ohio Railroad and almost parallel with it. Where the anticline is first crossed by the Potomac south of Fifteenmile Creek its limbs dip 82° W. and 63° E. Along the river west of the axis the dip of the strata changes gradually, decreasing to 47° W. at the Jennings-Hampshire contact near the big bend in the river. East of the axis also the dip is pretty regular, passing gradually through 74° E., 54° E., 44° E., 54° E., 42° E. to 56° E., the last measurement, 56° E., having been made one mile east of Doe Gully at the end of the bend in the river. The strata through which Doe Gully tunnel is cut dip 53° E. near the north end and 54° E. near the south end, the strike being 34° E. in a line with the tunnel. In the West Virginia area west of the tunnel, as well as in most of the Maryland peninsular area immediately to the south, the dip is not shown. However, going up the Potomac from the south end of the tunnel, the dip can be pretty frequently made out. The anticlinal axis having turned considerably to the west of its usual direction, crosses the river about one mile below Bairds on the Baltimore and Ohio Railroad, where the limbs of the anticline dip 74° W. and 45° E. Along this east and west section of the river, as in the one near Doe Gully Station, no secondary folding can be observed. The dip of 74° W. gradually increases to 82° W., then slowly decreases to 61° W. at the bend of the river near Bairds. East of the axis the dip gradually passes through 42° E., 54° E., 43° E., 36° E., 39° E., and 54° E., the latter dip, 54° E., being shown at the Jennings-Hampshire contact as well as farther east at the bend in the river.

Apparently taking more nearly its general course of S. 25° W.,

the axis passes across the next West Virginia area where its position is hidden but is shown again on the Potomac between Bairds and Magnolia in a much confused condition. Here five anticlines appear. The main axis is situated somewhere west of the canal tunnel north of Paw Paw and apparently crosses the river about one-half mile west of the tunnel. West of the axis the dip oscillates rapidly, 69° being the dip of the steepest strata observed. East of the axis the dip is less changeable, although considerable fluctuation occurs. Immediately above the opening at the northern portal of the canal tunnel a small asymmetric anticline is exposed which dips 44° W. and 28° E. The tunnel, which is three thousand four hundred and forty feet long, runs nearly with the strike, but at the south end this anticline is not seen, the dip being 36° E. At the north end, where a very large amount of rock has been removed in order to provide a suitable approach to the tunnel, a most magnificent slickenside surface of more than one thousand square yards is exposed. The surface has a slant of 52° W. and, although uncovered more than half a century ago, it is everywhere marked by the usual slickenside striation and still retains a high polish.

In the Hampshire formation at the bend in the river at Magnolia the dip is 78° E. Going westward the dip gradually grows less until it reaches 21° E. at a point about three-fourths of a mile west of the easternmost part of the bend. On the Maryland side of the river opposite the north end of the Paw Paw tunnel on the Baltimore and Ohio Railroad there is a strong anticline, the east line of which dips 30° E. The dip of the west limb could not be determined. At each end of the tunnel the dip is 41° E. Across the river from Paw Paw at the edge of the canal a small anticline is exposed. It is also shown a short distance further north at the canal, and is presumably identical with the one seen at the north end of the canal tunnel.

Almost three-fourths of a mile west of Paw Paw on the county road there is a fold which apparently locates the axis of the main anticline. The west limb has a dip of 80°, which gradually decreases to 40° one-fourth of a mile further west. The dip of the east limb is 71° and this decreases to 40° within a distance of eighty rods. South

of the county road the anticlinal axis apparently becomes much deflected to the west, although this cannot be definitely proven.

Along the river on the south side of the county only one obscure anticline was detected and this is about one hundred rods west of the point where Little Cacapon river enters the Potomac. The west limb dips 66° W., but gradually and uninterruptedly grows less steep. The dip of the east limb is not known, but opposite the mouth of Little Cacapon the dip is 32° E. In the absence of other evidence the Orleans anticline is considered as passing across the river and out of the county along the position of this, the only observed anticline in the region.

THE TOWN HILL SYNCLINE.

The Town Hill syncline, extending entirely across the county, has the general direction of N. 25° E., and may be considered to embrace the area covered by the two long narrow belts of Pocono at the top of Town Hill, the flanking area of Hampshire in the hollow of which the Pocono rests, together with that part of the Jennings included in the western slope of Green Ridge. So far as can be observed, this syncline is but little complicated, being particularly simple and symmetrical where cut through by the Potomac river. On the National Road near the eastern Pocono-Hampshire contact the dip is 24° W. Going eastward the dip slowly increases to 48° W., this observation having been made near the fork in the road about one mile west of Piney Grove. Near here the dip quickly changes through zero to 52° E., which position the strata retain a few rods west of Piney Grove post-office. From this point eastward the strata rapidly regain their westerly dip and at the post-office the dip is 57° W. One-fourth of a mile further east the dip is 23° W. This is soon followed by a fold, the presence of which is indicated by the position of the strata one-half mile east of the post-office where the dip is 25°-30° E. Beyond this the influence of the Orleans anticline becomes paramount.

On the National Road, west of the top of Town Hill, one small symmetrical anticline is seen with limbs dipping 28°. This is one-half mile west of the Pocono-Hampshire contact. Continuing west-

FIG. 1.—FAULTED ANTICLINE IN SILURIAN STRATA, FIVE MILES SOUTHWEST OF CUMBERLAND.

FIG. 2.—SHARP FOLDS IN DEVONIAN SANDY SHALES, NEAR LITTLE ORLEANS.

GEOLOGICAL SECTIONS IN ALLEGANY COUNTY.

ward this is followed by a regular easterly dip, gradually changing through 28° E., 38° E., 45° E., 32° E., 53° E., 35° E., and 50° E. The dip of 38° E. was measured at the side of the creek between Town Hill and Green Ridge, that of 32° E. is shown on the summit of Green Ridge near the Hampshire-Jennings contact, while the measurement of 50° E. was obtained near the bridge over Fifteenmile Creek. A few yards west of the creek the dip is 70° E., and further west the strata are more and more influenced by the Pratt Valley folds.

Along Fifteenmile Creek, as well as along the county road which runs nearly parallel with it, good exposures are frequent. West from the axis, which is in the center of the Town Hill Gap, the strata gradually become more steeply inclined until at the top of Green Ridge, where the creek road enters the ridge road, the dip is 40° E. Two miles south of this point attitudes of 50° to 54° were found on the western slope of the ridge. East of the axis the dip of the strata is more complex. Within three-fourths of a mile from the center of the gap the dip changes from zero to 44° W. Between this point and the Hampshire-Jennings contact further east, two secondary anticlines appear. As a result of these the dip changes from 44° W. to 55° E., then to 35° W. and again to 32° E., the latter dip indicating the position of the strata near the Hampshire-Jennings contact. A few rods east of this contact line the dip is 38° E., after which the influence of the synclinal axis ceases to be felt.

Near the southern end of Town Hill various observations were made which compare favorably with measurements obtained further north. On the Okonoko-Orleans road one and one-half miles north of the southern limit of the Pocono a dip of 56° W. was observed. Three-fourths of a mile south and a few rods west of this exposure a dip of 49° W. is shown. One hundred and twenty-five yards further west the dip is 21° W. Along the county road leading from Town Hill to Green Ridge there are various exposures. One in the bed of the ravine shows a dip of 61° E., and a few rods further west a dip of 49° E. was seen. This quickly decreases to 38° E., but at the top of Green Ridge the strata dip 52° E. Continuing northwestward

down to and along Town Creek the dip is generally quite steep, being much of the time considerably more than 50° E. and in several places 90°.

THE STRATFORD RIDGE ANTICLINE.

This anticline clearly asserts itself in the two Oriskany exposures east and northeast of Oldtown, and a good exposure locates the position of the axis. About one mile east of Oldtown on the canal near the water level, the dip on the west side of the axis is 30° W. The strata here are bent into a nearly symmetrical arch almost one hundred feet high, although on the east side near the canal level the strata quickly become steeper and plunge beneath the surface with a dip of 63° E. In the long narrow strip of Oriskany to the northeast of this the position of the area corresponds to that of the axis of the anticline. Here the rocks of the Oriskany formation being largely free from covering, show the anticlinal nature of the ridge distinctly. Almost at the extreme northern limit of the area where the county road and a small tributary of Town Creek cut across the ridge a dip of 12° was measured on the west side of the axis. Farther east where Town Creek cuts into the eastern side of the Oriskany the strata have an apparent overturned dip, the attitude there being 70° W. This seems to swing back through 90° very soon, as only a few rods further east a good exposure shows a dip of 44° E. Continuing east along the creek toward Green Ridge the strata wherever exposed show a strong dip, but at some places where the rocks are concealed there is an undoubted undulation, this fact being rendered evident by a dip of 70° W., observed near the angle formed by the creek as it turns west-northwestward from Green Ridge. Two miles south of this, where Town Creek makes an abrupt turn to the east, the dip near the Jennings-Romney contact is 53° E. This gradually increases eastward to 62° E., which observation was made where the creek turns southward. Along the West Virginia side of the Potomac, both east and west of the Stratford Ridge axis minor folds are shown, but on the Maryland side the strata are worn down and concealed in such a manner that these minor folds are not very apparent and, indeed, their

influence seems to die out almost immediately after passing across the river into Allegany county. A few yards east of the mouth of the South Branch the dip is 15° E., but this gradually increases without serious interruption to 90° near by, at which attitude the strata remain for much of the distance between the mouth of South Branch and the Jennings-Romney contact. Between this contact and the mouth of Town Creek the dip is about 55° E. Nearly one-half mile west of the main axis a fold of some importance is seen on the West Virginia side, but it is concealed in Maryland. The limbs dip 15° E. and 25° W.

One-half mile south of the north end of the Stratford Ridge area along the county road running parallel to and west of the axis a dip of 21° W. was found. North of this area, where the creek cuts across the Jennings-Romney contact zone, the dip is 65° E. This increases to 81° E. about one-fourth of a mile nearer Green Ridge, but decreases to 22° E. near where the creek turns south parallel to Green Ridge.

The effects brought about in the formation of the Stratford Ridge anticline are no doubt felt considerably further north than the Oriskany area extends, possibly even reaching for a considerable distance north of the creek, but owing to the paucity of exposures the true conditions cannot be made out.

THE OLDTOWN AND PRATT VALLEY FOLDS.

In the extensive area of Romney shales east, west and north of Oldtown the extreme poverty of exposures prevents any precise description of the structural details, but such definite observation as can be made shows that the strata are considerably folded. Whether or not these folds are very persistent or important in any way is not known. As a consequence, therefore, the structure sections for this part of the county have been made upon data that is necessarily somewhat conjectural, but the general condition of the strata is evidently that of gentle and frequent undulation and they have been so represented.

Pratt Valley may be roughly considered as including the compara-

tively low area lying between Polish Mountain and Green Ridge north of the lower course of Town Creek. With the exception of the exposures along the National Road the conditions for studying the exact features of the structure in this area are even more meagre than in the Oldtown area. The valley is very densely wooded, and over a considerable portion of the area the only means of gaining any knowledge of the underlying formation is to examine the loose shales lying in the cavities left by uprooted trees. On the National Road three hundred yards east of Pratt post-office a beautiful, almost symmetrical, anticline is seen. The west limb dips 40° W. and the east limb dips 44° E. For nearly one-half mile west of this the dip gradually decreases, finally reaching as low as 6° W. at a point about four hundred yards west of Pratt post-office. West of this point the dip increases more and more under the influence of the Polish Mountain syncline. About one-third of a mile east of the axis an exposure shows the strata dipping 30° E., but two hundred and fifty yards further east they dip 85° W. Beyond this for nearly a mile the strata are concealed. When next seen the dip is to the east. South of the National Road no distinct traces of these anticlines can be found, although various measurements on Town Creek and northward on some of its branches indicate much variation of dip with the probable presence of several folds.

At a point two miles west of Pratt two anticlines near each other are poorly shown on the National Road. Their limbs, so far as can be observed, dip nearly symmetrically at 30° to 40°. At a point almost one-half mile west of this the dip is 45° E., but three hundred yards further west the dip has decreased to 35° E. East of the two anticlines, which in fact may be considered as flexures of one main anticline, the dip changes rapidly until Fifteenmile Creek is reached. Starting with a dip of 30° E. the dip undulates through 90°, 50° E., 40° E., 87° W., 35° W., 70° E., 50° E., 45° E., the last measurement being one hundred fifty yards west of Fifteenmile Creek. The dip of 35° W. and 70° E. shows a crumpled anticline about five hundred yards west of the creek. We thus have at least three separate and distinct positions along the National Road in Pratt Valley where anticlines are developed.

By comparing this valley with the corresponding area north of the state line in Pennsylvania, it will be observed that the positions of the Pratt Valley anticlines correspond quite closely to the positions of important anticlines in Bedford county as worked out by the Second Geological Survey of Pennsylvania.[1] Beginning with the easternmost, these anticlines are known as the Broad Top anticline, the Snyders Ridge anticline and the Shavers Creek anticline. In the absence of opposing evidence it seems, with the information at hand, that we may say without probability of serious error that the above-named anticlines as traced out in Pennsylvania extend into Maryland and, crossing the National Road at or near the points suggested, continue an indefinite distance southward, being apparently seriously deflected and possibly entirely dissipated by other more or less important folds before reaching the Potomac river.

THE POLISH MOUNTAIN SYNCLINE.

This syncline follows the trend of Polish Mountain and is the gradually shallowing prolongation of the much more prominent Clearsville syncline of Pennsylvania. On the National Road the dip on the east side of the synclinal axis approximates 20° W., while on the west side it is about 40° E. On the Williams Road, about two miles south of the National Road, the strata on the east side of the syncline are concealed; but on the west side between Town Creek and the crest of the mountain the dip varies from 22° E. to 30° E. Near the south end of the mountain various observations were made, but only those on the western side of the axis are trustworthy. They indicate the average dip to be very nearly the same as that shown on the Williams Road. Further south the syncline becomes lost amidst the confusion of other folds. No rocks higher than those of the Jennings formation are contained within this syncline in Allegany county. Along the top of the mountain a heavy conglomerate is shown south of the Williams Road, but where the mountain is crossed by the National Road the conglomerate has apparently been

[1] Stevenson, J. J. Geology of Bedford and Fulton Counties, Report T2, Second Geological Survey of Pennsylvania, Harrisburg, 1882.

worn completely away, although its former position is shown by a few scattering but much weathered boulders. This conglomerate capping is apparently the same as the heavy conglomerate seen in many other places in the county near the top of the Jennings, and in Pennsylvania where the opportunities for studying the rocks of this syncline are better than in Maryland, the Pennsylvania Geological Survey has similarly located it and has correlated it with the Chemung Upper Conglomerate.[1]

THE TUSSEY MOUNTAIN ANTICLINE.

Within that structural division of the Appalachian system of which Allegany county forms a part, the folds of predominating importance are usually those long anticlines which are of sufficient magnitude to bring up the Silurian rocks. Of such anticlines Allegany county has three that are well developed. All of these enter the county from Pennsylvania, but in each case the position of the anticline becomes entirely obliterated or very much disturbed before reaching the Potomac river. The Tussey Mountain anticline is the easternmost and most quickly obliterated one and at the state line occupies the position of Tussey Mountain. Continuing nearly southward across the National Road and then more nearly southwest the anticline bifurcates, one branch following the direction of Warrior Mountain, the other that of Martin Mountain.

Near the state line where the Tuscarora of Tussey Mountain is cut through by Flintstone Creek the dip on the west side of the anticline is 18° W. Although not well known, it is apparently about the same on the east side. Further east the strata where not concealed show a varying dip, the Clinton being much folded there. Along Flintstone Creek northward from Flintstone for half a mile or more the general dip is 40° to 50° E. One and one-half miles west of Flintstone Creek on the National Road a dip of 40° E. is shown. One-half mile further west the dip is 5° W., the intervening area apparently representing the position of the main anticline. Further west, as far

[1] Stevenson, J. J. Geology of Bedford and Fulton Counties, Report T2, p. 31, Second Geological Survey of Pennsylvania, Harrisburg, 1882.

as the abandoned limekiln in the Helderberg formation, three miles west of Flintstone, the dip varies from 20° to 30° W., but the exposures are not good. Along a small ravine, about one mile south of the National Road and running nearly parallel with it, various measurements indicate the general attitude of the strata to be much the same as along the National Road. However, further east along the Murley Branch road considerable confusion of dip exists and this is found to be due to the presence of a minor fold running parallel with Murley Branch. The exact position of the axis of this minor fold is best seen a little more than half a mile east of Rush on the Williams Road. A few feet of the red sandstone near the bottom of the Salina is there shown in a small anticline whose limbs have a dip of 15°. The same anticline with a similar exposure of Salina is brought to view on the ravine two hundred yards south of this. It cannot be traced further south. The anticline is not well shown northward from the Williams Road, but its presence is sufficiently indicated to enable one to trace it for a distance of more than two miles. The Tussey anticline bifurcates in the vicinity of Rush, and the Murley Branch fold is no doubt one expression of the beginning of bifurcation.

On the county road leading west-northwest from Rush, various outcrops indicate a much disturbed condition of the strata. At least four anticlinal flexures cross the road within a mile of Rush. The positions of the axes of these folds cannot be actually seen, but their presence is sufficiently indicated by various exposures along the road. The dip at Rush near the iron bridge over Murley Branch is 55° to 75° E.

In the double southern extensions of the Tussey anticline but few measurements of the attitude of the strata can be obtained. The Warrior Mountain branch can be easily traced to within a mile of the Potomac. Along the eastern side on the county road running near the Oriskany-Romney contact the dip varied but slightly, 27° E. being the greatest dip observed and 17° E. the lowest. The dip along the western side is much the same.

In the vicinity of Twiggtown the western projection of the Tussey

Mountain anticline in turn becomes bifurcated, the western projection of this bifurcation forming the Collier Mountain anticline with east and west dips of about 40°.

THE MARTIN MOUNTAIN AND COLLIER MOUNTAIN ANTICLINES.

The Martin Mountain anticline occupies the position of that mountain and has been formed by a bifurcation of the larger anticline south of Rush Ridge. The dip varies from 35° to 50°, the two limbs having approximately the same inclination. Near the Potomac the dip is less, scarcely reaching 25° on either side.

THE BIG SPRING RUN SYNCLINE.

This syncline, which is formed by the gradually separating branches of the Tussey Mountain anticline, occupies the triangular Romney area west of the southern end of Warrior Mountain and includes within it a considerable portion of the valley of Big Spring Run. The rocks are almost wholly concealed, but along the Potomac river the observations indicate that the strata are considerably, although not deeply, plicated.

THE MARTIN SPRING BRANCH SYNCLINE.

This is a narrow syncline lying between Martin Mountain and Collier Mountain, and extends from the Potomac river northward to within about two miles of Twiggtown. It occupies the position of the long narrow Romney area in which Martin Spring Branch lies, and is in general appearance much like the Collier Run syncline which lies to the west of Collier Mountain. The dip on either side varies between 20° and 45°.

THE COLLIER RUN SYNCLINE.

Collier Run syncline stretches across the county in a general northeast-southwest direction. In its southern and middle portions it is flanked by Collier Mountain and Nicholas Mountain and is marked by a long narrow strip of Romney shales within which Collier Run lies. Near the headwaters of Collier Run, Nicholas Mountain and Martin Mountain gradually coalesce and become one synclinal ridge,

Nicholas Mountain losing its identity and its name. Martin Mountain, still capped by Oriskany rocks, continues northward beyond the state line.

Along Collier Run the dip of the syncline on either side is steep and seldom less than 30° near the Romney-Oriskany contact. It is generally more than 40°. More varying measurements, as might be expected, were obtained in the Romney exposures, but since the measurements usually express only unimportant local conditions they need not be given here. On the Potomac at the Romney-Oriskany contact on the east side of the syncline the dip is 39° W. At the corresponding point on the western side it is only 20° E., but increases farther west. The synclinal nature of Martin Mountain, where crossed by the National Road, is well indicated by the many measurements obtained, the dip on the east side being from 60° W. to 80° W., while on the western side the dip is much less, it being not more than 35° E.

THE EVITTS MOUNTAIN ANTICLINE.

This anticline enters the county from Pennsylvania and is distinctly marked for a short distance by Evitts Mountain. On the National Road, and for three or four miles further south, it is not well marked topographically, but south of the Williams Road the axis of the anticline gradually takes the position occupied by Nicholas Mountain.

Near the southern end of Evitts Mountain a branch of Evitts Creek has cut deeply across the Tuscarora quartzite and has disclosed to good advantage both limbs of the anticline. On the west side of the Tuscarora-Clinton contact the dip is 54° W. On the eastern side at the corresponding point it is 18° E. On the county road running around the southern end of the mountain a measurement of 50° W. was obtained on the west side and 22° E. on the east side. On the National Road the position of the axis seems to be just east of where the Johnson Road enters the National Road from the south. Immediately at this point of union the dip is 39° W. One hundred yards further west in the outcrop of red sandstone near the bottom of the

Salina the dip is 67° W. Continuing westward the dip in the Helderberg limestone undulates through 54° W., 70° E., and 72° W. Fifty yards east of the Johnson-National road fork the dip is 21° E. Nearly one-half mile further east the Hinckle Road enters the National Road from the south, at which point the dip is 32° E. One-half mile east of this where a county road from the north enters the National Road the dip is 17° E. Still further east, in the lower part of the Salina, the dip is 25° E., but increases shortly to 35° E., then rapidly to 78° E., then decreases to 30° E. near the middle of the Helderberg. East of this the dip gradually increases until near the position of the Collier Run syncline. On the Hinckle Road near the bottom of the Salina the dip is 18 E., gradually increasing southeastward to 36° near the Romney-Oriskany contact. Three-fourths of a mile south of the National Road on the Johnson Road the dip is 42° E., while further south, near the fork in the road, it is 34° E. East of this for half a mile the prevailing dip is less than 15°. On the Williams Road the anticlinal axis appears to be almost in the bottom of the valley on the western side of Nicholas Mountain. Here a small sharp anticline is exposed. East of this anticline, as far as Collier Run, all of the outcrops show an easterly dip of the strata, the dip varying from 7° to 34°. West of the anticline, as far as Evitts Creek, all of the outcrops show a westerly dip of the strata, the dip varying from 50° to 72°. Along the Potomac river the dip on the eastern side of the axis varies from 20° E. to 42° E., while on the western side the range of dip is from 15° W. to 54° W.

THE EVITTS CREEK SYNCLINE.

The Evitts Creek valley, together with the low-lying West Virginia and Maryland areas to the south, practically includes all of the Evitts Creek syncline. It is bounded on the east by a row of Oriskany hills which extend from the state line southward to near the Potomac river, where the hills become gradually absorbed by Nicholas Mountain. Shriver Ridge, in Maryland, and Knobly Mountain, in West Virginia, both protected by Oriskany sandstone, lie along the western side

In that part of the syncline which lies north of the Potomac river outcrops are frequent. Along the National Road, and along the Baltimore and Ohio Railroad, this is particularly true. In addition to these a county road about one mile south of the National Road discloses the attitude of the strata in many places, and on the eastern side of the syncline along the Williams Road a good series of exposures is also shown. In addition to these, many other more scattering and less easily located exposures were found. With but rare exception these exposures all show that the axis of the syncline is thrown far toward the eastern part of the valley, as is also Evitts Creek in much of its course. North of the National Road and west of Evitts Creek the dip is to the east in every place observed and in some instances the easterly dip continues a considerable distance east of the creek. Along the eastern side of Shriver Ridge the dip is 30° E. to 35° E., although about one and one-half miles south of the state line a measurement of 44° E. was obtained. One mile south of the state line on Evitts Creek the strata stand upright, as they were observed to do also two miles south of the state line. On the National Road about one-half mile east of the creek the dip is also 90°, but this may be a very local feature, since between this point and Evitts Creek there are two anticlines. Where Evitts Creek crosses the National Road the dip is 27° W. East of Evitts Creek on the Williams Road at the Jennings-Romney contact the dip is 70° W. Continuing eastward the dip varies through 50°, 65°, 72°, and 59°, the last measurement having been obtained near the Romney-Oriskany contact. Going south from Cumberland, then east along the Baltimore and Ohio Railroad, the dip, with insignificant exceptions, remains from 15° E. to 20° E. until within about one-fourth of a mile of the mouth of Evitts Creek, where a small amount of folding is observed. Just west of the creek the dip is 16° E., but the only observations in this locality east of the creek show a considerable dip to the west. In view of these facts it seems quite evident that the main axis of the syncline crosses the Potomac river at or near the point where Evitts Creek enters it.

In that part of the syncline which is occupied by the large west-

wardly projecting area west of the southern end of Nicholas Mountain no good outcrops were seen, the surface there being almost wholly covered by river-washed materials.

THE WILLS MOUNTAIN ANTICLINE.

This anticline, like the Evitts Mountain and Tussey Mountain anticlines, is distinctly marked by a ridge of Tuscarora quartzite. It enters Allegany county from the north and continues in an approximate S. 30° W. direction as a prominent topographic feature for a distance of more than ten miles. The eastern limb of the anticline has a moderate dip. The west limb dips steeply. Near the Tuscarora-Clinton contact line along the east side the prevailing dip is less than 30° and shows but very little variation, while along the corresponding contact line on the west the dip approaches and sometimes exceeds 70°.

The structure of the mountain is most admirably shown in the Wills Creek gorge known as "The Narrows," where, acting like a veritable saw and keeping pace with the gradually rising strata, the creek has cut for itself a narrow passage across the mountain and has thus disclosed on either side a rocky arch of magnificent proportions. Here immense talus slopes extending upward more than five hundred feet, are overhung by high precipitous walls of massive white quartzite. Toward the east end of the gorge, where the talus is less prominent, the strata may be seen to descend slowly, the dip increasing to 24° E. at the Tuscarora-Clinton contact. At the western end of the gorge the dip is precipitous, the well-exposed Tuscarora strata there plunging beneath the surface with a dip of 72° W.

South of the National Road, Wills Mountain becomes gradually deflected from its general course of S. 30° W., and for some distance before reaching Cresap runs nearly due south. At Cresap the Tuscarora passes beneath the surface, and with its disappearance the mountain becomes obliterated.

As a result of the eastward deflection of the southern end of Wills Mountain, some minor folding has been brought about along the Potomac river southeast of Cresap, where the upper beds of the Tus-

DANS ROCK, SHOWING POTTSVILLE CONGLOMERATE.

carora are raised to the surface in two sharp anticlines. One of these anticlines has exposed almost one hundred feet of the Tuscarora and can be traced for nearly five hundred yards in a general south-southwest direction. The smaller anticline which lies a short distance southeast of this is not sufficiently individualized to be distinctly traced longitudinally and is scarcely more than sufficiently prominent to bring the Tuscarora to the surface.

In the northern part of the county east of the Tuscarora-Clinton contact line east of Wills Mountain the dip increases slightly but rarely reaches more than 40° E. West of the axis the dip in the Clinton wherever exposed is great. Further west in the Helderberg and Oriskany formations several excellent exposures give a prevailing dip of 90°. This is admirably shown at the "Devil's Backbone" near Corriganville, as well as at either end of the low enlongated hill lying just west of the "Narrows."

Near the state line, a short distance west of the long narrow Oriskany area there is a slight fold which in some low places brings the Oriskany to the surface again. Immediately west of this the dip is steep, but continuing westward it gradually grows more nearly horizontal.

South of Braddock Run the high pitch of the strata is fully as prominent as further north and the excellent exposure at Potomac Station shows the strata in much the same attitude as at the "Devil's Backbone."

THE RAWLINGS SYNCLINE.

By the Rawlings syncline is designated that small, poorly defined structural region which lies to the north and east of Rawlings and which is marked by a southward projection of the Romney formation across the Potomac river into West Virginia. The upright strata of the Oriskany and the Helderberg may be considered as occupying the eastern side, while on the west the limits are poorly defined except near Rawlings, where the rather steeply dipping Oriskany strata are well shown. Good exposures are almost wholly lacking, but a study of the areal geology in connection with the topogra-

phy leads at once to correct conclusions as to the general synclinal nature of the fold.

THE FORT HILL ANTICLINE.

The high isolated Oriskany-Helderberg hill extending southward from Rawlings for a distance of more than four miles is a rapidly disappearing remnant of the Fort Hill anticline which extends from Rawlings to Keyser, West Virginia. The anticline has been much obscured by the corrosive action of the Potomac river and much of it now lies on the West Virginia side. Along the western side the prevailing dip of the Oriskany strata is from 70° W. to 90° W., although south of Monster Rock, in an exposure near the West Virginia Central Railroad bridge, an overturned dip of 65° E. may be clearly seen. Near Rawlings, where the Oriskany passes beneath the surface, the west limb dips 28° W., while a little further south the east limb dips 42° E. At Monster Rock the anticline is quite narrow and near Rawlings it comes to a point. Midway between the two the width is considerably more than a mile.

In the projecting area occupied by Monster Rock the east limb of the anticline is seen to dip gently to the east for a short distance, but before passing beyond the river the strata rise again with a dip to the west. The little syncline thus produced is worthy of notice, as it is apparently the prolongation of the Rawlings syncline which, passing along down the western side of Knobly Mountain in West Virginia, re-enters Allegany county near Monster Rock as indicated.

THE GEORGES CREEK SYNCLINE.

The Frostburg syncline is defined on the east by the Wills Mountain and Foot Hill anticlines already described. The western limit is west of Savage Mountain beyond the borders of Allegany county, hence need not receive further mention here. The full width of this syncline, of which only the eastern and central portions lie in Allegany county, remains approximately ten miles throughout its entire course across the state. This measurement, however, is not to be confused with the width of the high valley lying between Savage

Mountain and Dans-Little Allegheny Mountain which occupies scarcely more than one-half of the synclinal fold. The axis of the syncline has been designated with considerable detail by means of the various mining operations in the coal basin. Its general direction is N. 28° to 30° E. passing through Franklin, Barton, Moscow and Lonaconing. It lies a little to the west of Westernport and passes through the immediate vicinity of Mount Savage.

Steeply-dipping Silurian and Devonian strata occupy the eastern border of the syncline, but gradually growing less steep westward from Wills Mountain they disappear one by one beneath the high-lying Carboniferous strata of the coal basin.

In the gap through which Jennings Run flows, where many of the strata, particularly those of the Hampshire formation, have an excellent exposure, the gradually decreasing inclination of the beds may be clearly seen. Numerous good exposures further south along Braddock Run and still further south in the Potomac gorge also aid materially in arriving at correct conclusions concerning the structure of this part of the county.

At the Jennings-Hampshire contact in the Jennings Run gap the dip is 68° W. At the Hampshire-Pocono contact the dip has gradually decreased to 28° W. At the Pocono-Greenbrier contact it is 17° W., while at the Mauch Chunk-Pottsville contact the dip is only 13° W. Further west the dip continues to gradually grow less.

In the Potomac gorge and along Braddock Run the favorable places for observation cannot be concisely described but the measurements obtained correspond closely to those made along Jennings Run.

These measurements were all obtained near the level of the streams mentioned, hence following the various formations upward to the positions which they occupy in the higher parts of the Alleghany Front the dip is found to increase slightly. Opportunities are not good for learning definitely how much this increase is, but it is known that the Pottsville dips from 16° W. to 22° W. where best exposed along the high crest of Dans-Little Allegheny Mountain.

Outcrops of strata in Allegany county suitable for accurate measurement of the dip are rare west of the synclinal axis. Southward

from the state line the Allegany-Garrett line gradually approaches the position of the synclinal axis, hence the western limb of the syncline is but poorly represented in Allegany county. It seems, however, that the steepness increases somewhat less rapidly west of the axis and the prevailing dip of the Pottsville in the northwest corner of the county is thought to be not greater than 12° E. to 15° E.

DIP, STRIKE, AND PITCH.

Certain facts of prime importance in the study of Appalachian structure which have abundant illustration in Allegany county and which have been brought out to some extent in the description of the individual folds demand particular mention. These relate to dip, strike, and pitch. It was observed that the three principal anticlines in the county, viz., the Tussey Mountain anticline, the Evitts Mountain anticline and the Wills Mountain anticline all have moderate easterly dips. The same is not true, however, of their westerly dips. The west limb of the Tussey Mountain anticline, so far as is shown in Allegany county, happens to have apparently about the same dip as the east limb, but the west limb of the Evitts Mountain anticline has a dip more than twice as great as the east limb, while the dip of the west limb of the Wills Mountain anticline is almost three times as great as the dip of the east limb. A similar condition is observed to prevail in connection with many of the less important folds, hence we may say that the Allegany county anticlines tend to develop limbs sloping gently to the east and steeply to the west. Expressed in terms of synclines, we may say that the synclines tend to develop steeply-sloping limbs on the east side of their axes and gently-sloping limbs on the west side. These facts are in accord with observations made throughout almost the entire Appalachian region, and it is upon these facts that many able geologists have based the theory that the deforming force which produced these folds came from the southeast. These facts alone seem inadequate to prove the truth of the theory, but that the initial force did really originate in that direction has been pretty generally accepted by geologists.

The strike of the beds, as in most other parts of the Appalachian

region, varies within rather narrow limits. The Tussey Mountain anticline and the Evitts Mountain anticline extend approximately N. 27° E., while the Town Hill syncline, the Collier Run syncline, the Wills Mountain anticline, and the Georges Creek syncline all have a direction approximately N. 30° E. Observations in many other places show that in no case worthy of special note do the beds lie at great variance to the general direction given.

Nearly all of the folds show more or less axial pitch and this pitch is downward to the south almost without exception. The exact nature of this pitch along many of the folds cannot be easily computed, but from field observations on the major anticlines it seems that even in extreme cases the pitch scarcely reaches five degrees. It is to this pitching of the folds that much of the characteristic structure of the Appalachian Region is due. The effect of the pitch on the areal distribution of the formations is best illustrated in Allegany county by the Evitts Mountain anticline. At the state line on the north the axis of this anticline is indicated by the tongue-shaped area of Tuscarora quartzite. Southward the Tuscarora narrows and disappears beneath the later Clinton formation. The Clinton continuing southward upon the axis also narrows and disappears beneath the succeeding Niagara formation. This in like manner is followed in regular order by the Salina, the Helderberg and the Oriskany. The pitch in the southern part of the county is slight, as is evidenced by the emergence of the Helderberg again where the Potomac has cut across Nicholas Mountain. Similar areal distribution of formations brought about by pitching of the folds may be observed in almost every fold west of Town Hill. In much of the Georges Creek syncline this is not quite so apparent, but in the northern part of the county the upward pitch to the north becomes perceptible, and as a result the coal measures all come to the surface within some fifteen miles north of the state line.

FAULTS.

Faulting is rare and the amount of vertical movement is never great. Only the more thinly bedded strata present instances of faulting

worthy of note, and none of the observed faults have more than a local extent.

In the Jennings formation along the Williams Road on the hillside near the eastern edge of Cumberland there is a fault whose throw seems to be considerable, but no definite idea as to the exact amount of displacement could be gained.

On the Baltimore and Ohio Railroad west of Cedar Cliff, about three miles south of Cumberland, a small, clearly faulted anticline is seen in the red shaly sandstone bands near the bottom of the Salina formation. The throw here is only a few feet.

Other faults occur, but so far as observed they are of no special moment except in the general relation which they bear to the more important structural features of the region.

STRUCTURE SECTIONS.

On the structure-section sheet (Plate XVI) twelve structure sections are given. They represent the strata as they would appear along the sides of trenches cut across the county on the section lines and extending downward to the position of sea-level. All of the sections extend in the direction N. 60° W., S. 60° E. which is approximately perpendicular to the prevailing strike. The relative positions of the various section lines have been chosen with especial reference to lines along which most favorable conditions for field observations were found, combined wherever possible without sacrificing accuracy with such positions as best reveal the various structural changes. For this reason the distances between the section lines vary. Those crossing the eastern and central portions of the county are approximately two miles apart, while the distances between those lying wholly within the western part of the county average about four miles.

On the structure-section sheet the straight line at the upper edge of each blank space represents the section-line along or near which the field observations were made; the straight line on which the section rests indicates the position of sea-level; while the undulating line at the top represents the surface configuration along the section-line.

Interpretation of the Sedimentary Record.

General character and variation of sediments.

The three chief topographic phases of sedimentation indicated by sandstones, shales and limestones are well represented in Allegany county. Reviewing briefly that which has been given in detail in earlier pages, we find that four formations, the Tuscarora, the Oriskany, the Pocono and the Pottsville, are entirely or largely composed of heavy sandstones; that nearly the whole of the Helderberg and the Niagara, as well as much of the Salina and the Greenbrier are made up of limestones; and that all of the other Paleozoic formations consist more or less completely of soft shales and thin-bedded limestones and sandstones.

Marked changes in the character of the formations as they extend across the county are observed in only a few instances. The Oriskany and the Jennings thicken considerably toward the west, the Greenbrier thickens to the south and the Pocono apparently thickens to the north. Lithologically the Pocono on Town Hill differs materially from the Pocono in the western part of the county. In the east it is very massive and coarsely conglomeritic wherever observed, while in the western portion it is much less massive and is free from heavy conglomerate. The other formations do not change except in minor particulars, and as these changes have been mentioned elsewhere they need not be repeated here.

The early Paleozoic period.[1]

In early Cambrian time a long strait extending from the region of the Gulf of St. Lawrence southward to Alabama occupied approximately the position now occupied by the greater Appalachian valley. It separated a mountainous Archean continent known as Appalachia from a comparatively low-lying land area covering the Central States region. During Cambrian time erosion greatly reduced the height

[1] For the discussion of this period as well as for much that follows the author has drawn liberally from the writings of others, especially of the members of the Appalachian division of the United States Geological Survey and of the State Geological Surveys of Pennsylvania and New York.

of the Archean continent and the detritus thus obtained was deposited to the westward while the sea gradually transgressed eastward. Near the close of the Cambrian period the western land area began to sink and the strait gradually widening westward to Wisconsin and beyond the Mississippi formed a great mediterranean sea. Conditions were then poorly suited for the transfer of land-derived sediments, and a long period of limestone deposition set in. In course of time a disturbance of conditions took place and the limestone deposition gave way to a widespread distribution of shale. The deposition of this shale, besides indicating an uplift of the eastern land from which the sediments were derived, marks also a recession of the shore line and a probable shallowing of the sea. This shale, known in Maryland as the Martinsburg formation, was followed by a series of reddish shales and sandstones—the Juniata formation in Maryland—the upper part of which is exposed in Allegany county. With the history of this formation the immediate geological history of Allegany county begins. As shown on a previous page, the sandstones of the Juniata multiply and thicken toward the top and thus indicate a steady approach to conditions of shallow water deposition.

THE TUSCARORA PERIOD.

With the advent of the Tuscarora period a decided change in the factors of decomposition was introduced. The lithologic characters of this formation, which have been described on a previous page, indicate that the sediments were laid down in shallow water. However, to say that the Tuscarora formation is a product of shallow water deposition is only a meagre introduction to the explanation of the conditions involved. Dr. A. C. Spencer, in his paper on "The Geology of Massanutten Mountain in Virginia," has given a clear summary of the probable factors which operate to bring about such concentration and deposition of materials, and has discussed these factors in the light of sediments in the Massanutten area similar to the Tuscarora of Maryland. He says "The concentration of the more resistant products of rock-decay for the formation of extensive sandstones is a process of great complexity. During the early part of a

topographic cycle when denudation exceeds decomposition, the numerous rapid streams deliver to the sea large quantities of coarse materials of mixed composition which may be partially sorted by the waves and somewhat widely distributed by marine currents; but as drainage becomes more mature there will be a tendency for stream-derived detritus to accumulate at the mouths of large rivers, often without much wave-washing. In either case the deposits will be more or less heterogeneous, and the same will be true of the deposits derived by a transgressing sea from a land surface covered by a deep residual mantle. Such coarse-grained heterogeneous deposits would be confined to a rather narrow littoral zone, but brought a second time under the action of the waves by a slight elevation of the land, they would be re-sorted, the less resistant components would be largely ground up and removed as fine silt and the zone of coarse sediments would be moved seaward. At the same time the rivers might be bringing fresh material, but with continued slow, or intermittent rise of the land accompanied by marine planation, these and the older surviving materials becoming mingled, the final result would be a mass of sand and pebbles composed almost entirely of quartz."[1]

The uniform nature of the quartzite indicates a time of comparative quiescence and but one source of material. The period was perhaps initiated by a gradual but rapid uplift of the land accompanied by a shallowing of the sea which prevailed until the close of the period. As to the position of the shore-line at this time with reference to Allegany county but little is known except that it was in all probability a considerable distance east of the county. Southward in West Virginia and northward in Pennsylvania the formation is considerably thicker and in each of these areas the deposits are inclined to be coarser than in Allegany county, this being particularly true in Pennsylvania. Whether the lesser thickness of the formation in Allegany county is due to local or remote causes is not known. A shallowing of the sea may have deflected the currents or a deepening of the sea may have lessened their power, in either of which cases much of the sediment would have been deposited elsewhere.

[1] Spencer, A. C. The Geology of Massanutten Mountain in Virginia. Washington, 1897.

THE LATER SILURIAN PERIOD.

With the advent of the Clinton, conditions very similar to those immediately preceding the Tuscarora seem for a time to have prevailed. The red shales, with alternating sandstones, were again introduced, but they are more thinly bedded than those of the Juniata. That the Tuscarora represents only temporary invasion of pure quartzose materials which interrupted the deposition of red clays and sands may be possible. The topographic cycle may have advanced sufficiently slowly to allow the waves of marine planation to cut their way across the old littoral deposit and to reach again the region of uncovered crystalline rocks. If detritus was obtained in this way the waves would perhaps be unable to properly sort it but might be able to deliver the lighter materials to strong currents and thereby bring about the distribution as we find it. Whatever may have been the conditions it seems evident that the subsidence soon became sufficiently great to bring about decidedly new conditions. With the deposition of the upper part of the Clinton formation, limestone and iron ore were both introduced, the iron being of comparatively little importance in the Juniata except as a coloring matter, while the limestone is wholly absent.

Concerning the Niagara period, Professor James Hall says that the condition of the ocean seems to have been favorable to the production of corals and crinoids and to the deposition of calcareous beds of magnesian character, the sea being comparatively shallow.[1] In Allegany county the calcareous beds have been in part replaced by argillaceous sediments apparently indicating occasional changes in marine currents at this time. The corals and crinoids were acted upon with considerable energy by the waves, as is indicated by the immense quantity of broken and worn fragments thrown heterogeneously together and cemented by the calcareous mud produced by a more complete trituration of some of the materials.

These finely comminuted deposits, profusely filled with fragments of organic remains uniformly deposited over wide areas, show an un-

[1] Twenty-eighth Annual Report of the New York State Museum of Natural History. The Fauna of the Niagara Group. Albany, 1879, p. 101.

disturbed transition upward, and the abundance of carbonate of lime coming into the sea and entering into the secretions of the various marine organisms indicates the presence of much calcareous material easy of access. The Silurian limestone was evidently the source of this material, as it had no doubt been raised above the level of the sea in various places and thus brought under the influence of aerial degradation.

The lower portions of the Salina add further proof of the shallow water conditions. The red sandstone of that formation, with its salt, gypsum and fish remains, as found further north, was certainly laid down in reasonably shallow water and in all probability in more or less land-locked bays. At any rate, although no very great structural disturbance appears to have taken place at this time, the conditions affecting marine life appear to have been very greatly changed. In Allegany county no fossils have been found in the red sandstone and the presence of salt and gypsum has not been proven, but the conditions of deposition are believed to have been much the same as further north. Whatever may have been the condition, it is evident that when the Helderberg period was initiated the organic life which came with it was very unlike that which prevailed during the time immediately preceding the shaly sandstone deposition.[1]

THE HELDERBERG PERIOD.

From the general character of the Helderberg fossils it would seem that the depth of the water at this time was perhaps not far different from that of much of the later Silurian period, but one thing of especial note is the almost entire absence in the Helderberg of mechanical detritus, such as sand and clay. Apparently the surface configuration of the land was very subdued. Possibly conditions of base-level erosion now prevailed such as had existed during Lower Silurian time. If such were the case the streams, being weak, would be unable to transport the heavier detritus in suspension, but might continue to carry much calcareous matter in solution. The adjacent

[1] Clarke, J. M. The Hercynian Question. Forty-second Annual Report of the Trustees of the State Museum of Natural History. Albany, 1889, p. 436.

seas then being free from muddy sediments but highly charged with carbonate of lime would be in favorable condition for the growth of animal organisms such as the Helderberg contains, and extensive limestone beds would be formed from the detritus produced by them.

THE ORISKANY PERIOD.

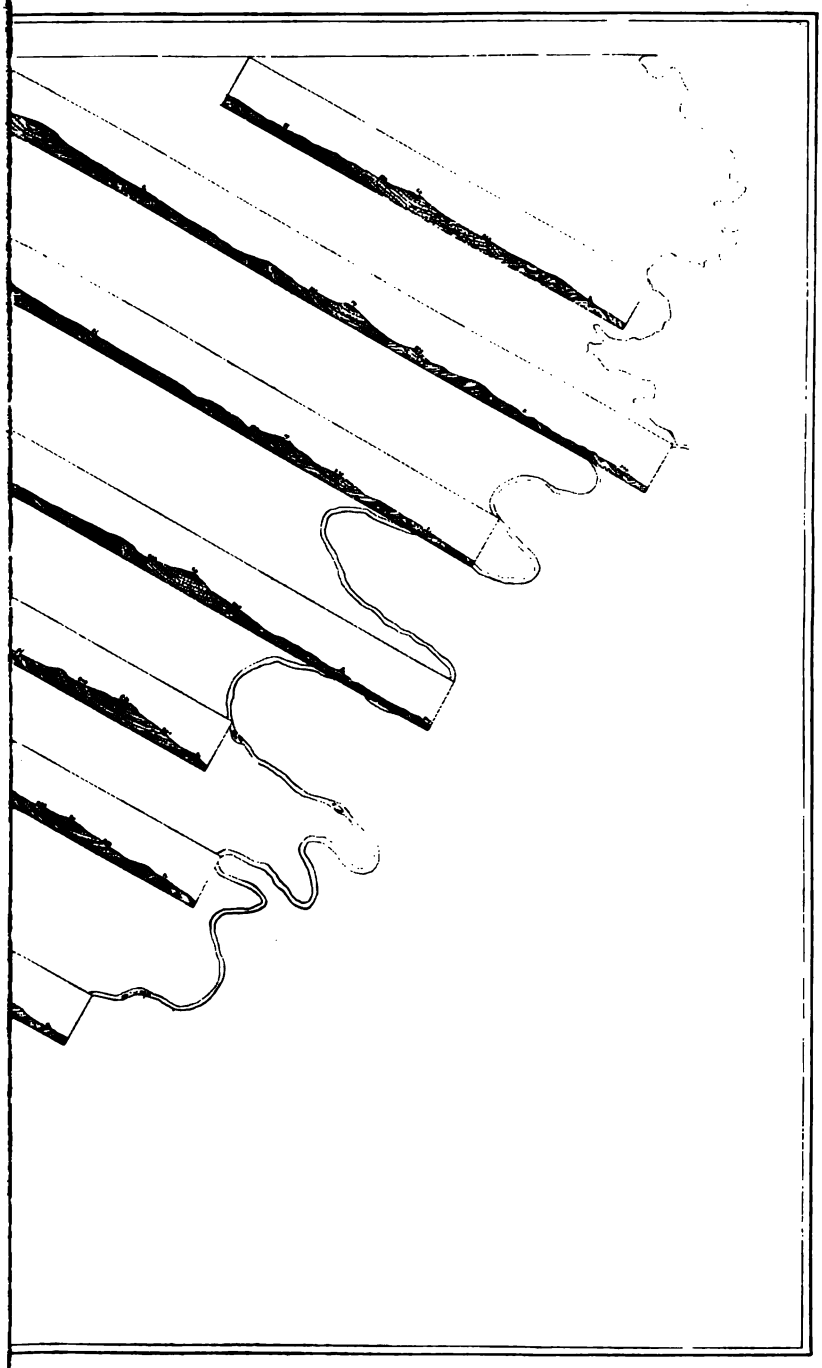
With the advent of the Oriskany a great change in the character of the sediments again took place. As has been stated elsewhere, the formation is made up of highly fossiliferous sandstones and conglomerates separated from the Helderberg proper by a transition zone of interbedded limestone. We have already seen how the coarse quartzitic detritus which contributed the sands of the Tuscarora may have been gradually stored up on a pre-Tuscaroran Coastal Plain. The events in the concentration of materials to supply the sands and pebbles of the Oriskany were perhaps much the same. As in the case of the Tuscarora, an upward earth-movement evidently initiated the principal factors of final distribution. Simultaneous with this the shallowness of the sea became sufficiently accentuated to admit of the currents acting with much energy, thereby enabling them to transport heavy materials for considerable distances.

The supply of carbonate of lime continued throughout the period in sufficient abundance to admit of prolific marine life. In many places the formation is a mass of shells and casts and the abundant cementing material is often so prominently calcareous that a perfectly fresh specimen has much the appearance of a true limestone.

THE DEVONIAN SHALE PERIOD.

The Romney, Jennings and Hampshire formations are largely composed of fine sediments, and may here be treated together. According to Mr. Willis, the lowlands of the early Devonian were general from New York to Georgia, continuing low in the southern Appalachian area throughout the Devonian, but northward becoming considerably elevated, produced mountains probably several thousand feet high, the degradation of which supplied the later Devonian sediments.[1] Near the close of the Oriskany period the area covered

[1] Piedmont Folio, U. S. Geol. Survey, 1896.



by Allegany county seems to have been elevated and possibly to a sufficient extent to allow of some erosion, although this is not proven. However, in Virginia and Pennsylvania, local non-conformities exist between the Oriskany and the Romney, and it seems probable that the changes in Allegany county were in harmony with the movements which brought about the non-conformities to the north and south. The lower shales, resting with sharp contrast upon the Oriskany, are extremely fine and highly carboniferous. Various hypotheses have been given to explain the manner of deposition of these fine sediments. It would seem that a gentle subsidence after emergence might so affect the currents that, sweeping swiftly over the arenaceous beds they might thoroughly wash away any superficial coating which may have previously collected there. The land surface was no doubt low, and thus for a long time not in a condition to supply coarse detritus. H. D. Rogers, in his admirable paper on the origin of the Appalachian strata, long ago suggested that these black sediments possibly accumulated in a very widely spread sea marsh or marine savannah, the carboniferous part of the shales being the result of plant growth.[1]

The argillaceous portions evidently came from a low-lying land surface. During the removal of the heterogeneous Coastal Plain detritus which furnished the materials for much of the Oriskany formation, the land surface farther inland was low and unaffected by rapid streams and gradually became covered with a coating of chemically disintegrated materials awaiting future transportation. Disturbances which we know occurred near the close of the Oriskany period may have easily brought about conditions favorable for the slow removal of this residual mantle.

A general but perhaps slight depression allowed the deposition of the limestone near the bottom of the Romney, following which shallow water conditions with only minor interruptions continued until after the beginning of the Carboniferous time.

[1] Rogers, H. D. The Geology of Pennsylvania, vol. ii, p. 791. Philadelphia, 1858.

THE LOWER CARBONIFEROUS PERIOD.

In Allegany county there is little apparent difference between the highest Devonian and the lowest Carboniferous sediments except in color and coarseness. In each case the sediments are almost wholly of quartzose materials and indicate shallow water and mountainous land conditions. Cross-bedding, ripple-marks and thin coal seams all attest a preparatory step toward the marshy condition of the Coal Measures.

The limestones and shales following the Pocono formation indicate a degradation of the Devonian mountains and an almost unvarying relation of land and sea. That the land appeared above the surface, however, in places not far from the Allegany county area seems proven by the bands of limestone-shale breccia at the Greenbrier-Mauch Chunk and the Mauch Chunk-Pottsville contacts.

THE COAL MEASURES PERIOD.

Following the limestones and shales of the lower Carboniferous period massive conglomerates, sandstones, shales, limestones, coals, fire-clays, etc., were laid down in rapid but irregular succession. The features of this deposition being much the same throughout a large part of the Appalachian region, a detailed discussion of the period need not be entered upon here. The general conditions which prevailed may be stated in the following words: "During middle and later Carboniferous time there ensued that general vertical movement of the eastern land area and the region of the interior sea which resulted in the withdrawal of the sea to the Mississippi embayment. The movement was not simple; it was composed of many episodes of uplift and subsidence, among which uplift preponderated. In the repeated oscillations of level the sea swept backward and forth over wide areas. It received from the Coastal Plain the coarse quartz detritus which had accumulated during previous ages, and the waves and currents of the shallow sea spread the concentrated sandstones and pebbles in beds which alternated with materials of less ancient derivation. The Carboniferous strata include shale and sandy shale, derived more or less directly from lands of moderate elevation, and

also the coal beds, each of which marks the prolonged existence of a marsh in which the peat-making plants grew. When the marsh sank beneath the sea the peat beds were buried beneath sands and shales, and the peat, by a process of distillation, became coal."[1]

SUBSEQUENT HISTORY.

In the review of the sedimentary record we have seen how elevation and subsidence followed each other with varying rapidity while the large volume of Paleozoic sediments was being deposited. It seems probable that during this time some lateral pressure was also exerted upon these sediments, producing incipient anticlines and synclines. It was not, however, until near the close of Paleozoic time that structural changes of exceptional magnitude were manifested throughout the entire Appalachian province. The strata which had been deposited upon each other in an approximately horizontal position were then squeezed and folded to an enormous degree, the forces being applied laterally in a direction perpendicular to the course of the present mountain ranges. How long this compression continued is not known. Suffice it to say that the earliest Mesozoic records show a new axis of drainage and that most of the rivers, instead of flowing to the west as the Paleozoic rivers had done, were then flowing to the east.

That there has been vertical upward movement of importance since the close of Paleozoic time is evidenced by the development of well-marked physiographic features, such as the Cretaceous and Tertiary peneplains and the various river terraces found along the streams of the county.

[1] Piedmont Folio, U. S. Geol. Survey, 1896.