WASHINGTON COUNTY

1951

DEPARTMENT OF GEOLOGY, MINES AND WATER RESOURCES STATE OF MARYLAND

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BOARD OF NATURAL RESOURCES
DEPARTMENT OF GEOLOGY, MINES AND WATER RESOURCES
JOSEPH T. SINGEWALD, JR. *Director*

THE PHYSICAL FEATURES OF WASHINGTON COUNTY

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PREFACE

The Washington County report is the fourteenth in the series of county reports started in 1900 which will ultimately include all of the twenty-three counties in Maryland. One of these reports covers two counties, so that Washington County is the fifteenth county to be completed.

The county reports supplement and describe the four series of county maps on the scale of one inch equals one mile initiated by the Maryland Geological Survey and continued by the Department of Geology, Mines and Water Resources. The basic series are the county topographic maps on which the maps of the geology, soils, and forestry series are overprinted. The latest edition of the Washington County topographic map was published in 1944. The forestry map was published in 1913, the soils map in 1920, and the geologic map in 1941. The reader of this report will be greatly aided if he provides himself with these four county maps, which are obtainable from the Department of Geology, Mines and Water Resources.

The county reports are the most comprehensive and complete descriptions of the natural resources of the counties of Maryland available. The Washington County report describes the geography, physiography, mineral resources, surface waters, ground waters, soils, forests, wild life, climate, and magnetic declination. The report is encyclopedic in scope with respect to the natural resources of the County. The authors of the report include not only personnel of the Department of Geology, Mines and Water Resources, but contributors from other State agencies and from Federal agencies. The Director expresses his deep appreciation to those who contributed to this report, both for their willing cooperation and for the excellence of their contributions.

The county reports are primarily geologic reports to accompany the county geologic maps, so that the section on geology is, as in previous reports, the longest section. The author of the geologic section of the report is Dr. Ernst Cloos of the Department of Geology, The Johns Hopkins University, who compiled also the geologic map of Washington County. The author of the paleontologic portion of the section on geology is Dr. Thomas W. Amsden of the Department of Geology of The Johns Hopkins University.

The section on the mineral resources was written by Dr. Cloos.

The section on the surface-water resources was prepared by Mr. Robert O. R. Martin, Hydraulic Engineer in the Surface Water Branch of the United States Geological Survey. The section on ground-water resources was prepared by Dr. Cloos, with the aid of the cooperative ground-water staff in Maryland of the U. S. Geological Survey and the Department of Geology, Mines and Water Resources.

The section on soils was contributed by Mr. Merle F. Hershberger, State Soil Scientist, and Mr. R. S. Long, Soil Scientist in charge of the conservation survey of Washington County, Soil Conservation Service of the U. S. Department of Agriculture working cooperatively with the Maryland Agricultural Experiment Station.

The section on forests is by Mr. Karl E. Pfeiffer, Assistant Director of the Maryland Department of State Forests and Parks.

This is the second county report including a section on the wildlife resources. This section was written by Mr. Edwin M. Barry, Chief of Game and Inland Fish Management, Maryland Department of Game and Inland Fish.

The section on the climate was prepared under the direction of Mr. G. N. Brancato, Meteorologist in Charge, Weather Bureau, Baltimore, United States Department of Commerce.

The section on magnetic declination was written by Dr. H. Herbert Howe, Mathematician, United States Coast and Geodetic Survey.

JOSEPH T. SINGEWALD, JR., *Director*

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BY

ERNST CLOOS

HISTORICAL REVIEW

FOUNDING AND SETTLING OF COUNTY

Washington County was created on Friday, September 6, 1776, by an act of the Provincial Convention of Maryland. Originally the area was part of Frederick County which also embraced Allegany and Garrett Counties.

The first mention of a separate County was made on July 26, 1775, in the legislative proceedings of the province. It became clear that it would be for the convenience of the people of the upper district (now Washington County) if they did not have to travel to and from Frederick, the county seat.

In 1789 a new County—Allegany—was formed out of Washington County and Sideling Creek established as boundary between the two.

The first settlers were probably established in the county as early as 1732, and their number increased rapidly after 1740.

"These settlers were Germans chiefly, the friends and relations of those who were then clearing away the forests of Frederick, Montgomery, Carroll and the lower counties of Pennsylvania.

"A few families among the early settlers, however, usually of English origin, and the proprietors of manors, or large tracts of land, lived in lordly style, and dispensed a generous hospitality. But the hardy pioneers who settled the country were a simple industrious people who ate out of wooden trenchers and platters, sat on three-legged stools or wooden blocks upon a dirt floor, used bears' grease for lard and butter, and cut their food with the same sheath knife which they used in dressing the deer killed by their rifles. Westward of the Conococheague the County was in possession of the savages. . . ." (Scharf, 1882, p. 981).

TRANSPORTATION FACILITIES

On the first of September 1796 a number of citizens of Hagerstown (then Elizabeth Town) met to discuss the utility of a turnpike to the seaboard. In March 1797 the assembly passed an act to lay out a turnpike from Baltimore "through Frederick Town to Elizabeth Town and Williamsport in Washington County." The Baltimore, Liberty and Hagerstown turnpike road was chartered in 1816. In 1817 the road was extended to the Conococheague Creek where it joined the Cumberland turnpike then under construction. This road—now U. S. 40—was completed about in 1820 and furnished a turnpike road from Wheeling to Baltimore 282 miles long, of which 177 miles were free of tolls.

Other roads were constructed soon after, and the county became one of the best accessible ones in Maryland. At that time a weekly passenger stage left Hagerstown on Tuesday arriving in Baltimore on Wednesday; the return journey took Friday and Saturday.

CITIES AND TOWNS

The County seat of Washington County is Hagerstown which was laid out in 1762 by Capt. Jonathan Hager who came from Germany in 1730. Capt. Hager had settled in the vicinity of Antietam Creek about two miles west of the present site of the town. His farm is said to have had the first two story log house with an arched cellar as refuge against attacking Indians.

The first name of the new town was Elizabeth Town which was changed to its present name by an act of the legislature in 1814. At the same time the town was incorporated. Ordinances by the commission were ordered published "in the German and English newspapers printed in the town."

In 1805 there were about 250 houses in Hagerstown, mostly built of logs, very roomy and substantial.

Sharpsburg was laid out in 1763 by Joseph Chapline and named in honor of Governor Sharpe. Surrounding the town is the famous Antietam battlefield.

Williamsport is situated at the confluence of Conococheague Creek and the Potomac River. It was founded by General O. H. Williams in 1787.

Clear Spring grew into a small hamlet in the beginning of the 19th century. A Post Office was established in 1823.

Hancock is the westernmost town in Washington County and was founded by Mr. Hancock, the first settler. It is located at the point where the State is only 1½ miles wide and where the Baltimore and Ohio Railroad, the C. & O. Canal, and the Cumberland turnpike came together.

Boonsboro was settled by William and George Boone, who are supposed to have been members of the Daniel Boone family. In 1796 there were five houses in the town, in 1829 there were 29. The Washington monument above Boonsboro on the summit of South Mountain was erected by the citizens of Boonsboro in 1827.

Cavetown at the foot of South Mountain received its name from Bishop's Cave. In 1820 the inhabitants were "103 whites and 2 slaves."

Funkstown was established by Henry Funk and a group of Germans who introduced the cultivation of vine in that area.

Weverton was named after Capt. Wever, a celebrated engineer connected with the Baltimore and Ohio Railroad, who built the first bridge at Harpers Ferry, laid out Pennsylvania Avenue in Washington, D. C., and was at one time Secretary of the U. S. Senate.

Tilghmanton village was named after Col. Frisby Tilghmanton who came to the County from the Eastern Shore and laid out the town in lots for poor people.

Ringgold named after Major Samuel Ringgold in 1850 was originally called Ridgeville and first settled by John Creager who built a log house there.

Keedysville was founded by Samuel Keedy who built the first brick structure in the town in 1836.

ELECTION DISTRICTS

At the time of the organization of the County, twelve election districts were established. They are shown in Table 1 with their original names and population as of 1880. The new districts are also listed and shown on the topographic map of the County published by the Department of Geology, Mines and Water Resources.

TABLE 1
ELECTION DISTRICTS OF WASHINGTON COUNTY

NO.	NAME	POPULATION 1880	POPULATION 1940
1	Sharpsburg	2311	1813
2	Williamsport	2625	3127
3	West Hagerstown	4031	6125
4	Clear Spring	2715	1735
5	Hancock	2233	2988
6	Boonsboro	2262	2339
7	Cavetown	1665	2044
8	Pleasant Valley (now Rohrersville)	1304	1366
9	Leitersburg	1564	1288
10	Funkstown	1534	1889
11	Sandy Hook	1585	1428
12	Tilghmanton	1580	1618
13	Conococheague	1630	1729
14	Ringgold	832	1662
15	Indian Spring	1736	1566
16	Beaver Creek	1199	1085
17	East Hagerstown	4591	4932
18	Chewsville	973	1230
19	Keedysville	1205	945
20	Downsville	1013	856
21	Hagerstown	new	5702
22	Hagerstown	new	6102
23	Wilson	new	1074
24	Hagerstown	new	4687
25	Hagerstown	new	7739
26	Halfway	new	1769

The old districts, West Hagerstown (No. 3) and East Hagerstown (No. 17) have been divided and a number of new districts were created as follows: Hagerstown Nos. 21, 22, 24, and 25; Wilson No. 23, and Halfway No. 26.

POPULATION

The increase in population of Washington County since 1790, has not been evenly distributed. As can be seen from Table 2 some areas have changed little during the last 50 years and some have even decreased in population.

The figures are rather interesting because they show the shift of the population from small urban centers toward industrial centers. With improvement of transporta-

TABLE 2

POPULATION OF WASHINGTON COUNTY 1790–1940

1790	15,822	1850	30,848	1910	49,612
1800	18,659	1860	31,417	1920	59,694
1810	18,730	1870	34,712	1930	65,882
1820	23,075	1880	38,561	1940	68,838
1830	25,268	1890	39,782	1950	78,648
1840	28,850	1900	45,133		

TABLE 3

POPULATION OF INCORPORATED TOWNS

	1880	1940
Boonsboro	859	938
Clear Spring	721	500
Funkstown	600	798
Hagerstown	6,627	32,491
Hancock	931	940
Keedysville	389	404
Sharpsburg	1,260	834
Smithburg	433	612
Williamsport	1,503	1,772

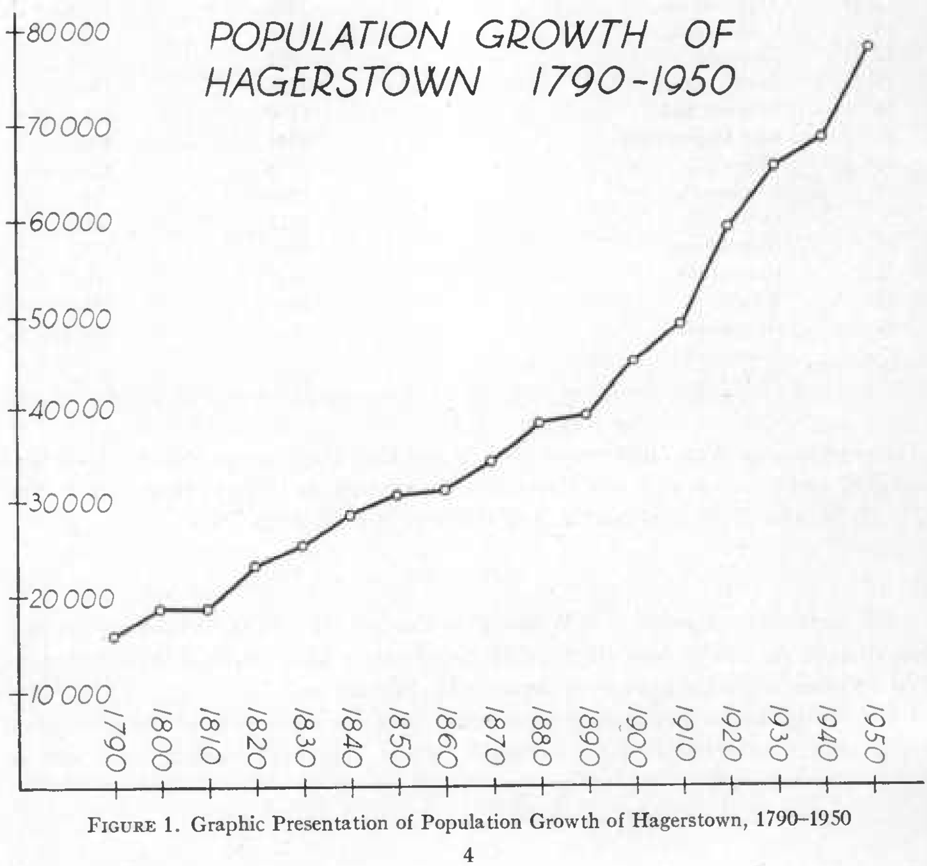

FIGURE 1. Graphic Presentation of Population Growth of Hagerstown, 1790–1950

tion there is now a tendency to move back again because the automobile makes the larger city accessible even from small outlying districts.

The fluctuating population is shown graphically in Figure 1 and in Tables 1–3.

GEOGRAPHY OF WASHINGTON COUNTY

LOCATION AND SIZE OF AREA

Washington County is bounded on the north by the Mason and Dixon line which separates Fulton and Franklin Counties in Pennsylvania from Maryland. The eastern boundary against Frederick County is the summit of South Mountain. Allegany County on the west is separated by Sideling Creek. The Potomac River forms the boundary against Morgan, Berkeley, and Jefferson Counties in West Virginia and Loudon County, Virginia. The triangular shape of the County is the result of the complicated and winding course of the Potomac River in relation to the straight course of the Mason and Dixon line.

The County is situated between 39°20′ and 39°45′ north latitude and 77°30′ and 78°20′ west longitude.

The area of the County is 467.95 square miles, of which 458.47 are land.

GENERAL DESCRIPTION

The largest portion of the County is in the Great Valley which is here called Hagerstown Valley and further north Cumberland Valley in Pennsylvania. The easternmost portion covers the western slope of South Mountain. West of Clear Spring the County is a part of the Ridge and Valley Province of the Appalachian Mountain area. Long ridges transect the County in a northeasterly direction and these are in turn transected by the Potomac River and its tributaries.

The west side of the Hagerstown Valley is formed by the Bear Pond Mountains. This is a group of ridges and peaks which are due to the erosion of a number of large folds in Silurian and Devonian strata. They are the northward extension of North Mountain or Massanutten Mountain in West Virginia. The entire group disappears further north in Pennsylvania where the Valley area is considerably wider than in Maryland.

To the west of the Bear Pond Mountains are several prominent ridges, Coon Ridge, Pigskin Ridge, Timber Ridge, and Cove Ridge, all of which are dominated by geological conditions and the distribution of hard and soft formations and their resistance to erosion.

West of Hancock are two prominent ridges which continue from Pennsylvania across the County into West Virginia: Tonoloway Ridge and Sideling Hill.

The highest point in the County is Quirauk Mountain in South Mountain with an elevation of 2145 feet. Other prominent elevations are Black Rock and Lambs Knoll in South Mountain; Fairview, Hearthstone, Rickards, and Powell Mountains in the Bear Pond area; and the crest of Sideling Hill. From all of these points a beautiful view can be had in clear weather.

The average elevation of the Valley is 500 feet above sea level. It slopes from about 600 feet in the northern portion to 350 feet in the southern. In the mountainous areas west of Clear Spring elevations range from 400 feet in the river valley to 1600 and 1800 feet in the mountains.

RAILROADS

Four railroads serve the County and converge at Hagerstown: the Western Maryland Railroad, the Shenandoah Valley division of the Norfolk and Western Railway, Cumberland Valley division of the Pennsylvania Railroad, and the Hagerstown branch of the Baltimore and Ohio Railroad (Fig. 2.)

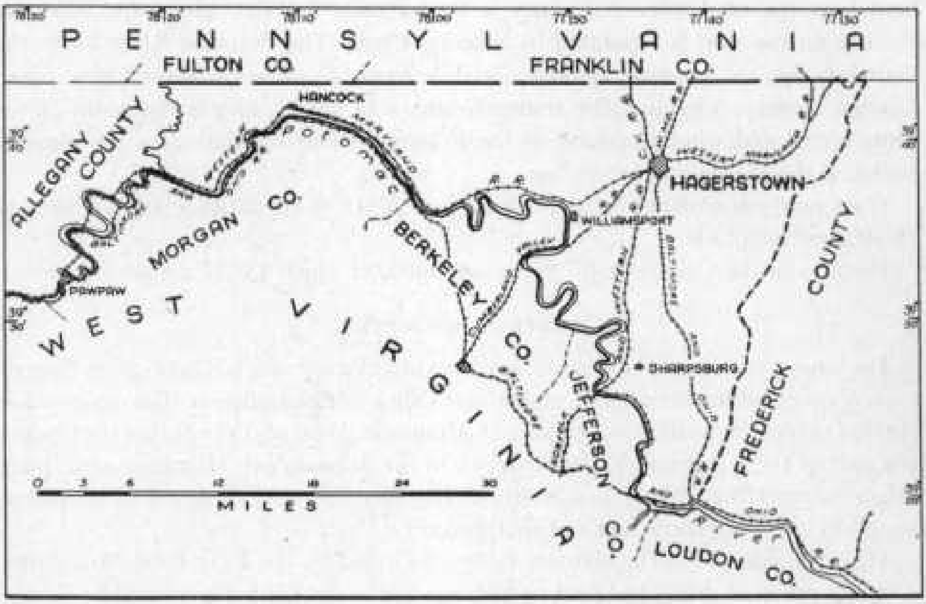

FIGURE 2. Railroads Serving Washington County

The Western Maryland Railroad enters the County on the crest of South Mountain at Blue Ridge Summit and descends southwestward into the Hagerstown Valley. A branch line from Edgemont extends to Waynesboro, Pennsylvania. The main line reaches the Potomac River at Williamsport and follows its course for most of its journey to Cumberland and the coal regions to the west. The line from Big Spring westward traverses some of the most attractive scenery and best geologic exposures in the county. Large portions of its tracks are blasted out of the solid cliffs and ledges as at Round Top, Great Cacapon, and Sideling Hill. A branch of the Western Maryland Railroad follows the Cumberland Valley northward from Hagerstown into the Chambersburg area and continues to Harrisburg. The Western Maryland was the last to be completed and reached Hagerstown in 1873. Trains ran from Baltimore to Westminster in 1861 and to Union Mills in 1862. The western continuation from Hagerstown reached Big Pool in 1892 and Cumberland in 1906.

The Cumberland Valley Railroad enters the County 2 miles south of Williamsport on a bridge across the Potomac River and proceeds through Hagerstown into Pennsylvania. Originally it ran from Martinsburg, Virginia (now West Virginia), to Harrisburg, Pennsylvania. Construction began in 1836 and it was opened to Martinsburg in 1874. It is now managed by the Pennsylvania Railroad.

The Norfolk and Western Railway traverses the County from north to south, following the Valley and intersecting the other railroads at Hagerstown. It enters the County from the south on a bridge across the Potomac River 2 miles southwest of Sharpsburg and leaves the County 5 miles north of Hagerstown. It was formerly the Shenandoah Valley Railroad and had been started as a local work by home capital. In 1880 its first train entered Hagerstown from the south.

A branch line of the Baltimore and Ohio Railroad enters the County at Weverton in the extreme south, follows Pleasant Valley between Elk Ridge and South Mountain, and terminates at Hagerstown. The last rail of the branch line was laid in 1867 and regular passenger and freight service instituted. The first shipment was a carload of wheat to Baltimore. The main line of the Baltimore and Ohio Railroad merely touches the County between Weverton and Harpers Ferry.

HIGHWAYS

Washington County is traversed by U. S. 40 from east to west and by U. S. 11 from north to south. In addition, there are many through State roads and improved County roads. U. S. 40 enters the County at Turners Gap and passes through Boonsboro, Funkstown, Hagerstown, Clear Spring, and Hancock. A new alternate and much shortened express highway from Frederick to Hagerstown enters the County south of Pine Knob along the right-of-way of the the now abandoned Hagerstown and Myersville electric railroad.

U. S. 11 enters the County at State Line from Chambersburg, Pennsylvania, passes through Hagerstown, and leaves the County at Williamsport.

Four major highway bridges span the Potomac River at Hancock, Williamsport, Sharpsburg, and Sandy Hook.

BUS CONNECTIONS

All points in the County are easily reached by bus. The major lines follow the main roads and run at frequent intervals.

MAPS

The entire area is covered by 15 minute topographic quadrangle sheets on the scale of 1:62,500 or one inch to one mile issued by the U. S. Geological Survey. The sheets which cover the County are shown in Figure 3. These maps and such information as could be gathered elsewhere have been combined into a County map by the Department of Geology, Mines and Water Resources. It shows in addition to topography, culture and drainage the election districts in green and the main roads as red overprint.

The Army Map Service issued 7½ minute quadrangles during World War II on scales of 1:31,250 and 1:25,000, showing topography, culture, drainage, and forests, covering the portion of the County east of longitude 78°.

Road maps are issued by the State Roads Commission on a scale of one inch equals one mile and one inch equals two miles.

The Maryland Geological Survey has also issued a forestry map (1913) and a geological map (1941) at the standard scale of 1 inch equals one mile. The forestry map shows forest areas in different colors representing commercial types and the geological map shows the geological formations in colors.

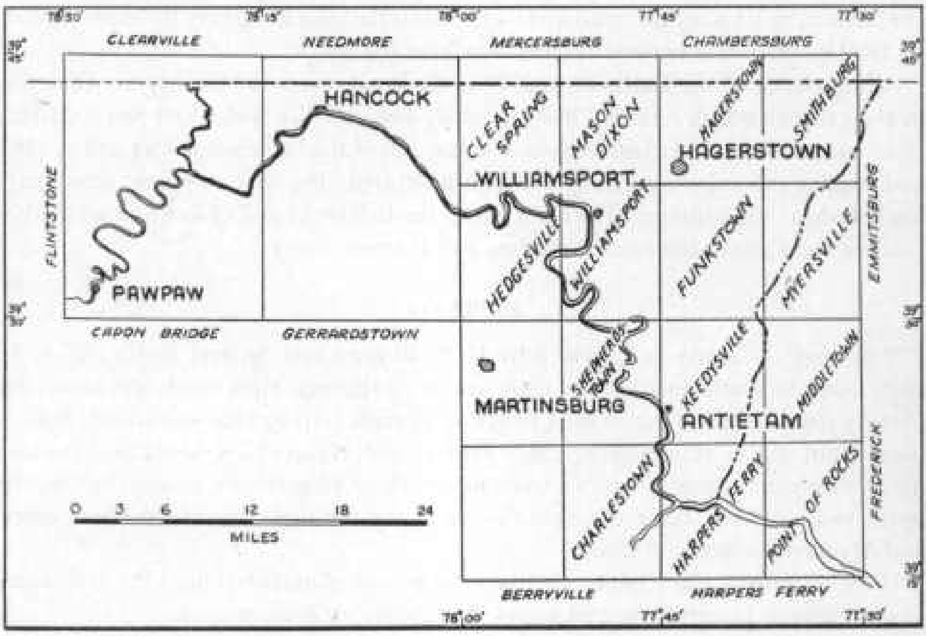

FIGURE 3. Topographic Maps Covering Washington County. Names are the names of the quadrangles published by the U. S. Geological Survey. The four eastern quadrangles are each divided into four sheets on the scale 1:25,000. Their names are written diagonally.

PHYSIOGRAPHY

RELIEF

The relief and drainage pattern of the County result from erosion attacking rocks of very unequal resistance against erosion. The differences in resistance are due to geological processes as folding, faulting, and uplift. Many different kinds of rock of varying hardness are side by side in spite of the fact that they had been deposited in layers one above the other. The rocks slowly disintegrate due to weathering, and running water carries the debris away.

Washington County includes parts of three major physiographic provinces: South Mountain and Elk Ridge are in the Blue Ridge Province, Hagerstown Valley is the northern continuation of the great Valley of Virginia, and the area west of Clear Spring is a portion of the Ridge and Valley Province. These three provinces constitute long parallel zones that extend from Alabama to New England.

The relief of the County is well shown in Figures 4 and 5. Figure 4 extends northward into Pennsylvania in order to present a more complete picture of the physiography. Figure 5 shows the relief in 26 cross sections. The Potomac River, Conococheague Creek, and Antietam Creek indicate the locations of the sections. Vertical elevations are at twice the scale of horizontal distances.

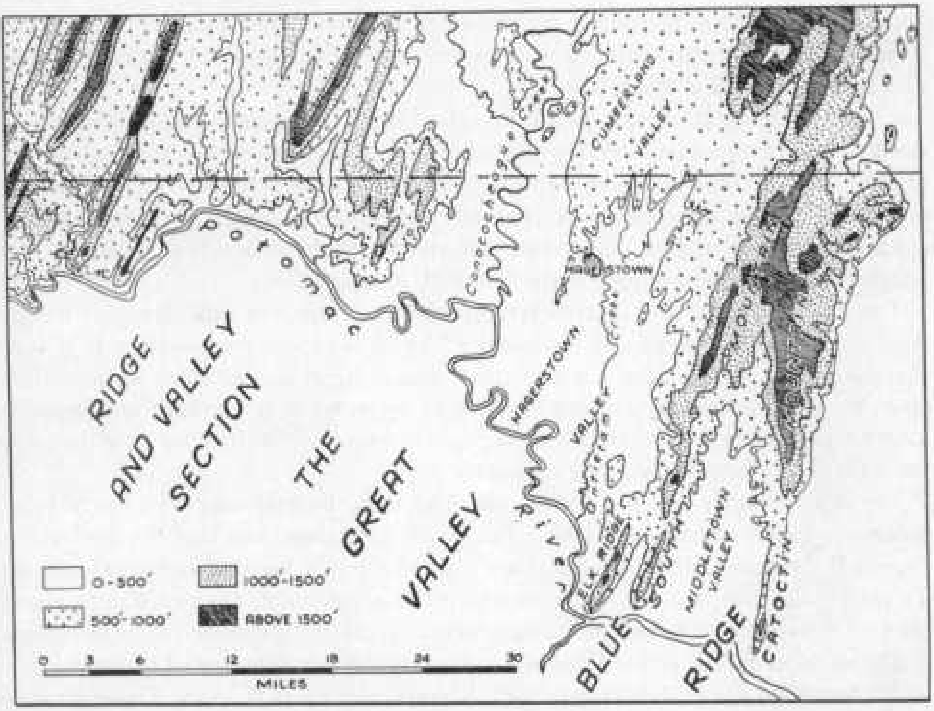

FIGURE 4. Map Showing Elevations in Washington County

The difference in elevation between the Valley floor and the mountainous areas in the east and west is clearly shown in Figure 5. Within the Valley there are slight differences of elevation and the floor slopes gently toward Conococheague and Antietam Creeks and the Potomac River. Between the Bear Pond Mountains and Tonoloway Ridge the general level is somewhat higher than in Hagerstown Valley and the slope toward the River is less pronounced. Here the river gorge is more abruptly entrenched, steeper, and narrower.

The maximum relief within the County is 1870 feet between its highest point in Quirauk Mountain and its lowest at Sandy Hook (275 feet).

DRAINAGE

Washington County is entirely within the drainage basin of the Potomac River. The major tributaries are Sideling, Tonoloway, Conococheague, and Antietam Creeks.

The Potomac River and its larger tributaries are meandering streams in a terrane which is at present unfavorable for the development of elaborate meanders. An inspection of the topographic maps, especially those issued by the Army Map Service, shows that the smaller streams rarely meander but flow more or less directly in a valley and rarely cross large ridges in gorges. The larger streams flow in deeply entrenched curves which are conspicuously displayed in the topographic map of the County and especially well developed in the Potomac River between McCoys Ferry where it leaves the Bear Pond Mountain area and Harpers Ferry where it crosses the Blue Ridge. Conococheague Creek meanders in a restricted valley which is geologically determined by differences in hardness of formations, and Antietam Creek also follows geological directions.

All the streams are entrenched in a valley below the general valley floor. This means that the meanders were formed when the stream flowed in a plain above its present level and became entrenched when the whole area was uplifted and the stream erosion became invigorated by steepening of the stream gradient. Meanders form in old landscapes where flood plains dominate and where the stream is sluggish and the gradient low. A good example is the lower Mississippi River.

The Potomac River and its tributaries present a problem of explanation of meanders indicating old age in an environment which is very much younger. It is furthermore difficult to understand how the Potomac River and all other streams that cross the Appalachian Mountains are able to do so when the terrane between the source and mouths of these rivers is a region much more difficult to traverse than are the valleys in which the streams originate.

The explanation is that the streams are older than the mountains and reached the ocean in a rather direct course before the mountains existed and that the mountains rose as the streams cut into them like a buzz saw into a log that is pushed into it. To accomplish this, the rise of the mountains must be slower than erosion to allow time for the river to cut the valley deeper and to avoid being dammed up or diverted.

The meandering streams of Washington County are thus interpreted as old streams which flowed on a peneplain truncating the largest portion of the area. These streams were then cut into the peneplain as the mountains rose. In this development several stages can be recognized and will be outlined below.

An inspection of the geologic map shows that the entrenchment of the streams is not accidental but closely related to distribution of rocks and their hardness and also to the position of formations in space. Several factors have thus determined the course of the streams: the slope of the peneplain, the rise of the peneplain, and the structure of the underground.

POTOMAC RIVER

The Potomac River enters the County at its confluence with Sideling Creek at elevation 500 and leaves the County at Weverton at elevation 260. The length of the river between these two points is 83 miles. The distance along a straight line is 42.2 miles. The difference is due to meanders. The average gradient of the river is approximately 3 feet per mile, which is a rather steep gradient for a meandering stream.

The upper portion of the river between Sideling Creek and McCoys Ferry is less complicated than that below. The river cuts through Sideling Hill and Tonoloway Ridge in a straight east-west course, bends to the northeast and reaches its northernmost point in the County at Hancock, and turns southeastward in a fairly straight

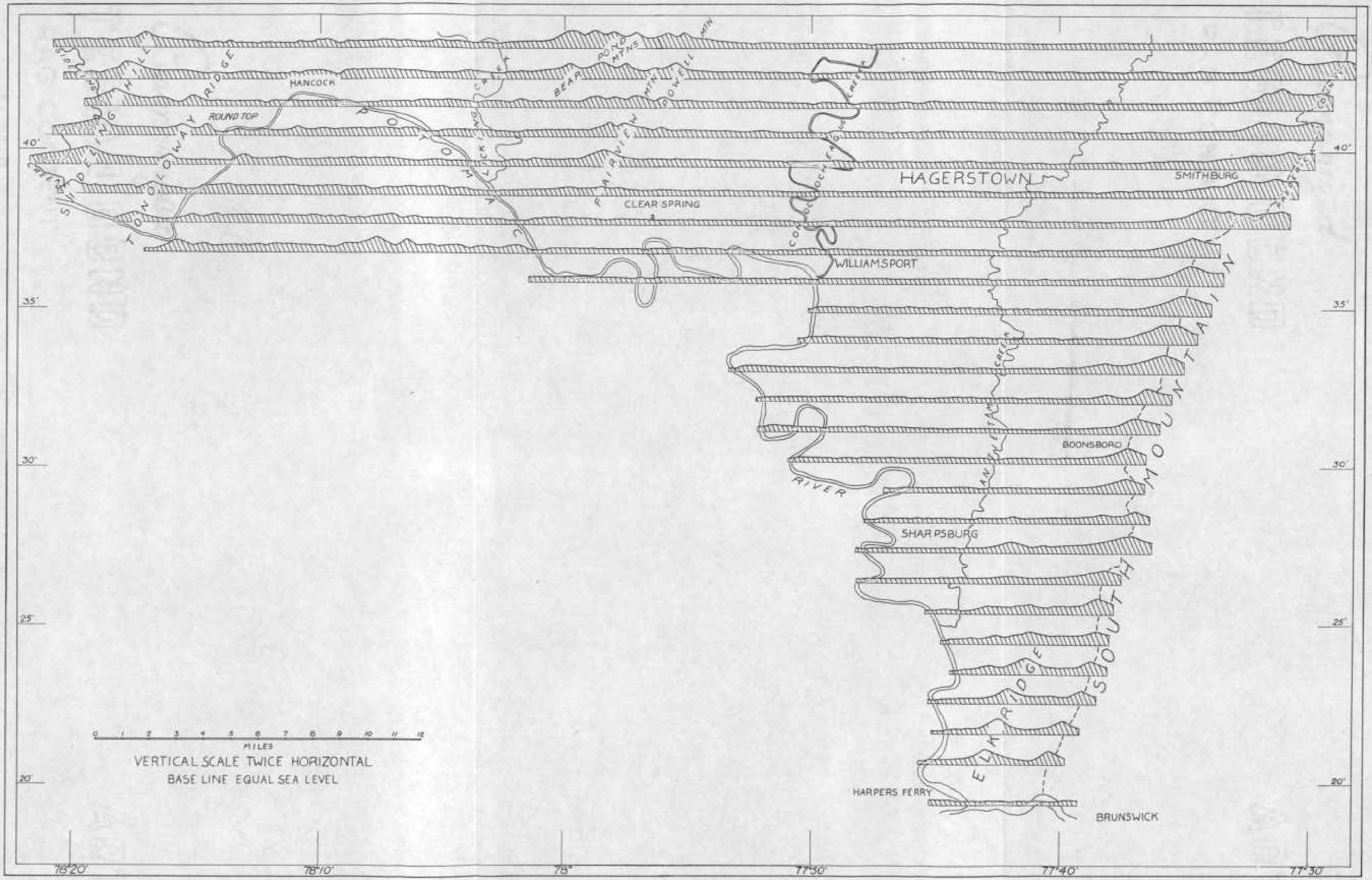

Figure 5. Twenty-six Cross Sections Showing Surface Configuration of Washington County.
Vertical twice horizontal scale. The sections are in their proper positions with respect to the map as indicated by the streams.

P. 10 B

P. 10 B

course to McCoys Ferry. Here it leaves the Ridge and Valley Province and enters the Great Valley. In its course through the former it transects two large ridges but avoids Cacapon Mountain. From Hancock it follows a course between gently plunging fold axes. The anticlinal axes of Elbow Ridge, Hearthstone Mountain, and Fairview Mountain plunge southward toward the river. These axes rise again in West Virginia. This may be coincidental or may have influenced the river course even at an early stage due to the unequal distribution of harder and softer formations.

At McCoys Ferry the river begins to meander and the meanders are entrenched about 100 feet below the general level of the Hagerstown Valley. That the river course fluctuated laterally is shown by its gravels on the valley floor at many places a mile or more from its present course.

The structure of the valley floor seems to have influenced the course at some points as, for instance, from Williamsport to the south the river follows the boundary between Martinsburg shale and the limestones for part of the way. From Powell Bend to Falling Waters the river imitates Conococheague Creek and crosses to the west side of the shale belt, but returns to the east when it meets the limestone wall.

West of Sharpsburg are several meanders which are alined in the north northeast-south southwest direction of the general strike of the formations in the area. Two miles southeast of Antietam the river touches the Antietam sandstone and turns back westward, but tries again south of Dargan where it has cut through the sandstone into the Harpers shale. Not being able to proceed across Elk Ridge here, it turns back westward once more and finally succeeds at Harpers Ferry to cut through Elk Ridge and South Mountain in a steep-walled gorge.

CONOCOCHEAGUE CREEK

Conococheague Creek displays the most beautiful meanders of any of the tributaries and has been discussed in the literature because of its prominent physical features. The stream is 22 miles long from where it enters the county to its mouth at Williamsport. The air distance is only $8\frac{3}{4}$ miles. It drops from 400 feet elevation to 360 feet, and the gradient is 1.8 feet per mile which is considerably less than the average gradient of the Potomac River.

Figure 6 shows the lower portion of the Creek in the Williamsport quadrangle. The boundaries between limestone (Stones River and Chambersburg formations) and the Martinsburg shale are shown as heavy black lines. The 500 foot contour is the irregular line and indicates the shape of the valley floor.

Conococheague Creek is entrenched approximately 100 feet into the gently southward sloping valley floor. Figure 6 shows that the elaborate and regular meanders of the stream are restricted to a narrow zone which coincides very closely with the boundaries of the Martinsburg shale against the Chambersburg limestone. Three of the meanders coincide with this boundary on the west side of the valley at Hicksville, between Hicksville and Wilson, and at Wilson. An older stream channel north of Pinesburg is also bounded by the limestone contact. The eastern curves are sharper and have not reached the limestone but are also well alined.

The contrast between the western flattened curves and the eastern sharper curves is probably closely related to the resistance of the limestone to mechanical erosion.

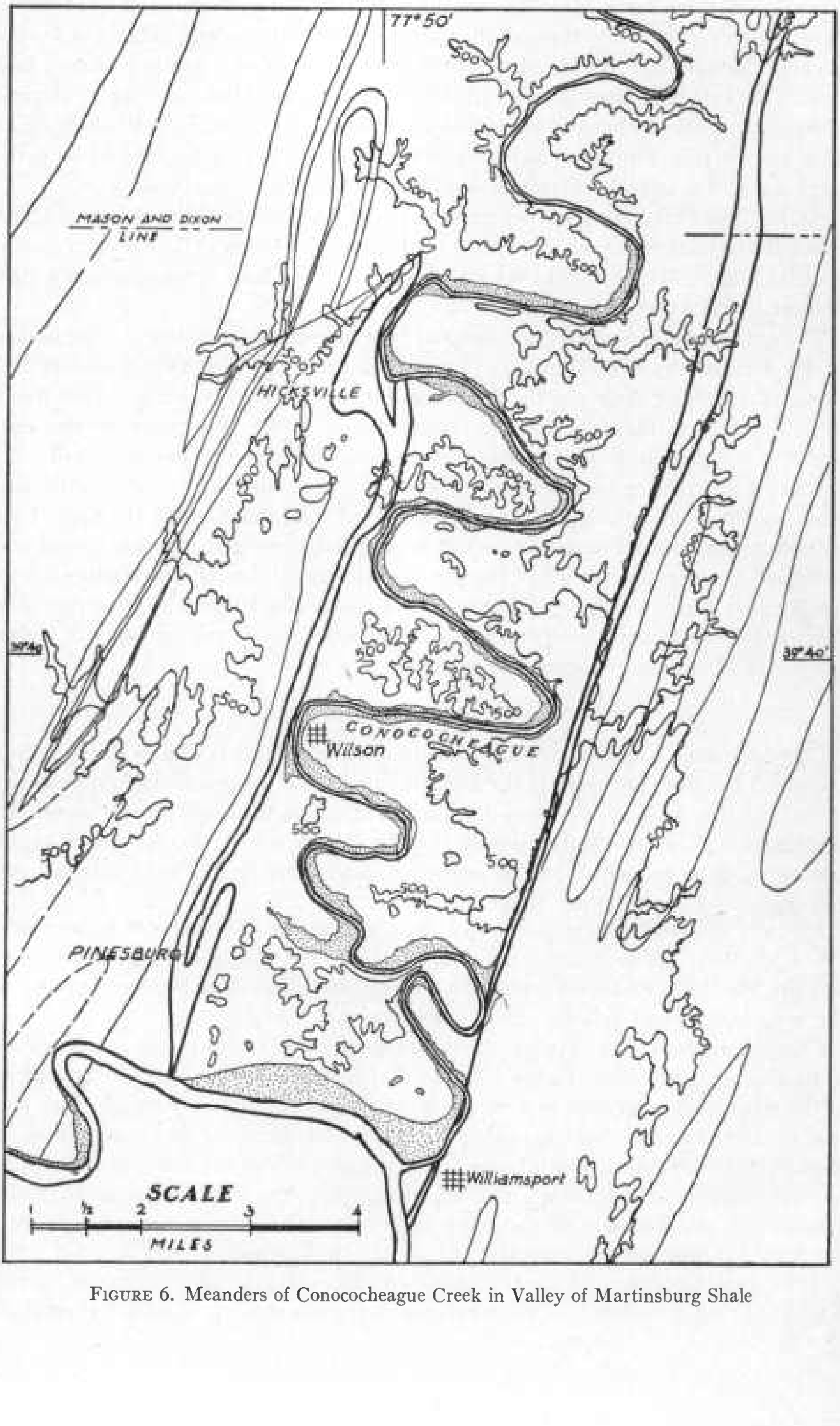

FIGURE 6. Meanders of Conococheague Creek in Valley of Martinsburg Shale

At Hicksville the creek follows the contact very closely. The strike of the limestone changes from N 45 E to N-S and the creek follows this strike of the limestone contact.

It has been suggested by Johnson, Bascom, and Sharp (1932) that the valley of the lower Conococheague was originally a valley in the Clinton shale between walls of Tuscarora sandstone and that after fixation of the creek's position erosion cut down through the Tuscarora, Juniata and into the Martinsburg. This interpretation seems unlikely because the gravels of the creek are found on the valley floor on limestone and the coincidence between present course and the distribution of shale seems to be too close to be inherited from a much higher level.

It is generally assumed and frequently stated that limestone resists erosion less than shale. This is probably true where chemical reaction predominates. It is not necessarily true where mechanical erosion may be particularly active and the shale is very intensely fragmented. The limestone on both sides of the creek valley are thickly bedded limestones with fractures which are widely spaced and always cemented by secondary calcite. The beds are mostly near vertical, offering the stream rather substantial and homogeneous barriers. The shale, on the other hand, is almost everywhere a pencil slate due to the large angle between very distinct slaty cleavage and bedding. The pencils are in the direction of the general strike and may well be less resistant to erosion than the solid limestone walls.

It would seem that the low resistance of the shale is responsible for the restriction of the meandering creek to the lowland. Originally the creek spilled over on the limestone surface, but eventually slipped off that surface. The surface which contains the gravels is most likely the valley floor and may be correlated with the Harrisburg peneplain.

ANTIETAM CREEK

Antietam Creek displays meanders of equal beauty, but on a much smaller scale. Its major tributary, Beaver Creek, is also an older stream which seems to have originated on the same plane as Antietam Creek.

The course of the creek roughly parallels the trend of formations from northeast to southwest. A relationship between its general course and the geology of the underground is not recognizable. Its meanders are deeply entrenched in all formations and cross their contacts.

DEVELOPMENT OF TOPOGRAPHY

A striking feature when looking westward across Hagerstown Valley or from Fairview Mountain, or eastward from the crest of Sideling Hill, is the even crest line of most of the mountain ranges. The crests of Sideling Hill, Cacapon Mountain, South Mountain, and Catoctin Mountain are long, almost horizontal lines, and when seen from east or west do not convey the impression of a mountainous region.

The even skyline of most of the Appalachian mountains is thought to be due to erosion of a former much higher mountain range down to a peneplain of very low relief with meandering rivers and isolated remnants rising above it.

This peneplain is preserved at a few places where the ranges show flat tops as in South Mountain north of Blue Ridge Summit or at Great Cacapon Mountain in

West Virginia. In most of the area the original plane is not preserved, but subsequent erosion after elevation lowered portions a few hundred feet and the less resistant ones a great deal more. The flat tops of the highest mountains are thought to be the remnants of an original plane of denudation or base level which covered the largest portion of the eastern United States from Ohio to the Atlantic Ocean. This is the plane in which the Potomac or Susquehanna Rivers flowed toward the ocean and drained the interior of the continent.

This plane was called the Schooley peneplain by W. M. Davis from its remnants on Schooley's Mountain in New Jersey. It is now at an elevation of about 2000 feet in South Mountain and at elevations of 2000 to 2200 feet farther west (Stose and Swartz, 1912). Stose (1909) considered the rather flat surface of Cross Mountain in the Bear Pond region a part of the same surface.

The Schooley peneplain is the remnant of the old base-level which represents a prolonged period of erosion after the Appalachian folding and also after deposition of the Triassic rocks farther east. It is probably the plane on which the Cretaceous sediments of the Coastal Plain region were deposited. As this plane was gradually uplifted the large rivers cut into it preserving their general course across the trend of the mountain system. Tributaries cut down the peneplain to only a few isolated remnants. The difference in resistance against weathering and erosion became a most important factor in the sculpture of the topography. Hard quartzites stood out as ridges, shales and limestones were cut down much faster. The ridge makers today are principally the Weverton sandstone and quartzite in South Mountain and Elk Ridge, the Tuscarora and Juniata sandstones in the Bear Pond Mountains, the Oriskany sandstone in Elbow Ridge and Tonoloway Ridge, and the Purslane sandstone in Sideling Hill. Minor ridge makers are the Antietam quartzites in southeastern Hagerstown Valley, the Keefer sandstone at Fairview Mountain and others.

Since erosion respected harder rocks their position in folds became influential. Where axes of folds plunge the surface frequently plunges also as for instance on Fairview Mountain and Hearthstone Mountain, and on Cross Mountain in Pennsylvania. Where axes were more or less horizontal large, continuous, almost horizontal ridges occur, only interrupted by a water or occasional wind gap. The slight plunge of folds in the South Mountain Ridge is largely responsible for the unevenness of its crest line and the isolated heights as Lambs Knoll and Pine Knob. Faulting may also play an important part.

In the large broad fold of Cross Mountain which continues eastward into Hearthstone Mountain, the Tuscarora and Juniata sandstones and conglomerates are nearly horizontal with a slight southward dip and east-west strike. This area has been thought to be the remnant of the Schooley Plain. It would seem, however, that the peneplain should be higher and the flatness of the mountain top is more closely related to the position of the sandstone.

Uplift of the Schooley peneplain was not uniform but occurred with interruptions. Such planes may be represented in Keith's Weverton stage, indicated by the summit of South Mountain north of Weverton. It is most pronounced in the elevation of the floor of the Hagerstown Valley.

The general elevation of Hagerstown Valley is 500 to 600 feet and is shown in Figure 5 and on the topographic map as a rather even surface into which the larger and smaller streams have cut deep valleys. Gravel deposits near the Potomac River and Conococheague Creek prove that these streams meandered in that plain and may be responsible for their existence.

Stose and Swartz (1912, pp. 148–149) have described the meanders of the Potomac west of Hancock and think that the river changed its course considerably in that plain. The straight course from Hancock to McCoys Ferry is probably little changed since it was cut into the Schooley peneplain. Gravels on both sides of the river show, however, that the land rose and the river cut into the peneplain due to increase of gradient.

The valley floor peneplain has been called the Harrisburg stage because it was described first in that vicinity. It has been traced along the Cumberland Valley to the Potomac River and farther south. The elevation of the surface of the plane is about 900 to 1000 feet on the east side of Sideling Hill. It drops to about 700 feet near Hancock and to about 600 feet west of Harpers Ferry (Stose and Swartz, 1912).

After formation of the Harrisburg peneplain the land was again uplifted, the meanders became deeply entrenched, erosion became more intense, and tributaries cut into the valley floor. Post Harrisburg stages have been recognized in river terraces and intermediate levels or erosion. One of these has been called the Sommerville Stage.

STRUCTURE AND TOPOGRAPHY

The topography depends largely on the distribution of rocks of varying hardness and erosion of softer less resistant rocks. Hagerstown Valley is a limestone valley. South Mountain in the east and the Ridge and Valley area to the west are mountainous areas because ridgemaking sandstones are eroded less readily than softer shales and limestones. Many smaller surface forms are still more intimately related to the underground geology.

The Bear Pond Mountains are one of the most obvious examples. From Cross Mountain and Hearthstone Mountain the Tuscarora sandstone dips southward in a gentle slope paralleling the surface. Cross Mountain and Hearthstone Mountain are the crest of a large anticline. To the east are Sword Mountain which is the western limb of the Fairview Mountain anticline. The ridge is sharp and narrow because the strata are vertical. Fairview Mountain is the crest of the anticline and slopes gently southward in the direction of the plunge of the anticlinal axis. Gillians Knob is at the crest of a syncline and forms a broad summit with gently dipping Tuscarora sandstone and higher than the limbs of the fold.

Throughout the entire area broad knobs and summits are at the crests of anticlines and synclines, and sharp ridges and elongate forms are the limbs of folds with steeply dipping or near vertical limbs. Sideling Hill and Tonoloway Ridge are long synclines with horizontal axes. Between Hancock and Clear Spring surface forms are determined by plunging fold axes and the intersection of folds with the horizontal.

Ridges and valleys within the Hagerstown Valley are influenced by the position of various formations. The Conococheague Creek valley has been described. The

Waynesboro formation usually makes narrow ridges favorable for the growth of peaches east of Hagerstown and near Boonsboro. The Antietam sandstone forms a broad Knob north of Boonsboro and east of Mt. Pleasant.

Most of the knobs and summits of South Mountain are folds and crests in the Weverton sandstone such as Lambs Knoll, Pine Knob, and Quirauk Mountain. Wherever the sandstone lies flat the summit is also a flat surface. This coincidence may lead the casual observer to infer peneplains where structure is the determining factor and not peneplanation.

STRATIGRAPHY OF SEDIMENTARY ROCKS

BY

ERNST CLOOS

INTRODUCTION

GENERAL REMARKS

This report aims at a description of the stratigraphic column as it is now known. The literature has been consulted extensively and new observations are included.

Detailed and very painstaking work had been done by C. K. Swartz and his collaborators in the Silurian and Devonian. Their results have been published in the systematic series of the Maryland Geological Survey. Nothing comparable exists for the Cambro-Ordovician or for the Carboniferous. The Cambro-Ordovician volume of the Maryland Geological Survey contains little original work and is not as detailed as the work by Swartz. Little detailed work has been done in the Maryland section, and a complete investigation of the Cambro-Ordovician section would have been beyond the scope of the report. Formations that have been more thoroughly studied recently are dealt with more extensively. J. T. Wilson and R. B. Neuman recently studied the Conococheague and Stones River formations. A more detailed study has been made by the author of the Weverton and Harpers formations, especially since structural observations have considerable bearing on the stratigraphy.

For fossil content the reader is referred to the chapter on the Paleontology by Thomas W. Amsden.

STRUCTURES AND LOWER PALEOZOIC SECTION

The stratigraphic sequence is presented in this report as shown in the legend of the geologic map of Washington County (1941). Figures 16, 18, and 19 are correlation charts of the Ordovician, Silurian, and Devonian formations.

West of longitude 78 the geologic map is a reprint of the PawPaw-Hancock folio by Stose and Swartz with some alterations in the legend suggested by C. K. Swartz. Changes necessary to bring the sequence and correlations up-to-date are discussed in this report.

Structural geology is discussed in another part of this report. But structures which are important in determining the position of beds in space, for finding top and bottom of a sequence, and in determining the age of a rock complex with respect to another are discussed in this introduction.

Stratigraphic succession and age are frequently linked to deformation and its traces, and cannot be accurately determined without observation of all necessary details. The author has made observations which are communicated here and applied in the interpretation. Since his conclusions vary from those of earlier workers, the evidence is presented in some detail.

Three kinds of observations have been used in the determination of stratigraphic sequence: cross bedding, graded bedding, and the position of axial plane cleavage in a fold. They play a fundamental part in the geology of eastern Washington County because they assure recognition of top and bottom of beds and sequences but have not been used by previous workers.

Cross bedding.—Figure 7 shows how top and bottom of a stratum can be determined by means of cross bedding. These criteria (described by Billings, 1942, p. 73) were applied at the crucial exposures of Weverton sandstone in South Mountain and Elk Ridge. In Figure 7A the strata are horizontal and the curves of cross-bedded layers are concave upward with disconformity of the bed above and gradation into the bedding plane at the bottom of the bed. The cross beds are repeated several times above one another.

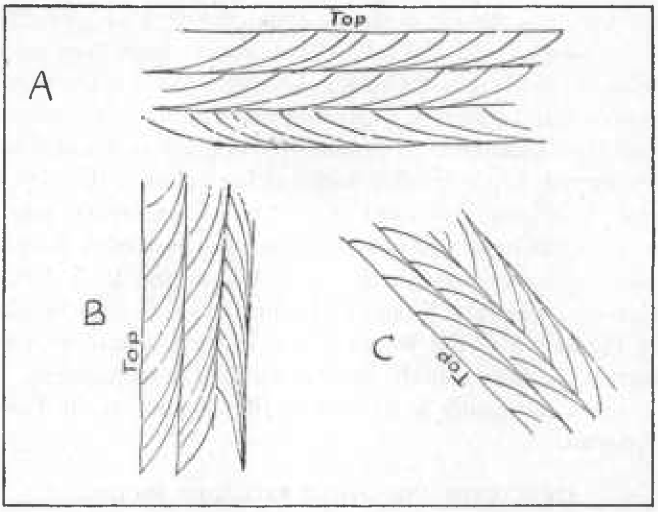

FIGURE 7. Cross Bedding in Different Positions. A—normal and right side up; B—vertical, top to left; C—overturned, top to left and down.

Figure 7B shows cross bedding vertical with the top of the beds to the west (left) in Weverton sandstone on the crest of Elk Ridge ½ mile northeast of the eastern bridgehead at Harpers Ferry. The outcrop is a few hundred feet above the trail from the highway to the crest of the ridge near the contact between Harpers shale and Weverton sandstone. Excellent cross bedding in Weverton sandstone can be seen in the many islands in the Potomac River. The beds become visible due to the presence of shaly partings and bluish and purple lines or layers of pebbles and large sand grains. This cross bedding is very common and cannot be confused with "torrent bedding" as described by Billings (p. 73).

Figure 7C shows cross bedding overturned to the west as exposed in Raven Rock Hollow, east of Smithburg and north of Crampton Gap. Here the beds of Weverton sandstone dip 40 to 60 degrees east and the top is on the overhanging side of the beds. Gentler overturned beds can be observed from Crampton Gap to the north and south along the Appalachian trail.

Graded bedding.—Graded bedding is shown in Figure 8 after Billings. The rock grades from coarser constituents like pebbles and sand grains into finer constituents upward. Where the beds are upside down the bed becomes finer grained downward.

Graded bedding is common in Weverton sandstone and well exposed in the islands in the Potomac River below Harpers Ferry where the Weverton sandstone crosses the river. It is also well exposed in the river islands at Weverton where the sandstone crosses the river.

Cleavage.—The relation between axial plane cleavage and stratification can also be used in the determination of top and bottom of beds, overturned limbs of folds, and the position of anticlinal and synclinal axes with respect to the observer's position within a fold.

Cleavage can only be used in those cases in which it comprises the entire fold and not where it is restricted to a zone of dislocation, as, for instance, a fault zone, or to individual beds with particular cleavage.

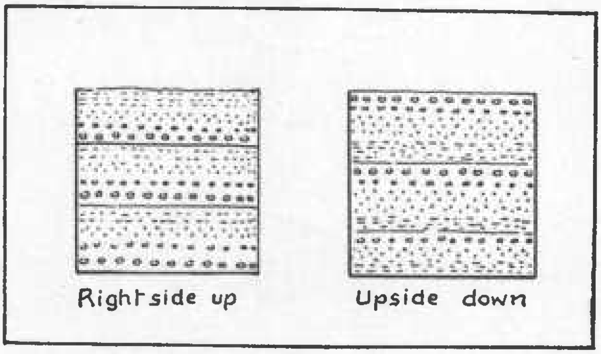

FIGURE 8. Graded Bedding. The material grows finer upward

In eastern Washington County, the South Mountain uplift shows a very dominant typical cleavage whose attitude is rather constant throughout the entire uplift. In that area the cleavage can be used to define the position of an outcrop within a fold.

Figures 9A and 9B show these relations diagrammatically. Figure 9A is a symmetrical upright anticline and syncline and shows 3 positions within that structure: 1) in the crest of either the anticline or syncline; 2) in the eastern limb of an anticline or the western limb of a syncline; and 3) in the western limb of an anticline or eastern limb of a syncline.

Figure 9B shows the same mutual relationship in an overturned asymmetrical fold. Location 1 can be in either crest, location 2 in the overturned limb of the anticline to the right or the syncline to the left, and location 3 is in the upper limb of an anticline. In location 1 cleavage is perpendicular to bedding; in location 2 cleavage is gentler than bedding, and in location 3 cleavage is steeper than bedding.

The same principles are described by Billings (1942, Pl. XV and pp. 224 to 231) and by Nevin (1949).

If such cleavage observations agree with cross bedding and graded bedding, the position of beds and sequences are determined with considerable assurance and accuracy.

All rocks of South Mountain show cleavage, and some important formations like the Weverton sandstone, the Harpers shale, and the Antietam sandstone show cross bedding, graded bedding and cleavage.

In the Weverton quartzite cleavage is not always readily recognized in massive layers but can always be seen in thin sections cut normal to the intersection of cleavage and bedding. All less competent beds show good cleavage in rather constant orientation.

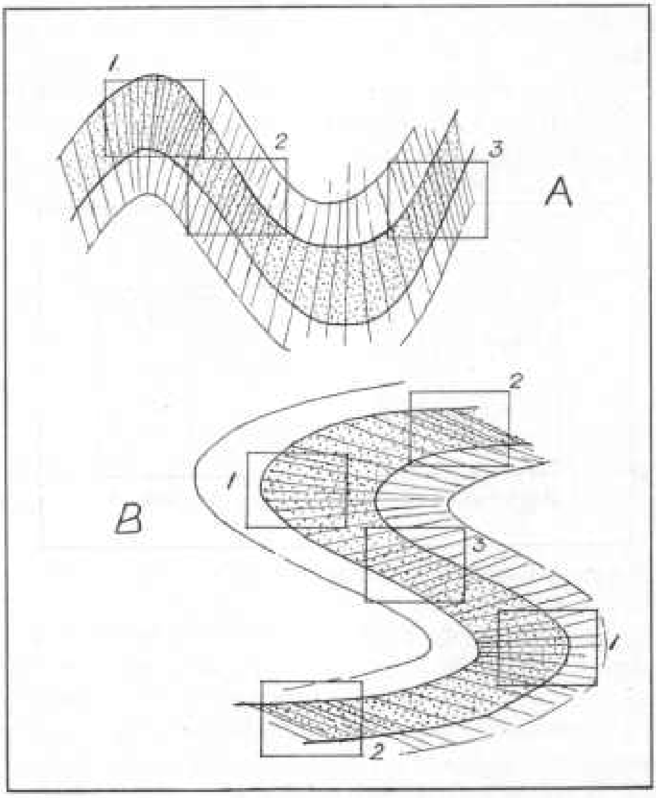

FIGURE 9. Axial-plane Cleavage in Folds. Area 1: cleavage normal to bedding in crests of folds; Area 2: anticline counter clockwise; Area 3: anticline clockwise.

TOP AND BOTTOM OF SECTION

The type sections for Loudon, Weverton, and Harpers formations are in the vicinity of the Potomac River gorge below Harpers Ferry, West Virginia. From here the formations have been traced to the south and the north.

The Weverton quartzite crosses the Potomac River in three prominent ridges: Elk Ridge which becomes Blue Ridge to the south and disappears northward near Rohrersville; South Mountain which disappears to the south and continues northward through Maryland and into Pennsylvania; and Catoctin Mountain to the east. In the Potomac River gorge Elk Ridge and South Mountain are excellently exposed in hundreds of islands and innumerable exposures on the north and south banks of the river. The new highway (U. S. 340) along the south side of the river provides continuous outcrops through Elk Ridge.

In order to establish accurately the structural and stratigraphic relations the entire section from above Harpers Ferry to below South Mountain, one half mile downstream from Weverton, was surveyed with planetable.

Keith (1893) interpreted both Elk Ridge and South Mountain as synclines underlain by Loudon and volcanics and both separated from Harpers shale to the west by faults. At Harpers Ferry the fault was thought to be an overthrust along which the Elk Ridge syncline overrode Harpers shale. Keith never published details or showed the evidence on which his conclusions were based. In a first paper by Keith and Geiger (1891, p. 158) the reason is given as follows: "Some parts of the axis are flat,

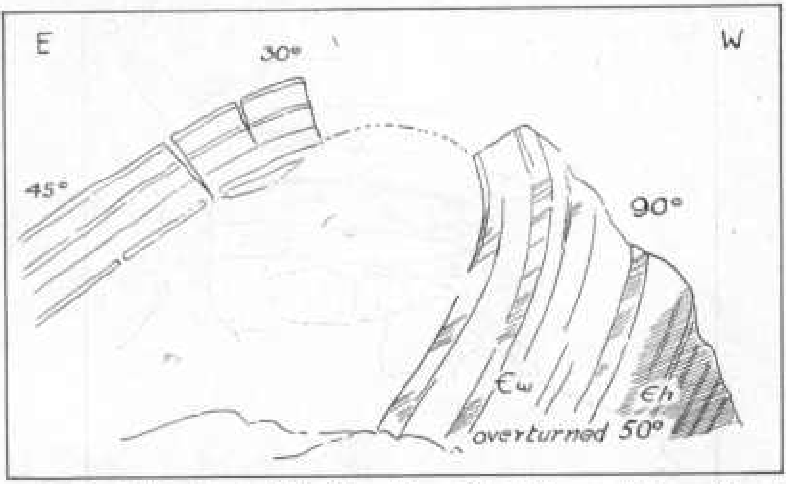

FIGURE 10. South Mountain Anticline Viewed from U. S. 340 across Potomac River. Distance from limb to limb at base approximately 2,000 feet. Top limb almost a dip slope, west limb overturned, cleavage gentler than bedding, both dip east (see also Figure 23).

some are closely folded. In many cases no ledges occur to furnish dip observations, but the sandstones are caps of hilltops surrounded by slopes of shale, so that they can be nothing but synclines in structure."

Stose and Stose (1946) adopted this interpretation and speak of the Elk Ridge syncline (p. 110) and the "overturned isoclinal syncline" at Weverton (p. 103). Two diagrams illustrate these views.

Detailed work like plane table mapping on a large scale (1:200) and analysis of cross bedding, graded bedding, and the relation between cleavage and bedding show that both Elk Ridge and South Mountain are recumbent anticlines overturned westward and with normal sequence on their west sides. Elk Ridge is really the much contorted crest of the South Mountain fold of a larger order of magnitude, whereas South Mountain is an anticline with normal sequence in the type locality at Weverton. Further details are described under structural geology.

These observations are not isolated but were repeated along the entire western slope of South Mountain and in Elk Ridge. The crest of South Mountain between

Potomac River and Crampton Gap is overturned westward as can be seen at many places along the Appalachian Trail where cross-bedding and cleavage are well visible. North of Crampton Gap to Lambs Knoll the overturned Weverton forms the crest of the ridge. At the southern termination of the platform of Weverton sandstone which forms the top of Lambs Knoll, the crest turns over into Lambs Knoll where the Weverton is normal. Figure 11 shows the western edge of the Lambs Knoll fold where the upper limb can be seen and cleavage dips gently eastward, indicating that the axial plane of the fold may dip about 30 to 45 degrees east. This is about the same amount of overturning as in the crest between Lambs Knoll and the Potomac River.

South of Pine Knob in the road cut of U. S. 40 at the summit of the new highway horizontal Weverton or Loudon beds can be seen with a cleavage dipping about 25

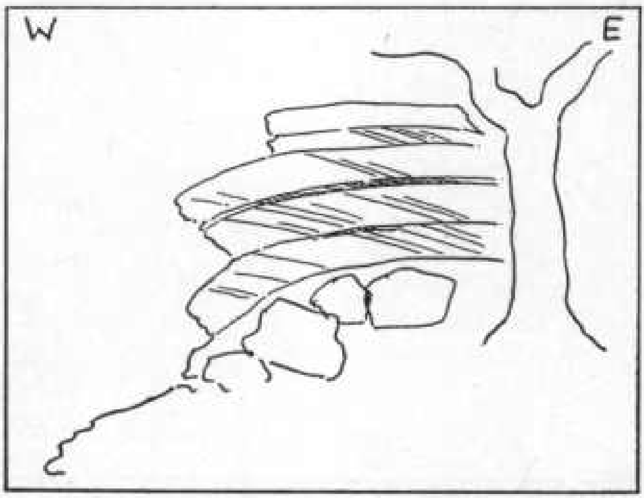

FIGURE 11. West Side of Lambs Knoll in South Mountain Anticline. Cleavage dips east, bedding curves downward to the west. Height of cliff about 30 feet.

to 45 degrees east. In Pine Knob to the north of the road cut and north of the apple orchard a cliff in the forest shows Loudon conglomerate with bedding horizontal and gently curving downward to the west. Cleavage dips more steeply to the east (Fig. 12).

At Raven Rock Hollow cross bedding indicates that the top of the section is to the west and cleavage is gentler than bedding. Bedding dips about 60 degrees and cleavage about 30 degrees east. The valley to the south shows the same relationship (Fig. 13). The section is in the lower limb of the overturned fold.

Similar examples could be multiplied—all indicating the same overturned anticline and a normal sequence along the western slope of South Mountain.

The top of South Mountain is in part the upper limb of the fold and in part the lower limb of the next fold above. Cleavage-bedding relations permit easy recognition of the structural relationship which is mostly supported by cross-bedding.

The northern termination of Elk Ridge is an easily recognized anticline. Bedding dips outward from the northward plunging axis.

These facts mean that the top of the section at Weverton is to the west and that the Weverton is overlain normally along the west side by Harpers shale. There is no

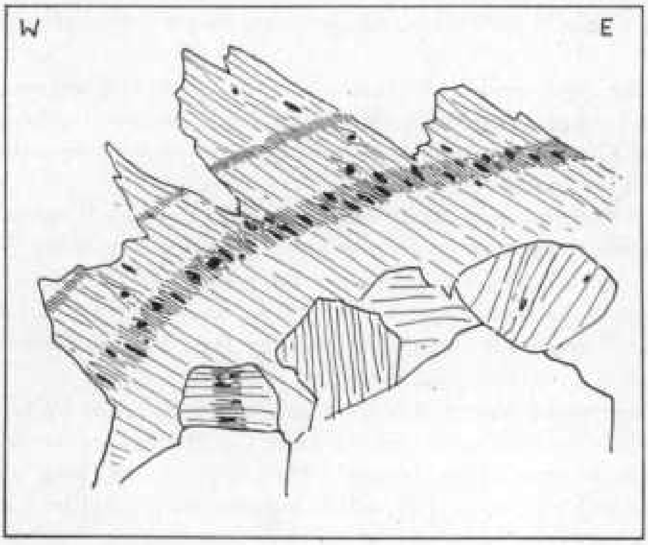

FIGURE 12. Bedding, Elongate Pebbles, and Cleavage West of Pine Knob, 500 Feet West of Appalachian Trail. Bedding dips west, cleavage east. Height of cliff about 30 feet.

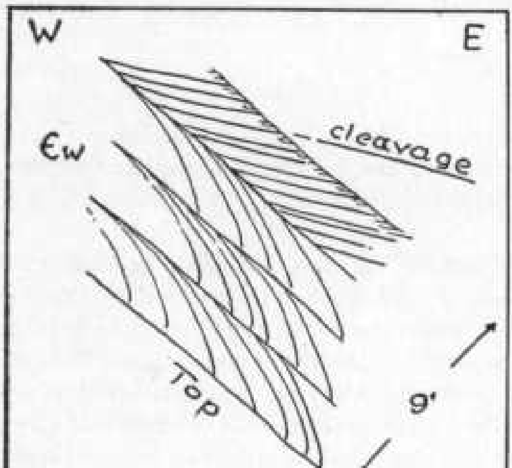

FIGURE 13. Cross Bedding, Cleavage, and Bedding at West Side of South Mountain, Raven Rock Hollow, in Weverton Quartzite.

Loudon on the west side, and where shales are exposed they are lower Harpers formation. The west side of Elk Ridge is also a normal sequence as can well be seen in the many outcrops. In the new road cut at Potomac River gorge bedding in the Weverton is greatly contorted, but at the contact it is vertical with the west side at the top. In Harpers shale bedding is parallel and also vertical at the contact. Farther away and to the west it flattens out and is overturned up to 45 degrees as may be expected in a fold-crest where the less competent bed thickens considerably. Cleavage in the contact zone is horizontal and even dips west shortly before the contact is reached.

B. L. Mather spent considerable time in identifying top and bottom of the Weverton along the crest of South Mountain and Elk Ridge between the Pennsylvania line and Potomac River. The results of his investigations were incorporated in the geological map of the county.

Since Keith interpreted the South Mountain and Elk Ridge Weverton as synclinal it became necessary to interpret also the fact that the bottom of the Weverton rests on Harpers which led to the conclusion of the presence of the Harpers Ferry overthrust. Observation shows, however, that the normal sequence is not disrupted and the top of the Weverton is normally overlain by Harpers. An overthrust cannot be seen and there is no necessity for one.

The type section at Weverton is described in general terms by Stose and Stose with the synclinal interpretation in mind. Since the relations are reversed the section as described by Stose and Stose is upside down and the lower ledge maker becomes the upper one and vice versa. The section is discontinuous and poor and rather incomplete.

The above observations are fundamental for the interpretation of the stratigraphy of the area. The author did not map the entire South Mountain uplift, but observations in Catoctin Mountain seem to indicate also that that area is anticlinal and not synclinal.

THICKNESS OF SECTIONS

The thickening of beds in anticlinal crests is a well known fact, but has rarely been considered in measurements and interpretations of stratigraphic thicknesses. Large as well as small anticlines can be distorted considerably and doubling or tripling of thicknesses is common.

Sections measured in anticlinal crests are apt to be exaggerated. If they are compared with other sections from limbs of folds or unfolded sections correlations may lead to erroneous conclusions about thickening and thinning of stratigraphic sections and variations in the depths of troughs or geosynclines. The differences may be due to deformation and post-sedimentary alterations rather than primary differences.

Even if the actual thickening in one or the other section may not be considerable it would be of utmost importance to know the order of distortion that may be expected in an area. If, for instance, a section may double because of such distortion the limit of errors is 100 per cent and it would seem fruitless to compare variations of thicknesses of 25 or 50 per cent and postulate deepening of ten to twenty per cent. Changes of 200 feet in a 1000 foot section become irrelevant in a tectonic area like the Appalachian region under discussion. The question has been discussed in connection with a systematic investigation of oölite deformation in the South Mountain fold (Cloos, 1942, 1947).

Formations along the western slope of the South Mountain uplift are at the crest of the recumbent South Mountain anticline and their thickness is generally exaggerated. The systematic investigation of oölite distortion has proven that these thicknesses may be doubled and tripled in the limestones. As a general rule one can assume that thickening is considerable in those sections in which intense cleavage transects strata at a large angle.

Observation of sand grains in the Weverton sandstone permits determination of the position of cleavage and probably thickening. Since Weverton quartzite is a much more competent layer than the Harpers shale, it thickens less than the shale.

The section at Harpers Ferry shows these relations beautifully. Figure 14 is a diagrammatic illustration of the principle which dominates the entire western slope of the Blue Ridge-South Mountain anticlinorium. The contact of Weverton and Harpers shale is vertical and bedding in both formations is also vertical near the contact. Proceeding westward the bedding in the Harpers formation is inclined toward the east and the cleavage dips gently west or is horizontal, since the section is not in the axial plane but below it. The axial plane dips gently about 20 to 30 degrees eastward.

The position of the Harpers shale in the crest of the anticline means a greatly exaggerated thickness in this section and explains why the Harpers formation is so thick at this locality. Unfortunately, it also means that the thickness as estimated at this locality is meaningless in terms of other sections and its true thickness is simply not known.

All other formations, including the Antietam, Tomstown, Waynesboro, Conococheague and parts of the Beekmantown, may also be exaggerated greatly. Many of these type sections have been measured in the crestal portions of South Mountain fold and should be carefully checked for tectonic distortion. In sections where cleavage is not readily visible, like the limestones or the Weverton quartzite, a thin section normal to the intersection of cleavage and bedding will usually reveal its position under the microscope.

Sections are given or referred to in this report as described in the literature and a systematic investigation of distortion of stratigraphic thicknesses must be reserved for future investigation. It may well be that stratigraphic sections of the Cambro-Ordovician along the Blue Ridge-South Mountain anticlinorium are in need of revision and that such revision would prove of fundamental importance in stratigraphic correlations in the Appalachian geosyncline.

THE CAMBRIAN-PRE-CAMBRIAN UNCONFORMITY

There seems to be general agreement by previous writers on a basal unconformity below the Loudon formation. This would mean that pre-Loudon volcanics are pre-Cambrian and since the Loudon-Weverton-Harpers-Antietam sequence is conformable and fossiliferous at the top, that sequence is lowest Cambrian. This conclusion is furthermore supported by local conglomerates at the base of the Loudon. In addition, an overlap of Loudon on Swift Run Tuff, aporhyolite, metabasalt, and granodiorite has been described by Stose and Stose (1946, p. 28). They also call attention to diabase dikes which are genetically related to the Catoctin metabasalt and intrude the granodiorite but not the Paleozoics above.

There are, however, other facts which indicate that the volcanics may be Lower

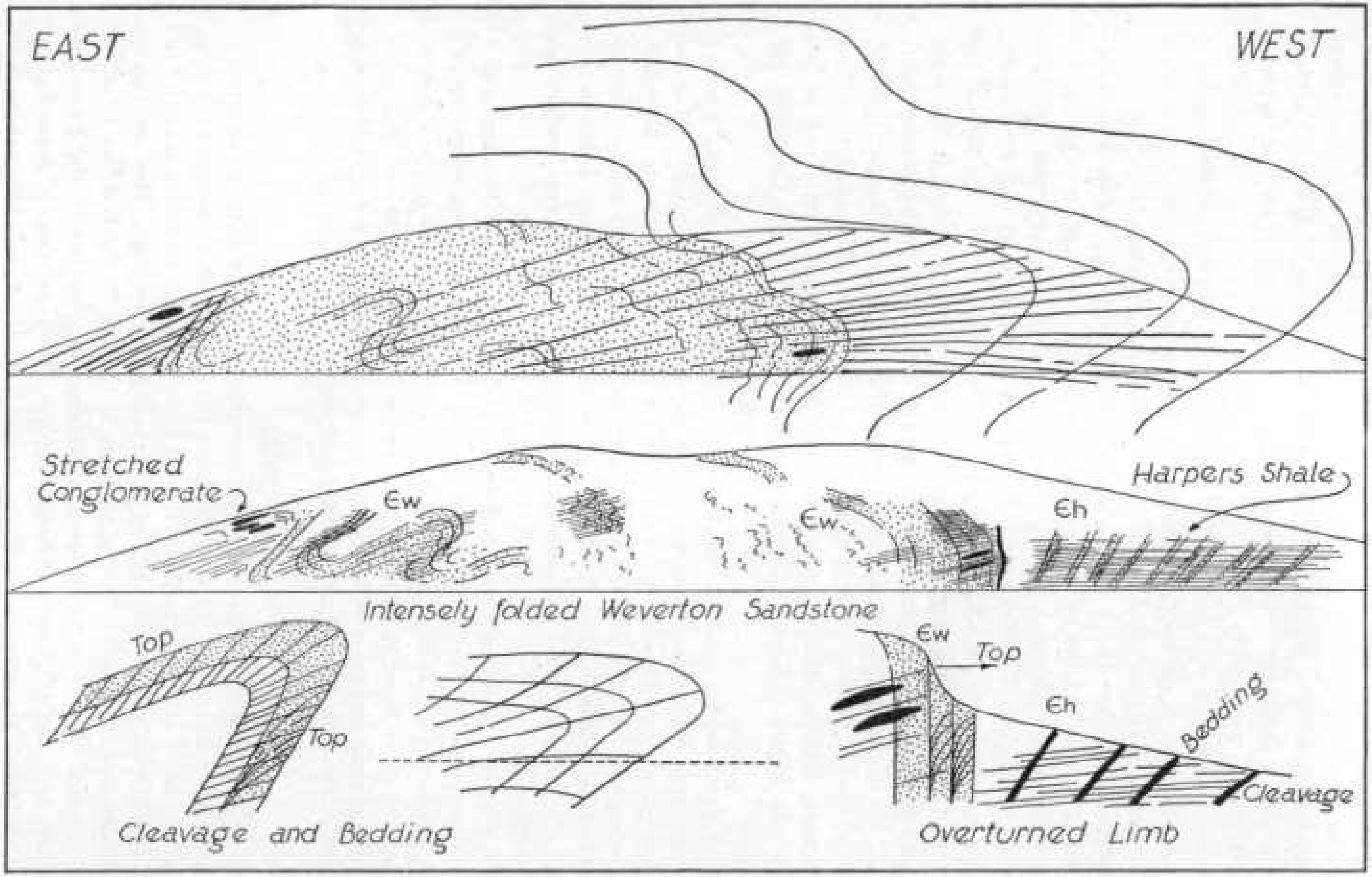

FIGURE 14. Diagram of Weverton Fold below Harpers Ferry. Top section: generalized view of recumbent fold. Center: intense folding of Weverton. In Harpers, beds diverge due to thickening of fold-crest. Cleavage becomes more gently dipping in lower limb due to increasing distance from axial plane. Bottom left: fan cleavage in general; bottom center: cleavage dips with respect to axial plane; bottom right: general situation at Weverton-Harpers contact. Black ellipses: quartz grain orientation.

Cambrian and not pre-Cambrian. The granodiorite is probably pre-Cambrian with an unconformity below the volcanics.

At many places there are gradational changes from the volcanics into the Loudon above. Sand grains appear in well-bedded volcanics below the Loudon and tuffaceous purple bands are interbedded within the Loudon and above the conglomerate. Downward and upward the change is gradational and not abrupt as should be expected if an unconformity were present.

The deformation of volcanics and the overlying Cambrian is conformable and there is no structural unconformity. Cleavage continues upward without deflection, lineations are parallel, and fold axes above parallel those below.

The conglomerate at Pine Knob contains phyllite pebbles, jasper, quartz, slate, and other detrital material made up of worked up underground.

The conglomerate deserves special attention. Its constituents are poorly sorted, heterogeneous, and much distorted. Especially the phyllite pebbles are flat and thin lenticular bodies. If these had been thin, disc-shaped pebbles flattened prior to their inclusion in the conglomerate they would now lie parallel to the bedding planes. These pebbles, however, parallel the cleavage and where cleavage intersects bedding at a large angle, the pebbles also stand upright on the bedding plane making a large angle between their longest dimension and the bedding surface. It is obvious that the pebbles were not phyllite when they became included but of the same or similar consistency as the adjacent phyllite within the conglomerate and below it. The deformation of the Loudon beds is common and identical to the beds below.

The overlap described by Stose and Stose (1946) could well be explained by an irregular distribution of the volcanics above the granodiorite basement. Such irregular distribution would be expected in volcanics and is the rule in all recent volcanic areas. Lava flows are local, ash and tuff deposition is uneven, and some areas remain uncovered. The Loudon formation itself is erratic and irregular and of varying thickness, absent at many places and thicker at others. This may well be the typical deposition on an irregular volcanic surface of some relief.

Diabase dikes which cut the basement may have been feeding channels for the genetically related greenstones above and would not need to cut the Cambrian above, since it was then not present.

The volcanics above the granodiorite may well be Cambrian and the base of the Cambrian may be the surface of the granodiorite below the volcanics. The reasons are: the conformity of deformation in the volcanics and the lower Paleozoics, the gradation of sand downward and tuffaceous material upward, and the absence of a clear cut unconformity indicating an hiatus. The irregularities which exist are continued in the Loudon-Weverton contact.

The basement complex is probably the granodiorite-gneiss which is the only complex which shows structures that digress the regional trends above. Above the basement there have been volcanic eruptions and flows of various kinds, fed possibly through dike-like channels in the basement. This landscape was gradually submerged and filled in with sandy sediments and conglomerates, and stratified layers became prominent, but the distribution of this formation (the Loudon) is still irregular.

Finally, the sand deposits became a far-extended sheet which covered the entire area but still with varying thickness.

During the subsequent deformation of the area, folding of volcanics and overlying sediments was very similar and rather conformable. The basement participated but less willingly.

CAMBRIAN SYSTEM

LOUDON FORMATION

Name.—The Loudon formation was first described by Keith in 1892. The type locality where the formation is best developed is Loudon County, Virginia.

Character and thickness.—The Loudon is a rather erratic and irregular formation. At most Maryland localities it is absent. Very locally a prominent conglomerate is conspicuous but it is not widely or evenly distributed.

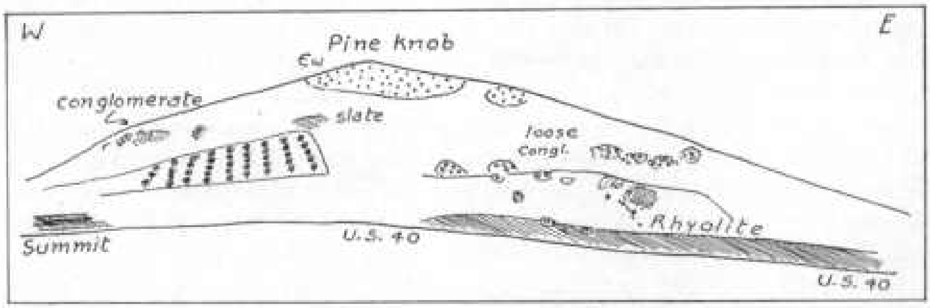

FIGURE 15. General View of Pine Knob from the South. Vertical equal horizontal scale. U.S. 40 about one-third mile closer to observer than Pine Knob. Cleavage dips gently east in all rocks. Bedding is horizontal and bends downward in the western slope.

The sandy formation grades downward into volcanic beds. Sand grains appear in the new road cut of U. S. 40 through South Mountain within the purple volcanics and increase upward in amount. Purple volcanic layers also occur between conglomerate and sandstone and graywacke within the Loudon.

At the southern slope of Pine Knob above the road cut a section as described by Stose and Stose (1946, p. 33) is:

SECTION OF THE LOUDON FORMATION AT PINE KNOB

Hard vitreous quartzite (Weverton)	Feet
Crumbly dark-banded feldspathic quartzite	100
Purple banded quartzite and thin vitreous feldspathic quartzite, in part current bedded	60
Blue to purple shiny tuffaceous slate	20
Thick coarse conglomerate of 2–4 inch pebbles of quartz and red jasper, with interbedded shiny blue micaceous slate or phyllite	20
	200

Southwest and west of Pine Knob a ledge of conglomerate is well exposed below the trail to Pine Knob leanto. In the first exposures west of the trail intersection and above the orchard is a small cliff which shows the conglomerate interbedded with purple tuffs and with flattened pebbles parallel to cleavage and at angles of from 40 to 90 degrees with bedding. In these exposures the bedding bends down to the west and the relation between cleavage and bedding shows an asymmetrical anticline overturned to the west (Fig. 15).

Pine Knob is the upper limb of an overturned anticline or the lower limb of an overturned syncline. To the west the sequence Weverton-Harpers is normal and the beds are steep.

The section in the road cut at South Mountain summit on U. S. 40 consists of green sandstone and graywacke layers interbedded with slaty beds 1 to 2 inches in thickness. The relation between these beds and the Pine Knob section is not clear, but since the bedding at Pine Knob dips very gently to the east and becomes horizontal at the crest of the anticline west of Pine Knob, it would seem that the graywacke beds are either Harpers or Loudon and faulting has probably dislocated the section. To the east of the road cut follows a considerable profile of loose rock and dirt and then the tuffaceous volcanics. Figure 15 is a schematic sketch of the approximate situation at Pine Knob and to the south along U. S. 40.

Good exposures of the Loudon are so rare that it is difficult to measure a section. Most measurements are on scattered exposures. Keith estimated the Loudon as anywhere from 0 to 800 feet thick. Stose and Stose (1946) also call attention to the variations in measured thicknesses.

Distribution.—The Loudon is restricted to the east side of South Mountain where it is rarely exposed because the much more resistant overlying Weverton quartzite furnishes large quantities of debris which covers the formation.

It has been shown by previous authors to the east and west of Weverton quartzite on South Mountain (Stose and Stose, 1946, fig. 5). The author was unable to find it west of South Mountain or Elk Ridge, but found much Harpers shale instead. Particularly good exposures in the Potomac River gorge indicate a normal sequence from Weverton to Harpers west of South Mountain and Elk Ridge from the river to the State line. The details of the structure are described under structure.

Due to the re-interpretation of the Harpers Ferry section as anticlines, the basal Cambrian section may have to be reversed. The Loudon formation thus disappears and the slaty shale and phyllite become lower Harpers. This agrees very well with the Harpers section east of Waynesboro, and the question arises whether the rocks that have been called Loudon elsewhere are not also above the Weverton and a part of the Harpers. The author is inclined to this interpretation but not yet prepared to eliminate the Loudon entirely.

WEVERTON QUARTZITE

Name.—The Weverton sandstone was described by Keith in 1892 and is named after the locality of its most prominent exposure in the Potomac River gorge below and east of Harpers Ferry. Weverton is on the north side of the river in Washington County just west of the Frederick County line.

Character and thickness.—The Weverton quartzite consists mainly of fresh, light, partly milky-white quartz grains in a matrix of secondary recrystallized quartz. Some feldspar is common and magnetite is very abundant locally. Bedding planes are visible due to interbedded shaly layers which are now sericite layers, frequently mixed with purple or reddish volcanic dust (?). The quartzite is mostly white, in some beds bluish or gray. Locally the quartz grains are ellipsoidal and much deformed and broken.

Bedding is mostly prominent, but where folding is very intense it may be obliterated. There are several coarse and conglomeratic layers with a gray matrix, weathering brown.

The section is well exposed east of Harpers Ferry in the river gorge through Elk Ridge and South Mountain. The bottom of the section is not exposed in either of the two localities and complete sections cannot be measured.

Several sections were published by Stose and Stose (1946, pp. 37 and 38). All are in Washington County and the following is the best.

SECTION OF WEVERTON QUARTZITE IN SOUTH MOUNTAIN EAST OF WEVERTON AT POTOMAC RIVER

		Feet
Largely concealed; some dark ferruginous quartzite		50±
Thick-bedded, coarse to conglomeratic, hard light-gray quartzite, banded with purple (upper ledge maker)		60±
Largely concealed; some dark ferruginous quartzite	100±	270±
Hard white quartzite	40	
Largely concealed; some dark ferruginous quartzite	100±	
Softer thick-bedded quartzite	30±	
Thick and thin-bedded granular quartzite (lower ledge maker)		95±
		475±

The above section is the type section for the formation. Neither top nor bottom are exposed.

As shown on page 21 the section is upside down since it is measured in an anticline and not as previously assumed a syncline.

A section at Raven Rock hollow east of Smithburg is fairly completely exposed. The beds are overturned to the west and dip 60° east. Cross-bedding is visible in several layers. The section begins at the Western Maryland Railroad bridge and follows the road up the valley to the east.

Keith estimated a thickness for the formation of between 1,000 feet at South Mountain and 200 feet at Catoctin Mountain. The formation seems to be thicker at South Mountain because it appears in the crest of folds, whereas in Catoctin Mountain it is located in the upper limb of an asymmetrically overturned anticlinorium.

WEVERTON SECTION IN RAVEN ROCK HOLLOW, NORTHEAST OF SMITHBURG

Section begins 0.45 miles east of railroad underpass of Western Maryland Railroad and follows road up the valley.

Traverse 110 degrees

1–10 feet, Harpers shale exposed in road. Cleavage dips 45° E

10–86 feet, concealed, loose shale in bank

86–100 feet, well-banded Harpers shale. Bedding N 28 E, dip 70 SE. Cleavage N 28 E. dip 35 SE

Traverse 107 degrees

100–154 feet, banded shale

154–157 feet, sandstone layers, harder, more massive than sbale

157–200 feet, loose shale, weathered yellow

Traverse 100 degrees
200–220 feet, loose shale
220–300 feet, three good exposures of bluish-gray fresh shale, weathering yellow with rust spots. At 285 feet, fresh exposure of lower Harpers. Finely laminated as in lower portion of Waynesboro section. Laminations 1 mm, dark and light bands. Excellent stratification. Bedding N 30 E, dip 70 SE. Cleavage N 30 E, dip 40 SE
Traverse 100 degrees
300–311 feet, laminated shale
311–400 feet, loose shale, weathered yellow
Traverse 110 degrees
400–465 feet, loose shale in bank
465–476 feet, laminated shale. Stratification vertical. Cleavage dips 50 SE. Blue-gray when fresh; brown, drab or yellow when weathered
476–800 feet, loose shale in bank. At 800, large slabs of shale, fresh, but loose
Traverse 120 degrees
800–900 feet, large loose blocks of Weverton quartzite float on yellow shale
900–1000 feet, loose shale
Traverse 120 degrees
1000–1200 feet, loose Weverton blocks on shale in ditch along road
1200–1400 feet, loose Weverton quartzite dominating
Traverse 112 degrees
1400–1500 feet, loose quartzite dominating from here
Traverse 105 degrees
1500–1600 feet, loose quartzite
Traverse 110 degrees
1600–2000 feet, loose quartzite in huge blocks
Traverse 117 degrees
2000–2100 feet, loose quartzite
Traverse 115 degrees
2100–2200 feet, loose quartzite
Traverse 111 degrees
2200–2300 feet, loose quartzite
Traverse 115 degrees
2300–2400 feet, loose quartzite
Traverse 120 degrees
2400–2500 feet, foot of alluvial fan. Rise in terrane with steepening slope
Traverse 122 degrees
2500–2600 feet, loose quartzite
Traverse 126 degrees
2600–2633 feet, loose white quartzite
2633–2700 feet, dark slate between sandstone beds. Stratification good, dip 45–65 SE. Cleavage dip 25–30 E.
Traverse 130 degrees
2700–2800 feet, loose quartzite
Traverse 128 degrees
2800–2937 feet, loose quartzite
2937 double tree under cliff

In the continuation of the section measurements were made with yardstick normal to stratification uphill across the face of the cliff.

Section across quartzite in cliff

About 100 feet north of road, beginning at tree (2937)
0–19 feet, white quartzite, very well bedded
19–19.5 feet, schistose quartzite

19.5–44 feet, white quartzite, dip 45 SE. Massive with some purple layers
44–45.2 feet, cross-bedded quartzite, overturned
45.2–46.2 feet, quartz schist
46.2–48.2 feet, cross-bedded quartzite with purple layers
48.2–60 feet, massive white quartzite with cross bedding, some torrent bedding
60–66 feet, quartzite. Purple conglomerate layer at 66 feet
66–70 feet, quartzite
70–82.5 feet, white heavy-bedded quartzite
82.5–88.5 feet, quartzite
88.5 feet, section offset about 50 feet to north
88.5–91.2 feet, quartzite
91.2 feet, stratification dips 60 SE, cleavage 25 SE
91.2–97.2 feet, white massive quartzite
97.2–154.0 feet, well-bedded white quartzite; occasional purple bands, cross bedding mostly very clear. Overturned beds
154–170 feet, well-bedded partly laminated quartz schist with purple layers. Stratification dips 60–75 SE, cleavage 25–30 SE. Excellent cleavage-bedding relationship. Conglomerate layers
170–190 feet, quartzite and quartz schist; cleavage dips gently east
190–210 feet, schistose quartzite; bedding N 30 E, dip 50–70 SE; cleavage 10–25 SE. Somewhat irregular
210 feet, on alluvial fan—loose quartzite

Discussion of section.—The section shows several thousand feet of Harpers shale to the west of approximately 200 feet of Weverton quartzite. At nine widely distributed localities cleavage and bedding can be seen excellently. In every case the cleavage dips more gently southeast than the bedding. Bedding is thus overturned to the west at angles from 80 to 40 degrees, with an average of from 60 to 40 degrees. Cross-bedding is readily seen at many localities in the quartzite and also shows overturned beds to the west.

There is little doubt that the sequence is overturned and normal and that the cliffs along the road are the western limb of an overturned anticline.

Distribution.—The Weverton quartzite forms the crests of South Mountain and Elk Ridge. To the east is the Loudon which is visible only at few places, and to the west and above the quartzite is the Harpers formation. The configuration of both mountains is closely related to the strike and dip of the Weverton. Narrow ridges are common where the quartzites are steep. Broad tops occur where the quartzite is approximately horizontal. In the broad flat summit of Lambs Knoll south of U. S. 40 the quartzite caps the mountain in the crest of a broad anticline. The dip is also gentle at Black Rock where the strata are overturned as shown by cross bedding. In the northernmost portion, the belt of Weverton is very wide due to repetition by folding.

In Elk Ridge the width of the Weverton is considerable due to repetition of the section in two anticlines which continue northward to the northern termination of Elk Ridge where the anticlinal structure can be observed. (See details under structure.)

The general appearance of the Weverton can be seen best in the Potomac River gorge, where the two major quartzites show in two excellent asymmetrical folds. The river islands are fresh and show the lithology of the quartzites very well. Good outcrops are abundant all along the Appalachian Trail from the Potomac River in the south to the State line in the north. At some places prominent cliffs stand out above the forests and offer favorable lookout points, as at Lambs Knoll, Black Rock, High Rock, and others.

HARPERS FORMATION

Name.—The Harpers formation was first described by Keith for its extensive outcrops and its prominence at Harpers Ferry, West Virginia. Since the formation is usually much changed through metamorphism, it has been called schist, slate, phyllite and albite schist (Wilmarth, 1938, p. 913). The name Harpers was first used by Clark and Williams in 1893. In the text accompanying the Harpers Ferry folio Keith used the term Harpers shale.

Character and thickness.—The Harpers formation is a series of shales and sandstones which are intensely altered due to folding. Since they are in the crest of an overturned and probably recumbent anticline cleavage is extreme and individual beds are not always seen. Along the western slope of South Mountain are some good outcrops but mostly the Harpers is found loose and highly weathered in fields or road cuts.

In fresh exposures, as in the road cut east of Waynesboro, Pennsylvania, north of the tunnel entrance east of Harpers Ferry, and along the new U. S. 40 west of South Mountain summit, the shale is bluish, brittle, dense, but always well banded. The bands are light and rather wrinkled in the crest of the fold. When exposed for some time the shale becomes gray or yellowish, the white bands turn red-brown. The bands are usually traversed by cleavage and show as brown-red lenses that are stacked one upon the other indicating bedding at a large angle to cleavage.

Several prominent sandstone beds occur at 100 feet and 1400 feet below the top of the formation. The lower 1500 feet are largely dark shales and slates with a number of sandstone beds of varying thickness in the northern portion of the area. The banding in the lower Harpers is a fine lamination.

The thickness of the formation cannot be determined readily because of the position in the South Mountain fold. In the Waynesboro section it is about 3100 feet thick, but cleavage is at a large angle to bedding and exaggeration is considerable. It is impossible to determine the amount of thickening due to lack of reference units.

At Harpers Ferry cleavage in the uppermost Weverton and Harpers is horizontal and bedding vertical or overturned. Thus exaggeration of thickness probably is considerable. At Weverton an additional fold occurs in the Harpers formation and to the west the formation is bounded by a fault which throws granodiorite against the Harpers shale. There are no other estimates on the thickness of the formation. Keith's estimate is 1200 feet at Harpers Ferry, Stose calculated 2750 feet including the Montalto quartzite member in Pennsylvania, and Stose and Stose (1946) estimated its thickness as 2000 feet in adjacent parts of Pennsylvania and Virginia.

Distribution.—The Harpers formation is limited to two long belts west of the Weverton quartzite in South Mountain and Elk Ridge. In the Potomac River gorge the Harpers composes the islands west of the Weverton in both ridges. The contact is not exposed, but the gap between outcrops is very narrow. There is no indication of a fault contact or a thrust as postulated by Keith (1898) and Stose and Stose

(1946). In both the Weverton sandstone and the Harpers bedding is vertical and cleavage very gentle or horizontal, the interval between the two formations is less than 100 feet. Cleavage shows that the fold is recumbent and that the area east of Harpers Ferry is the crest of that fold.

At Turners Gap east of Boonsboro, Harpers shale is well exposed along the old route U. S. 40. Other partial sections are at Raven Rock Hollow and along the western foothills of South Mountain.

Sections.—Complete sections of the Harpers formation are rare and only two provide data on the upper limitation and the base. The section east of Waynesboro, Pennsylvania, is probably the best one and has been measured. The Harpers Ferry section is greatly improved by construction of the new highway along the south bank of Potomac and Shenandoah Rivers.

SECTION OF HARPERS FORMATION EAST OF WAYNESBORO, PA.

Section begins at west end of road cut east of Red Run Lodge, 12 feet west of sign "Park Entrance", in Antietam sandstone

Traverse	*Thickness of Unit*	
Antietam sandstone		
feet	*feet*	
0–98	85	Blue-gray fine-grained quartz phyllite with light bands at regular intervals. Weathers gray or dark, white layers weather red-brown. Spacing of light bands 4 to 6 feet, thickness of bands from 1 to 4 inches. Bedding is very striking, dips from 90 to 40 west. Very intense slaty cleavage dips 20–40 E. In weathered exposures (in valley south of highway) cleavage dominates and red-brown beds can be seen only at few places (Pl. 8, fig. 1).
98–146	45	Dark uniform sandstone bed.
146–305	150	Blue-gray, banded, very brittle dense splintery quartz-phyllite.
305		Center of concrete culvert.
305–707	390	Banded, blue-gray, brittle, dense quartz phyllite with light bands at from 2 to 3 feet apart. Layers 1 to 3 inches thick. 70 light beds between 401 and 707.
707–740		Concealed.
740		Concrete culvert.
740–880		Concealed.
880–1410	500	Banded quartz schist, massive, well jointed and bedded.
1410–1500	85	Coarse sandstone, small pebbles and large sand grains in dark matrix, cross bedded.
1500–1600	95	Banded quartz schist.
1600–1846		Concealed, at 1621 culvert.
1846–1921		Loose sandstone, very fine-grained, dense, splintery, spheroidal weathering boulders 20–30 feet in diameter.
1921–2271	310	Banded quartz phyllite with bedding weathering red-brown. intense cleavage.
2271		Culvert.
2271–2407	128	Quartz phyllite, grading downward into softer shale.
2407–2527	110	Drab, pink, blue soft shale.
2527–2677		Loose shale, mostly concealed.
2677		Culvert, end of cut. Cable fence begins.
2677–4308		Concealed. The amount of concealed section is about 500 feet.

Traverse *feet*	*Thickness of Unit* *feet*	
4308–4479		Loose sandstone.
4479		Culvert.
4479–4627		Loose shale.
4627–4660		Cross-bedded coarse sandstone, loose, bedding vertical, strike N 45 E.
4660–4678		Loose shale.
4678–4768		White sugary, cross-bedded sandstone, fairly coarse, weathered.
4768–4924		Mostly concealed, loose, deeply weathered shale.
4924–5013	89	Loose shale and sandstone interbedded.
5013		Road sign. Soft shoulders on south side.
5013–5074	61	Blue shale, slate, laminated, interbedded with friable sandstone.
5074–5077	3	Hard coarse quartzite, light yellow.
5077–5083		Concealed.
5083–5149	66	Sandstone, weathering brown with shale partings. Beds about 1 inch thick. Intense cleavage. Bedding N 45 E, 85 SE overturned, cleavage N 40 E, 40 SE.
5149–5182	33	Green shale, sandy. Small elongate blebs down-dip of cleavage. Cavities filled with rust. Interbedded with purple sandy shale with numerous impressions of pyrite cubes.
5203–5206		Soft blue shale.
5206–5226	20	Sandy shale and sandstone, finely laminated. Bedding N 45 E, 80 SE overturned, cleavage N 45 E, dip 50 SE. Lineation down dip of cleavage. Well-elongated quartz grains.
5226–5256	30	Schistose sandstone, laminated with dark layers, weathers green or rusty brown. Blue when fresh. Bedding and cleavage very distinct.
5256		4-inch conglomerate bed with white quartz and blue slate fragments.
5256–5295	39	Phyllite and sandy schist interbedded. Fine lamination.
5295–5299	4	Hard, glassy, coarse quartzite, gray, porous, not completely cemented.
5299–5333	34	Sandstone and phyllite 50–50. Phyllite slaty.
3533–5339	6	Coarse hard sandstone with quartz veins.
5339–5339.1	.1	Phyllite.
5339.1–5341.4	2.3	Sandstone, coarse with quartz veins.
5341.4–5342.1	0.7	Sandy phyllite.
5342.1–5345	2.9	Sandstone, brown.
5345–5346.9	1.4	Sandy phyllite with magnetite.
5346.9–5374	27.1	Phyllite and sandstone interbedded in 22 layers of sandstone in phyllite.
5374–5375.8	1.8	Heavy coarse quartzite.
5375.8–5380	4.2	Phyllite and sandstone interbedded (arkose?)
5380–5384.5	4.5	Cross-bedded arkosic sandstone.
5384.5–5389	4.5	Quartz schist, gray-bluish.
5389–5396.6	7.6	Coarse, partly conglomerate sandstone or graywacke.
5396.6–5398	1.4	Phyllite and sandstone layer.
5398–5400	2.0	Sandstone.
5400–5402	2	Sandy phyllite with folds in sandstone layer.
5402–5404.4	2.4	Sandstone, very coarse.
5404.4–5428	23.6	Sandy phyllite and sandstone beds.

Traverse *feet*	*Thickness of Unit* *feet*	
5428–5430.2	2.2	Massive sandstone bed.
5430.2–5475	44.8	Phyllite and sandstone interbedded.
5475–5488	13	Blue slate, laminated with rusty blebs. Good bedding and cleavage, lineation down dip 40°.
5488–5497	9	Green sandstone, schistose with dark-blue slate bands.
5497–5502.6	5.6	Blue slate.
5502.6–5511.6	9	Green, sandy, laminated phyllite. Thousands of paper-thin layers.
5511.6–5522.6	11	Laminated purple slate with dark long magnetite spindles down dip of lineation (40 SE).
5522.6–5543.6	21	Green sandy phyllite with laminations.
5543.6–5600	56.4	Laminated blue slate, deeply weathered.
5600–5639	39	Green sandy phyllite interbedded with laminated slate. Bedding N 40 E vertical, cleavage dips 55 SE.
5639–5750		Concealed.
5750–5756	6	Hard coarse sandstone.
5756–5792	36	Loose, mostly sandstone.
5792–6026	34	Weverton quartzite, cross-bedded with top to west.
6026		First post of cable fence.

Discussion of section.—The Waynesboro section consists essentially of three distinct parts: an upper member of gray phyllite with light bands; a middle member of sandstone, conglomerate, and arkose; and a lower member of banded phyllite which grades downward into a finely laminated slate with sandstone beds. The laminations are very prominent and only $\frac{1}{10}$ to $\frac{1}{4}$ inch thick.

It is suggested to divide the Harpers formation into an upper, middle and lower member accordingly. Of these members about 1100 feet of the upper and lower members and almost 200 feet of the middle member are exposed.

If the adjacent outcrops in the creek are taken into consideration, the section is almost completely exposed, including top and bottom.

The bedding dips west at the top of the section, but becomes vertical about 300 feet below the top and remains vertical to its base. Cleavage dips uniformly to the east and indicates that the entire section is in the lower limb of an asymmetrical anticline but not very far from the crest. The top of the beds is to the west in all portions of the section as shown by cleavage-bedding relations as well as cross-bedding (Pls. 8 and 9).

The section is continuous and in normal position with respect to the Antietam sandstone and Weverton quartzite. The lower Harpers formation resembles the lithology which has frequently been described as Loudon. Since South Mountain has been shown to be an anticline it would seem evident that the portion of Loudon shown west of South Mountain should be considered lower Harpers.

Very similar lithology can be seen in Raven Rock Hollow to the south where a finely-laminated phyllite occurs next to the Weverton quartzite.

At Harpers Ferry, laminated and banded phyllite occurs throughout the entire section, but the division into three distinct members has not been possible.

SECTION THROUGH HARPERS FORMATION ALONG U. S. 40 (OLD) EAST OF BOONSBORO TO THE SUMMIT OF SOUTH MOUNTAIN

Section begins at 25 m.p.h. sign on north shoulder near last house on south side of road, just west of sharp curve around cliff on south side.

Traverse 100 degrees
0–23 feet, loose fragments of shale
23 feet, shale in ditch, small exposure
23–31 feet, loose shale
31 feet, cleavage N 10 E, dip 40 east
31–43 feet, loose shale
43 feet, sandstone bed 1 foot thick overturned. Strike N 10 E, dip 80 E
43–63 feet, sandstone beds with interbedded shale. Bedding excellent, vertical. Cleavage dips 25 E
63–76 feet, shale, intensely sheared
76–77 feet, sandstone bed, coarse dark rough graywacke, bedding vertical
Traverse 127 degrees
77–81 feet, sandstone and shale
81–96 feet, shale
Traverse 142 degrees
96–108 feet, shale, gray, strong cleavage
108–126 feet, several small exposures of shale
126–131 feet, concealed
131–143 feet, well-exposed shale, bedding seen as bands, vertical. Cleavage dips 35 E
143–153 feet, shale
153 feet, concrete culvert
153–181 feet, loose shale with some small exposures
Traverse 142 degrees
181–195 feet, loose shale
Traverse 134 degrees
195–235 feet, loose shale. Bedding N 70 E, dip 40 NW indicating minor fold. Well banded. Cleavage N 50 E, dip 30 SE. Lineation down-dip of cleavage N 13 E, plunge 35 SE. Intersection of cleavage and bedding N 50 E, plunge 20 SW
Traverse 135 degrees
235–295 feet, laminated shale in several small exposures
295–321 feet, excellent exposure (cliff). Well banded shale. Bedding N 40 E, dip 30 NW. Cleavage N 30 E, dip 40 SE
321–339 feet, shale, mostly loose
339 feet, concrete culvert
339–341 feet, fresh shale
341–376 feet, loose shale with some small exposures
376–393 feet, well exposed banded shale. Bedding E-W, dip 5–10 north. Cleavage N 40 E, dip 30 SE
393–408 feet, shale
408–453 feet, shale; bedding almost horizontal; cleavage dips east
At 453 feet, bedding N 50 E, dip 10 NW; cleavage dips 30 SE; lineation in cleavage plane plunges 30 degrees in direction 115 degrees
453–477 feet, excellently banded shale
477 feet, transformer on pole; laminated shale, bedding very obvious N 35 E, dip 20 NW; cleavage N 20 E, 35 SE. Small conglomerate layers
477–516 feet, well-exposed shale
516 feet, telephone pole
Traverse 140 degrees
516–549 feet, well-exposed banded shale with gentle dip
549 feet, spring
Traverse 124 degrees

549–601 feet, shale, intense cleavage dips E
Traverse 110 degrees
601–640 feet, concealed; shale in creek on north side of highway
640–678 feet, partly loose shale, mostly continuous exposure
678–700 feet, shale
700 feet, highway sign; road intersection
700–746 feet, concealed
746 feet, sign; U.S. 40, road north to Washington Monument
746–834 feet, concealed but shale in creek
834–854 feet, loose shale
854 feet, gray shale
854–925 feet, loose shale
925–950 feet, concealed
Traverse 105 degrees
950 feet, good exposure of shale
950–1011 feet, concealed
Traverse 115 degrees
1011–1069 feet, loose shale
Traverse 130 degrees
1069–1095 feet, shale in place
Traverse 135 degrees
1095–1121 feet, loose shale
1121 feet, house on north side of road
1121–1247 feet, concealed
1247 feet, culvert
Traverse 110 degrees
1247–1510 feet, concealed
1510 feet, sign: 50 mile limit
1510–1560 feet, concealed
1560 feet, old house
Traverse 90 degrees
1560–1640 feet, large loose blocks of Weverton quartzite
1740 feet, summit

Discussion of section.—The Boonsboro section shows sandstone beds in Harpers shale at the top of the section. Below these are typically banded phyllites with cleavage that dips constantly east at from 30 to 40 degrees.

An asymmetrical anticline appears at the road curve with cleavage gentler than bedding. To the east are some smaller folds as shown by the reversal of the dip to the west. In this respect the section is similar to that along the new U. S. 40 where reversal of dip is common along the western slope. This is interpreted to represent a syncline, overturned westward within the major anticlinal structure.

Cleavage remains constant, but the bedding cannot be measured between the last westward dip and the summit. Harpers shale is exposed along the road at many places. At the summit the bottom of the section is in Weverton quartzite.

To the north of the section at Washington Monument, the Weverton caps the mountain and is very much farther to the west at the higher level. This is most likely due to recumbent or overturned folding. Cross faults are, however, abundant and may be responsible for the forward surge of the Weverton above the Harpers.

ANTIETAM SANDSTONE

Name.—The Antietam formation was first described by Keith (1893) and named in a report by G. H. Williams and W. B. Clark for exposures east of Antietam Creek, Washington County, where it is well exposed in many of its tributaries.

Since the formation has been folded intensely along with all other lower Cambrian formations the degree of metamorphism varies from point to point depending on its position within the South Mountain fold. In Pennsylvania, especially in York and Lancaster Counties, the formation has been called Antietam quartzite (Stose, 1909), or Antietam schist. In the vicinity of Safe Harbor and Mine Ridge Upland, the formation is a mica schist.

Character and thickness.—The sandstone is described as white to bluish-gray quartzite and sandstone by Bassler (1919, p. 58) and as a pure coarse-grained quartzose sandstone, in places bluish or granular white or pinkish, by Stose (1910, p. 33). The latter author distinguishes a lower dense, hard, partly bluish layer and an upper white one.

To the south, Butts (1940, p. 38) describes the Erwin quartzite and the Antietam sandstone as medium to fine-grained, gray, whitish-weathering rock which appears to have been thoroughly sorted clean white beach sand. Locally, the grains are completely recemented with silica to form a compact quartzite. Keith reported conglomerate beds with pebbles half an inch in diameter from Tennessee, but Butts states that no such conglomerates have been observed in Virginia.

To the east of South Mountain uplift, in Frederick County, metamorphism is more intense. Stose and Stose (1946, p. 41) describe the formation as a well-bedded light-gray, rusty-weathering, granular quartzite and underlying crumbly, sericitic quartz schist. In the upper portion the quartzite becomes calcareous with distinct bedding planes in which the molds of fossils can be seen.

East of Frederick Valley the formation consists largely of quartz schist with beds of thin-bedded tough gray quartzite with rust specks. Cleavage is so intense that bedding can only rarely be observed (Stose and Stose, 1946, p. 42).

Distribution.—The Antietam formation occurs only in eastern Washington County in the foothills of South Mountain and Elk Ridge.

North of Harpers Ferry the Potomac River has cut into the narrow band of the formation. West of Rohrersville a larger area is underlain by Antietam sandstone due to its position in a northward-plunging anticline. North of Rohrersville the formation follows South Mountain, thickening north of Boonsboro in another anticline and eliminated by faulting east and northeast of Smithville. Here the Harpers shale can be seen resting on limestone along the road from Smithville to Edgmont. North of Edgmont the formation reappears and is well exposed at the entrance to the scenic area along the highway east of Waynesboro.

As a whole, the belt of Antietam is wider than its thickness would permit. This is due to its position in the crestal position of the recumbent South Mountain fold. Cleavage in the Antietam is intense and mostly at a large angle to bedding, indicating an exaggerated thickness. At many localities wrinkling of the bedding planes and small folds indicate repetition and also thickening of the sequence.

TOMSTOWN DOLOMITE

Name.—The Tomstown dolomite was named by Stose (1906, p. 208) after the locality where it was first mapped and particularly well represented a few miles north of the Pennsylvania line in Franklin County, Pennsylvania, near the village of Tomstown.

To the south the same formation has been recognized by Keith and called Shady from Shady Valley, Tennessee. Butts (1946, p. 40) calls attention to its dolomitic character and calls the formation the Tomstown dolomite. The name Tomstown has been used north of Roanoke; the name Shady south of Roanoke. According to Butts the name Shady is the older.

Character.—The formation is composed largely of dolomite and limestone. Massive beds alternate with thin ones, and shaly beds and partings are common. The yellowish dolomite is interbedded with white massive beds which have been burned for lime locally. Marble beds are common.

Distribution.—The Tomstown limestone is fairly easily mapped because it is bounded at the bottom by the Antietam quartzite and at the top by the red shaly and sandy Waynesboro formation. It is far enough from South Mountain not to be covered by the debris which covers the lower boundary almost everywhere.

The Tomstown limestone area is continuous from the Potomac River to the Pennsylvania line in a very broad belt of irregular width. Study of some of the structure details shows many shallow folds which explain the repetition of the formation and the width of the exposed belt.

North of the Potomac River the belt of Tomstown limestone is about one mile wide indicating several repetitions due to folding. One rather intricate northward plunging fold occurs to the northeast of Sharpsburg where the Waynesboro redbeds well indicate the folds. South of Keedysville are several anticlines and synclines as emphasized by the Antietam Ridge of McClellans outlook. North of Rohrersville the Tomstown is in contact with greenstones and Weverton quartzite due to faulting. The anticline of Weverton at the northern termination of Elk Ridge has been faulted into an anticline of Tomstown limestone.

At Boonsboro the limestone area is widest with innumerable small folds.

From here on northward the limestone narrows and widens repeatedly and its general structure is well portrayed by the overlying and easily traced red Waynesboro formation.

From Cavetown and to the north there are several large anticlines and synclines with remnants of Waynesboro redbeds on the limestone.

The entire area is within the crest of South Mountain fold and intense eastward-dipping cleavage is common. Many of the cleavage planes show intense lineation in their steepest dip. Folds are mostly asymmetrical and overturned westward. A considerable portion of the thickening of the limestone may be attributed to folding due to its position within the crest of the South Mountain fold. Oölites in the Conococheague several miles to the west of the Tomstown limestones are still influenced by the South Mountain fold and thickening in some of the beds exceeds 100 per cent.

Thickness.—Due to the position of the Tomstown in the crest of the South Mountain fold reliable and undistorted thicknesses can hardly be expected.

Complete sections are not available in Washington County.

In Franklin County, Pennsylvania, Stose (1910) has estimated the thickness as 1000 feet. Butts (1940, p. 41) describes several sections from Virginia, varying from about 5000 feet to less than 1000 feet. Since these sections are also located within the rather disturbed area west of Blue Ridge, the variability may well be related to deformation also.

WAYNESBORO FORMATION

Name.—The Waynesboro formation was named by Stose (1906, p. 209) after the town of Waynesboro, immediately north of the Pennsylvania line and 11 miles northeast of Hagerstown. Here the formation dips gently in an anticline and forms some of the hills on which the town is built.

The equivalent of the formation to the south is the Rome as named by Hayes (1891, p. 143). This name is used by Butts (1946, p. 56) since it has priority over the Waynesboro.

Character.—In Washington County the formation consists mainly of two major portions: an upper unit of shales and sandstones and a lower one with interbedded dolomite and shales and only few isolated sandstone layers. North of the Pennsylvania line there are also heavy conglomerate beds.

Stose (1910, p. 39) observed three divisions in the type locality at Waynesboro. A lower siliceous gray limestone weathers to slabby porous sandstone and contains chert. The middle division consists of dark-blue limestone, dolomite, and fine-grained marble. The upper shales and sandstones are ripplemarked and cross-bedded.

The thickness estimated by Stose is about 1000 feet.

Bassler (1919, p. 68) also distinguishes three divisions, an upper shale and sandstone unit, a middle member of limestone, and a lower one of siliceous gray limestone and calcareous sandstone.

In Washington County, there are many outcrops of the formation but complete sections are not known. Folding has been intense and irregularities are probably largely due to deformation. One rather complete section has been measured and is described below. East of Chewsville at least two divisions can readily be seen: an upper shaly and sandy part, and a lower one containing limestones, dolomites, and some shale beds, particularly near the base.

In Virginia several sections have been described by Butts (1946), and the sections seem thicker and still more variable than in Maryland.

Generally, the Waynesboro is easily recognized and serves as a welcome key horizon. The redbeds, yellow shales, and sandstones form hills and can be traced across country with facility. Its position between two limestone formations poses an interesting problem and its detailed study may be a fruitful subject for investigation.

Distribution.—But for a small interruption near Beaver Creek, the formation can be traced from the Potomac River at Antietam to the State line south of Waynesboro. Its width of outcrop varies greatly depending on its dip, and at some localities it is repeated due to intersection of the surface with plunging folds. Two such anticlines seem to exist between Antietam and the new U. S. 40 near Wagners Crossroads. Here intense faulting probably thinned out the formation and northeast of

Beaver Creek the section is upside down and above the overlying Elbrook formation. At Cavetown the area widens in a southward plunging syncline. From here northward some remnants of Waynesboro rest on Elbrook indicating the gently folded upper limb of an asymmetrically and northwestwardly overturned anticline.

The entire outcrop area is still within the crestal portion of the South Mountain fold which accounts for many irregularities. Cleavage dips east and in many beds dominates bedding.

Sections and thicknesses.—

SECTION THROUGH WAYNESBORO FORMATION ALONG WESTERN MARYLAND RAILROAD 0.8 MILES EAST OF CHEWSVILLE

(Section measured with tape from west to east along north side of right-of-way beginning at west end of railroad cut at first limestone exposure.)

Traverse 105 degrees

0–1 foot, white sugary limestone, finely crystalline, laminations appear in weathering, invisible when fresh. Bedding strike N 45 E, dip 45 SE

1–9 feet, concealed

9–9.5 feet, white laminated very hard limestone

9.5–21.5 feet, concealed

21.5–23.25 feet, yellow sandstone

23.25–25.25 feet, green shale, weathers yellow, thin plates in soil; distinct cleavage N 35 E, dip 45 SE

25.25–29.25 feet, concealed

29.25–31.25 feet, green shale, weathering yellow or purple

31.25–32.25 feet, orange-yellow sandy shale

32.25–34.75 feet, concealed; loose shale fragments

34.75–35.75 feet, purple shale, mostly loose fragments

35.75–36.75 feet, yellow shale

36.75–171.75 feet, concealed; loose yellow shale with purple layers

171.75–181.75 feet, small cliff. Red-purple sandstone and shale. Well-bedded with mud cracks in lower layers. N 45 E, dip 55 SE. Fold axis N 45 E horizontal

181.75–183 feet, red-purple shale, micaceous

183–187 feet, concealed with loose yellow shale

187–190 feet, yellow, much broken graywacke, sandstone; cross-bedded, purple layers, micaceous

190–192 feet, concealed

192–198 feet, yellow shaly sandstone, breaks into rhomboidal fragments. N 50 E, 40 SE

198–234 feet, concealed, loose yellow shale

234–235 feet, hard gray dolomite, very impure, weathers reddish

235–240 feet, dense dolomite weathering yellow sandy

240–241 feet, yellow shale

241–245 feet, siliceous, very hard, white dense dolomite. Cross-bedded with ripple marks, beds N 45 E, dip 40 SE. Calcite-covered joints N 40 E, 50 NW.

245–246.5 feet, sandy shale with mud cracks

246.5–248 feet, blue limestone, cross-bedded with shale partings

248–252 feet, concealed

252–254.8 feet, green shale

254.8–259.4 feet, yellow, sugary, dense dolomite weathers bright yellow. Well-bedded. Beds N 45 E, dip 70 SE

259.4–265.4 feet, concealed; retaining wall

265.4–268.4 feet, finely-laminated, purple, banded shale

268.4–271.4 feet, dense yellow dolomite, banded, very hard

271.4–273.4 feet, laminated dolomite, weathers purple. Mud cracks at under surface

273.4–278.9 feet, laminated dolomite with sandy layers about ½ inch thick

278.9–280 feet, massive, red-weathering dolomite
280–283 feet, gray, hard sandstone
283–284.5 feet, red shale
284.5–285.5 feet, yellow sandstone
285.5–289.1 feet, red shale
289.1–290.1 feet, yellow laminated sandstone
290.1–291.2 feet, red shale N 50 E, dip 65 SE. Striae down-dip of bedding planes
291.2–294.75 feet, retaining wall
294.75–295.3 feet, green shale
295.3–298.3 feet, laminated yellow dolomite, sandy
298.3–304.5 feet, purple sandstone, well-bedded, mud cracks, micaceous, striae down-dip of bedding planes N 45 E, dip 70 SE
304.5–311.5 feet, red micaceous hackly shale
311.5–314 feet, concealed
314–323 feet, blue banded massive limestone, grading upward into dolomite
323–328 feet, concealed
328–330 feet, yellow shale
330–332.6 feet, sugary white dolomite, weathers yellow. Joints filled with carbonate
332.6–338.6 feet, dolomite with sandy layers, weathers yellow
338.6–341.6 feet, purple slate N 45 E, vertical
341.6–353.6 feet, concealed
353.6–359.6 feet, gray dolomite, weathers yellow. 3 thick, hard, beds
359.6–363 feet, cross-bedded sandstone and red shale; N 45 E, vertical
363–414 feet, concealed, with purple sandy shale fragments
414–418 feet, yellow shale
418–649 feet, concealed
649–664 feet, dolomite with green shale partings
664–672 feet, concealed
672–675 feet, purple shale
675–750 feet, concealed
750–752 feet, yellow shale
752–787 feet, fresh blue limestone of Tomstown formation, N 40 E, dip 65 NW
799 feet, railroad crossing, farm road
874 feet, semaphore Western Maryland Railroad

The above section is uncorrected in order to enable visitors to recognize the units more readily in the field. Correction for divergence of strike is ten per cent for the entire section. Dip corrections vary from 67 per cent for 45 degree dip to zero for vertical dip. The change in dip and the gradual steepening indicate an asymmetrical fold overturned toward the west with thickening of the crest in the incompetent shale layers and corresponding thinning of the limb. The section has probably been thinned due to deformation and the thickened crest has probably been eroded.

The section is summarized and corrected below for comparison with other sections.

Generalized section.—

Waynesboro formation	
0–135	Green and yellow shale, purple and yellow sandstones. Overturned limb of anticline
135–290	Dolomite and shales with some sandstone beds.
290–590	Mostly concealed. Loose shale and dolomite, redbeds at about 25 feet above base.
Tomstown limestone	
590–	Fresh blue limestone.

ELBROOK LIMESTONE

Name.—The Elbrook limestone was named by Stose (1906, p. 209) for the locality where it is most typically developed approximately 5 miles northwest of Waynesboro and about 13 miles northeast of Hagerstown.

Character.—The Elbrook limestone is overlain by the Conococheague limestone and rests on the Waynesboro formation both of which differ considerably to make distinction readily possible. Stose describes the Elbrook as a thick series of gray to light-blue shaly limestone and calcareous shale. Lamination is prevalent and the shale forms plates which are found loose abundantly in road cuts and fields. Massive beds of limestone and dolomite, siliceous limestones which weather to porous sandstone, and siliceous oölites occur in the middle portion of the formation. The upper portion is largely composed of calcareous shale and laminated limestone. The upper boundary against the Conococheague is below a series of siliceous conglomerate beds with flat pebble limestone conglomerate and oölites.

Butts (1946, p. 74) has listed four sections of Elbrook from Virginia where dolomite and limestone beds seem more in evidence than in Pennsylvania or Maryland.

Thickness.—Stose estimated the thickness in Franklin County, Pennsylvania, as 3000 feet. Butts's sections south of the Potomac River vary between about 1400 and 2000 feet, but he feels that the formation may become thicker to the northeast because Stose estimated it as 3000 feet thick.

In Maryland no well-exposed or complete sections are exposed and none have been measured. In view of the fact that the Elbrook is still in the crest of South Mountain fold and strongly influenced by its tectonics, measurable sections would probably not show the original thickness which could be compared with others elsewhere.

Distribution and exposures.—The Elbrook formation occurs in a broad belt following the South Mountain fold in the west and in an area along the west side of the Hagerstown valley where it reappears below the Conococheague. On the west it is here faulted against Martinsburg shale.

There are many good exposures of Elbrook limestones or shales, but no good sections which seem complete and not intensely folded.

Several larger folds can be observed along the north side of the Potomac River Valley. These are reflected in the reëntrants of Conococheague limestone at Sharpsburg. A beautiful recumbent fold is exposed southeast of Roxbury. The front and crest of the fold are exposed at the east end of the mill race of Roxbury Mills. Cleavage and bedding intersect at large angle, and deformation is most intense. The axis of the fold plunges gently northward and one proceeds in the lower limb of the fold to the south and in the upper limb to the north. The beds are also overturned along the Boonsboro-Lappans road in the vicinity of Antietam Creek, but flat-lying and normal on top of the hill.

Somewhat similar relations must prevail in the vicinity of Beaver Creek and Wagners Crossroads. Here Waynesboro clearly overlies Elbrook, but exposures do not permit complete analysis of the situation.

In the vicinity of Waynesboro, fold axes plunge southward and the area of Elbrook widens considerably. Many good outcrops of Elbrook limestone can be studied along Antietam Creek, in road cuts, and in the open fields. The exposures are always discontinuous because only the resistant beds protrude and the less resistant ones are weathered and mostly covered with soil.

CONOCOHEAGUE LIMESTONE

Name.—The Conocoheague limestone was named by Stose (1908, p. 701) after Conocoheague Creek just north of the Pennsylvania line in Franklin County. The term Conocoheague is also used by Butts (1946, p. 86) in Virginia.

Character.—The Conocoheague limestone consists predominantly of dark blue, mostly banded, limestone with some more massive beds of dolomite or finely-laminated dolomite. The individual bands range from one to two inches thick and are separated by shaly partings of one tenth of an inch or little more. Upon weathering these siliceous partings resist and stand out as thin ribs. Stose (1909) calls attention to this appearance as a distinguishing feature.

Stose placed the base of the formation below conglomerate beds of rounded limestone pebbles one inch or more in diameter and edgewise conglomerate beds. Chert, cryptozoon reefs, and oölites occur also near the base. The top of the formation is placed below the Stonehenge member of the Beekmantown, which consists of rather pure light-colored limestones.

The major portion of the formation consists of dark-blue, rather impure limestones with shaly bands, layers of edgewise conglomerate, oölite beds, and sandstone layers near the base. Toward the top pink marbles and lighter-colored limestones appear more frequently interbedded with dark-blue limestone.

The character of the Conococheague limestone varies considerably with the intensity of deformation it has suffered. In the eastern area, South Mountain uplift still exerts its influence and a strong cleavage is common and dips persistently and gently to the east. Oöids are strongly deformed and the beds have thickened considerably. Where cleavage is at a large angle to bedding the laminae are intensely wrinkled, and at some localities deformation has resulted in a cellular and mottled limestone with shale partings in many directions, or in the direction of the newly formed cleavage.

On the west side of the valley deformation has been much less intense and fossils are more common.

J. L. Wilson (personal communication) measured sections at Big Spring, Maryland, and Waynecastle Dairy, Pennsylvania, just north of the State Line. The Big Spring section is listed below.

The Big Spring section may be divided from top to bottom into: an upper 1,400 feet of laminated limestone with dolomites, oölites, some sandstones, edgewise conglomerates, and shaly partings; a middle portion of mainly dolomite beds; and a bottom unit consisting mainly of dolomite, shale, sandstone beds, oölite, and cryptozoon limestone. The base of this section is at the first carbonaceous sandstone bed above the Elbrook. The lowest member has been called the Big Spring member by Wilson from the type section at that locality.

Distribution.—The Conococheague formation occurs in two major belts: one along the western foothills of the South Mountain uplift and a western belt along the western boundary of the limestone valley adjacent to the Bear Pond Mountain area.

Two anticlines of Conococheague limestone cross the Potomac River from the south toward Downsville and Spickler. Since the axes plunge northward the Conococheague disappears below the Beekmantown. Two southward plunging anticlines in Pennsylvania do not reach the State Line.

Another area of Conococheague limestone is shown on Bassler's map near Hagerstown. Such an area probably exists but the author was not able to map it due to the lack of precise information on the boundary between Beekmantown and Conococheague and the lack of detailed information on either formation in this region.

Thickness.—Stose (1910, p. 45) determined the thickness of the formation at the type section at Scotland as 1635 ± feet. Stratification in that section dips approximately 70 degrees west, a strong cleavage dips 30 to 40 degrees east. Oöids in an oölite bed are elongated and show a maximum elongation in the direction of the cleavage. The deformation ratio is 38 per cent (E. Cloos, 1947, pls. 9, 12) which indicates maximum elongation at an angle of 80° to bedding. Laminations between dark-blue limestone beds are intensely crenulated which confirms an elongation near normal to bedding. It seems rather certain that the section at Scotland is considerably thickened due to deformation and that the measurement does not reflect original thicknesses.

The two sections measured by Wilson at Waynecastle Dairy and Big Spring show 1897 and 1914 feet, respectively. The former is not complete. Butts (1946, p. 89) states that the thickness in Virginia is substantially 2000 feet. Bassler (1919, p. 78) estimated the thickness in Maryland to be about 1650, but calls attention to lack of continuous exposures and structural irregularities.

Sections.—Sections are published by Stose (1910, p. 45) and Butts (1946, p. 89) from Pennsylvania and Virginia. The following sections are by J. T. Wilson at Big Spring, and by the author at Roxbury Mills on the property of the Maryland Penal Farm. The latter section begins at a fence 1100 feet west of center of bridge across Antietam Creek. The traverse is N60W. In this section, accurate data on the carbonate residue ratio are provided by 54 residue analyses.

SECTION ACROSS CONOCOCHEAGUE LIMESTONE AT ROXBURY MILLS

Feet		*Sample and analysis number (see table 5)*
0–10	limestone, banded, blue, weathering yellow, N 20 E, vertical	
10–30	concealed, analysis from 6-inch bed	(1)
30–32	banded blue limestone	
32	analysis	(2)
32–52	dense, blue, finely-laminated limestone	
52–56	reddish-weathering gray limestone, laminated	(3)
56–59	concealed	
59–62	dark-blue dense dolomite	
62–70	concealed	
70–74	sandy dolomite, light, round sand grains	
74–86	concealed	
86–88	dense-blue dolomite	
88–90	oölitic light and laminated blue limestone	
90–96	concealed	
96–100	blue laminated limestone	(4)

Feet		*Sample and analysis number (see table 5)*
100–109	concealed	
109–110	dark-blue dense dolomite	(5)
110–115	concealed	
115–147	lumpy, partly oölitic limestone with dolomite patches	
118	analysis	(6)
146	analysis	(7)
147–149	concealed	
149–150	slaty dolomite, dark blue, dense when fresh	
150–158	concealed	
158–161	laminated blue limestone	(8)
161–174	concealed	
174–176	laminated limestone	(9)
176–181	concealed	
181–190	laminated limestone with light-gray dolomite layers. Solution channels	
190–195	concealed	
195–197	light-gray limestone	
197–199	concealed	
199–200	light-gray limestone	
200–210	concealed	
210–214	laminated gray and blue limestone	
214	oölite bed	(10)
214–224	concealed	
224–226	laminated blue limestone	
226–230	concealed	
230–236	laminated blue limestone with oölites	
236–252	concealed	
252–256	dense blue limestone	
256–266	concealed	
266–272	dense blue limestone	
272–283	laminated dark-blue limestone	
283–284	blue dense limestone, weathers yellow	
284–347	concealed	
347–396	dense blue dolomite with few thin limestone beds, shaly partings	
396–407	concealed	
407–410	blue-gray mottled limestone	
410–416	bluish-gray limestone	(11)
416–424	concealed	
424–426	dense blue limestone	
426–428	concealed	
428–431	blue laminated limestone	
431–448	concealed	
448–455	dense blue dolomite	
455–477	concealed	
477–485	dolomite with thin limestone bands	
485–487	blue limestone	
487–493	concealed	
493–500	blue laminated limestone	
500–505	concealed	
505–509	blue limestone	(12)
509–513	concealed	

Feet		*Sample and analysis number (see table 5)*
513–514	blue limestone	
514–521	concealed	
521–524	laminated blue limestone	
524–539	concealed	
539–542	oölitic light-gray limestone	(13)
542–551	concealed	
551–562	gray limestone	
562–569	concealed	
569–571	blue limestone	(14)
571–574	concealed	
574–581	light-gray limestone	
581–588	concealed	
588–591	blue-gray limestone with shaly partings	
591–596	blue limestone	
596–597	shale	
597–600	concealed	
600–608	blue limestone with shaly partings	
608–613	concealed	
613–615	blue dense limestone	(15)
615–621	concealed	
621–630	blue and gray limestone, laminated with edgewise conglomerate	
630–640	concealed	
640–650	blue dense limestone with shaly partings	
650–656	concealed	
656–661	blue dense limestone, shaly partings	
661–667	concealed	
667–671	gray limestone, medium-grained	(16)
671–679	gray and blue limestone, shaly partings	
679–687	concealed	
687–694	gray dense limestone	(17)
694–695	dark-blue dolomite	
695–700	concealed	
700–705	gray and blue limestone	(18)
705–714	concealed	
714–717	blue laminated limestone	
717–724	concealed	
724–733	gray limestone	(19)
733–738	concealed	
738–741	blue dense dolomite, finely laminated	(20)
741–746	concealed	
746–748	gray limestone	(21)
748–758	concealed	
758–761	dark-blue limestone with shaly partings	(22)
761–762	light-gray and reddish limestone	
762–776	bluish-gray limestone, shaly partings	
776–783	concealed	
783–788	gray and blue limestone	(23)
788–795	concealed	
795–801	massive gray limestone with irregular bands	
801–819	thin-bedded limestone with dolomite and shale layers	
819–843	massive gray limestone, few partings	(24)

Feet		*Sample and analysis number (see table 5)*
843–849	shaly limestone, very thin partings	
849–851	massive gray limestone	(25)
851–754	shaly limestone, laminated	
854–867	thin-bedded limestone with shaly partings. Four massive beds ½ inch thick each	
867–872	blue laminated limestone	
872–878	concealed	
878–881	thin-bedded limestone	
881–886	concealed	
886–888	blue limestone in 1-inch beds	
888–889	massive gray limestone	(26)
889–890.5	blue dense dolomite	
890.5–895	shale with two thin dolomite bands	
895–900	gray and blue banded limestone	(27)
900–910	gray thickly-bedded limestone with shaly partings N 10 E, dip 80 E	
910–934	light-gray, mostly reddish limestone	(28)
934–947	blue laminated limestone with shaly partings	
947–958	pink dolomite	(29)
958–1043	concealed	
1043–1050	gray and pink massive limestone	(29)
1050–1098	concealed	
1098–1102	blue dense dark-banded limestone	
1102–1130	concealed	
1130–1146	blue-banded limestone, 1 inch bands	
1146–1148	blue finely laminated dense limestone	(30)
1148–1157	concealed	
1157–1158	blue banded limestone	(31) and (32)
1158–1166	concealed—fence	
	Section offset 300 to north along fence.	
1166–1175	concealed	
1175–1181	blue banded limestone	
1181–1192	concealed	
1192–1193	light-gray limestone	
1193–1247	concealed	
1247–1251	blue banded dense limestone	(33)
1251–1257	blue banded limestone	
1257–1260	finely-laminated limestone	
1260–1274	laminated limestone with dolomite beds	(34)
1274–1343	blue laminated limestone, at 1308 oölite bed	(35)
	Section offset 300 feet north along strike N 10 E. beds vertical	
1343	banded blue limestone	(36)
1343–1354	dark-blue, massive, slightly banded limestone	
1354–1373	concealed	
1373–1375	light-gray crystalline limestone	
1375–1396	concealed	
1396–1408	edgewise conglomerate	(37)
1408–1427	massive, hard, banded limestone	
1427–1437	concealed	
1437–1445	massive, banded limestone	(38)
1445–1461	thin-bedded, shaly limestone	
1461–1466	pinkish-white crystalline limestone	(39)

Feet		*Sample and analysis number (see table 5)*
1466–1469	concealed	
1469–1486	blue and light-gray banded limestone	(40)
1486–1493	blue dolomite, weathers yellow	
1493–1507	light-gray limestone with carbonate veins	(41)
1507–1546	concealed	
1546–1562	blue thin-bedded limestone, edgewise conglomerate	(42)
1562–1593	massive limestone with edgewise conglomerate	(43)
1593–1630	blue and gray banded limestone	
1630–1633	gray limestone	(44)
1633–1639	white and pink limestone	
1639–1690	blue and gray banded limestone	
1690–1767	concealed	
1767–1771	thinly-banded limestone	
1771–1773	pink finely-laminated limestone	(45)
1773–1779	light-gray and white dolomitic limestone	
1779–1786	light-gray finely-laminated limestone	(46)
1786–1788	concealed	
1788–1800	light-gray coarse limestone	
1800–1805	blue banded limestone with chert	
1805–1809	finely-laminated dolomite, weathers yellow	
1809–1830	banded massive limestone	
1830–1832	oölite with chert	
1832–1839	fissile thin-bedded limestone	
1839–1913	dark-blue thin-banded limestone	(47)
1913–1999	concealed	
at 1999	blue banded limestone	(48)
1999–2061	blue banded limestone with edgewise conglomerate beds. Bands 1 to 1½ inches thick	
2061–2081	concealed	
2081–2103	white sugary limestone, reddish or gray	(49)
2103–2153	dark-blue banded limestone with some thicker layers	(50)
2153–2161	concealed	
2161–2164	gray to pink oölitic limestone with yellow spots	
2164–2239	concealed	
at 2239	N-S fence	
2239–2259	concealed	
2259–2308	light-gray fine-grained dense limestone with many calcite veins	(51) and (52)
2308–2327	dark-gray massive dense limestone	
2327–2376	pink and light-gray much-fractured limestone	
2376–2396	gray and pink partly-crystalline limestone	
2396–2424	concealed	
2424–2460	gray banded limestone, stratification N 20 E, vertical Cleavage dips gently E	(53)
2460–2481	concealed	
2481–2500	white and pink to gray limestone, much fractured	
2500–2519	black and dark-gray banded limestone; few thin light-gray bands	
2519–2536	white and light-gray limestone	
2536–2549	pink and black laminated limestone	(54)
2549–2600	dark-blue and dark-gray banded limestone, edgewise conglomerate beds	

Feet		*Sample and analysis number (see table 5)*
2626–2711	concealed	
2711–2759	light-gray dolomite, dense, weathering yellow	
	Center of synclinal axis	

TABLE 5

ANALYSES OF CONOCOCHEAGUE LIMESTONE SECTION AT ROXBURY MILLS

SAMPLE NO.	CALCIUM OXIDE (CaO) PER CENT	MAGNESIUM OXIDE (MgO) PER CENT	TOTAL OXIDES (CaO AND MgO) PER CENT	SAND AND INSOLUBLE MATERIAL PER CENT
1	50.05	1.34	51.39	4.01
2	22.45	12.20	34.65	30.45
3	45.70	5.41	51.11	6.86
4	51.55	2.30	53.85	2.46
5	11.00	8.13	19.13	58.63
6	39.15	12.09	51.24	4.40
7	53.45	0.83	54.28	2.48
8	40.85	1.11	41.96	9.25
9	46.10	3.33	49.43	10.10
10	50.45	3.62	54.07	1.83
11	43.05	9.18	52.23	3.66
12	51.00	3.00	54.00	2.23
13	52.00	1.60	53.60	3.36
14	52.70	1.43	54.13	3.12
15	44.05	3.60	47.65	13.48
16	47.45	1.56	49.01	11.32
17	52.05	1.13	53.18	4.33
18	52.00	1.08	53.08	4.61
19	50.35	2.03	52.38	5.34
20	40.35	9.51	49.86	6.23
21	50.90	0.83	51.73	7.09
22	37.90	7.96	45.86	15.05
23	50.70	0.97	51.67	6.82
24	52.60	0.69	53.29	4.22
25	42.50	4.25	46.75	14.48
26	51.05	0.76	51.81	6.04
27	53.15	0.62	53.77	3.16
28	41.45	4.22	45.67	16.78
29	44.30	3.88	48.18	11.94
30	49.15	2.50	51.65	6.47
31	42.30	3.22	45.52	16.73
32	41.60	2.65	44.25	19.04
33	46.70	1.17	47.87	13.05
34	51.75	0.67	52.42	5.43
35	40.85	4.49	45.34	16.64
36	47.30	0.96	48.26	12.91
37	50.95	0.65	51.60	7.06
38	36.15	9.77	45.92	14.10
39	51.05	1.02	52.07	6.51
40	51.60	1.16	52.76	5.00
41	48.05	0.91	48.96	11.78
42	42.50	5.33	47.83	11.17

TABLE 5—*Continued*

SAMPLE NO.	CALCIUM OXIDE (CaO) PER CENT	MAGNESIUM OXIDE (MgO) PER CENT	TOTAL OXIDES (CaO AND MgO) PER CENT	SAND AND INSOLUBLE MATERIAL PER CENT
43	46.80	2.83	49.63	9.24
44	50.55	2.29	52.84	4.65
45	33.85	6.53	40.38	24.17
46	36.95	3.76	40.71	22.75
47	50.25	0.70	50.95	8.29
48	48.40	1.47	49.87	10.10
49	50.95	0.66	51.61	5.67
50	52.05	0.87	52.92	4.81
51	51.00	1.52	52.52	5.34
52	50.35	1.08	51.43	7.14
53	48.55	0.68	49.23	11.58
54	46.35	0.71	47.06	14.76

Sample numbers are shown in section.
L. E. Bopst—Associate State Chemist.

Discussion of section.—The section was measured to ascertain the availability of limestone for industrial purposes in connection with operation of the penal farm. It is presented because 54 analyses show the impurities of various limestones and it shows the gradation from Conococheague to the Beekmantown formations. The lower portion is typical in the alternation between blue limestone and shaly partings. The middle section shows edgewise conglomerates. In the upper part light limestones and massive beds dominate. The analyses are given in Table 5.

The contact between Conococheague and Beekmantown cannot be spotted on lithological differences alone, but faunal variations must be taken into consideration.

In the entire section a cleavage persistently dips gently to the east; bedding is vertical. The entire section still belongs to the South Mountain fold as can be seen in the orientation of the cleavage and the deformation of oölites.

Special features in Conococheague.—The Conococheague limestone offers a number of features which are of special interest for study in sedimentation. Oölite beds are common and widely distributed from the Potomac to the Susquehanna Rivers. They have been described and their deformation analyzed (Cloos, 1947). A short summary of this investigation is on pages 147–148 of this report. Their origin has, however, not been particularly studied as they were used merely as indicators of deformation.

Many of the limestones are accumulations of small dark lumps in a carbonaceous matrix and thought by some authors to be due to animal action.

Detrital sand grains of quartz and carbonate are very common and have been described (Cloos, 1947).

Oölite pebbles in oölite rock are common, and conglomeratic layers are numerous, especially microconglomerates visible only under binocular or microscope. Edgewise conglomerates have been observed by the early workers and described also from the Beekmantown. Bassler describes the conglomerates and discusses their origin in the Cambro-Ordovician volume of the Maryland Geological Survey. They occur in the entire Appalachian region, but have never been the subject of a detailed and exhaustive study. Whilst some authors consider these conglomerates as typical and worthy of note, they do not appear in the index of Butts' exhaustive treatise on the Appalachian Valley. Detailed study of these features may provide pertinent information on the formation of the limestones and their primary environment as well as on the Appalachian geosyncline generally.

SECTION ACROSS CONOCOCHEAGUE LIMESTONE AT BIG SPRING STATION

The section was measured at railroad cuts north of and in fields west of Big Spring Station on the Western Maryland Railroad about 3 miles south of Clear Spring, Washington County. The section is almost complete. A few beds may be missing from the top which ends in the axis of a minor syncline west of and behind one of Mr. Newkirk's farms. This farm is on the road just north of where it turns and passes beneath the railroad. The section continues east (going down; dip 60° N 32° W) through beds exposed at the barn and directly behind the house on the road, crosses the road, and ascends a hill to the railroad. The lower part of the section is found in railroad cuts in the first bend of track north of Big Spring Station. These cuts are excellent exposures of the lower member of the formation. This lower portion of the formation is equally well exposed along the old barge canal beside the Potomac River ½ mile south on the Charles place. Although neither of these exposures of the lower part of the formation has afforded fossils, a pygidium of the Dresbach genus, *Ankoura*, was collected in the pasture above the bluffs along the canal. Beds furnishing the trilobite were traced down to the exposures along the canal with some degree of error. It is estimated that the fossil comes from above the middle of the sandstone beds and from between 100 and 150 feet below their top.

	Feet
Conococheague formation:	
Laminated limestones, partly covered (in axis of minor syncline in meadow back of the barn)	83
Laminated limestone	15
Covered	69
Laminated limestone	37
Laminated limestone about half exposed (dip 54°)	126
Total Conococheague formation above Trempeleau trilobites	330
Plethometopus sp.?	
Laminated limestone (dip 58° N 65° W)	100
Laminated limestone	48
Dolomite	2
Laminated limestone	5
Covered interval	43
Alternating limestone and dolomite (by cow shed)	6
Laminated limestone	12
Sandstone	1
Limestone	32
Arenaceous limestone	0.5
Massive limestone with cryptozoan	6
Limestone (dip 65°)	29
Coarsely sandy limestone	1.5
Laminated limestone (behind farm house)	37
Covered interval	46.5
Covered interval (crossed to east side of road)	90
Plethopeltis, thin sandy limestone	
Conococheague limestone with Trempeleau fossils	459.5
Limestone (dip 57° N 67° W, ascending hill to railroad)	10

	Feet
Laminated limestone, about half covered	99
Covered interval	46
Limestone, about half covered	113
Laminated limestone, about half covered (dip 61° N 65° W)	125
Mostly covered, some laminated limestone	55
(Following beds exposed in railroad cuts north of Big Spring Station.)	
Laminated limestone (north side of railroad)	2
Covered interval	1
Laminated limestone	15
Massive, partly-laminated limestone, some intraformational conglomerate	3
Dolomite	1
Covered interval	3
Massive laminated limestone	3
Covered interval	11
Limestone intraformational conglomerate	1
Pure limestone	2
Dolomitic limestone	1
Covered interval	2
Laminated limestone	3
Pure oölitic and crystalline limestone	3.5
Laminated limestone	11.5
Massive limestone	1.5
Laminated limestone	5
Crystalline limestone	1
Laminated limestone	8.5
Covered interval	2
Laminated limestone	9.5
Covered interval	12
Laminated limestone with some crystalline limestone	5.5
Covered interval	2
Pure-white massive limestone	2
Laminated limestone and dolomite	11
Massive crystalline limestone	2
Laminated limestone	17
Limestone intraformational conglomerate	1
Laminated limestone	2.5
Oölitic limestone	3
Laminated limestone	5
Covered (crossed to south side of railroad track)	31
Typically laminated Conococheague limestone	632.5
Dolomite (on south side of railroad)	5
Pure limestone, laminated	6
Platy-weathering dolomite	1
Laminated dolomitic limestone	6.5
Covered interval	3
Dolomite	5
Massive limestone	10
Massive dolomite	5
Covered interval	3
Dolomite	1
Limestone	2.5
Covered interval, likely dolomite	1
Dolomite	1

	Feet
Laminated limestone	4
Limestone	1
Dolomite	1.5
Covered interval	1
Platy limestone	2
Covered interval	79
Massive dolomite	1
Covered interval	2
Massive dolomite	9.5
Covered interval	5
Massive dolomite	2
Covered interval	4
Massive dolomite	4
Shale and in part covered interval	6
Calcareous dolomite	1.5
Laminated platy dolomite	5
Total dolomitic beds of Conococheague formation	178.5

BIG SPRING MEMBER OF THE CONOCOCHEAGUE FORMATION; THE TYPE SECTION

81. Very sandy dolomite	2.5
80. Massive dolomite, includes a sandstone stringer	10
79. Massive dolomite	9
78. Dolomite and shale	7
77. Sandstone	1
76. Dolomite	1
75. Covered interval	4
74. Dolomite	1
73. Sandy dolomitic shale	40
72. Sandstone with some sandy dolomite	4
71. Dolomite	1.5
70. Covered interval	4
69. Massive dolomite	2
68. Platy dolomite	1
67. Massive dolomite with chert	2
66. Thin-bedded dolomite	2
65. Sandstone	.5
64. Massive dolomite	3
63. Sandstone	.5
62. Platy dolomite	2
61. Massive dolomite	7.5
60. Platy yellow-weathering dolomitic shale	3
59. Sandstone	2.5
58. Shaly platy dolomite	1
57. Dolomitic sandstone	1
56. Massive dolomite	5
55. Limestone intraformational conglomerate	1
54. Dolomitic sandstone	.5
53. Massive calcareous dolomite, laminated toward top	22
52. Covered interval	2
51. Massive dolomite	2
50. Sandy dolomite	1.5
49. Massive dolomite	4
48. Sandstone and dolomitic shale	17

47. Shaly dolomite	2
46. Sandstone and dolomitic shale	12
45. Massive dolomite	8
44. Covered interval	8
43. Massive calcareous dolomite	6
42. Limestone	.5
41. Massive dolomite with some limestone	5.5
40. Dolomitic sandy shale	16
39. Oölitic limestone and intraformational conglomerate	2
38. Laminated silty yellow-weathering dolomite	2
37. Dolomite and sandy siltstone	1
36. Massive pure limestone; top of beds shows cryptozoan or mud cracks	1
35. Laminated limestone	1.5
34. Oölitic limestone	1
33. Laminated limestone	3
32. Oölitic massive limestone	2.5
31. Calcareous sandstone and conglomerate	1
30. Sandy limestone	.5
29. Laminated limestone	1
28. Covered interval	2
27. Massive dolomite and limestone	6
26. Laminated limestone and dolomite, typical Conococheague facies	5
25. Covered interval	2
24. Oölitic limestone	1.5
23. Dolomite	3.5
22. Covered interval	5
21. Dolomite	2
20. Oölitic limestone	1
19. Coarse dolomitic sandstone	1
18. Yellow shaly dolomite	1
17. Massive cryptozoan limestone	3.5
16. Coarsely sandy limestone	.5
15. Shaly dolomite	.5
14. Massive dolomite and limestone	7
13. Sandy siltstone	1
12. Massive dolomite	2.5
11. Limestone	3
10. Medium-bedded laminated dolomite	2
9. Dolomite, coarsely sandy at top	1
8. Pure, pastel-pink limestone with cryptozoan and intraformational conglomerate	1
7. Dolomite	1
6. Cryptozoan limestone	1
5. Covered interval	8
4. Limestone	2
3. Covered interval	5
2. Dolomite	1
1. Coarse dolomitic sandstone	.5
Total Big Spring member	312.5
Total Conococheague limestone exposed	1913.0
Elbrook formation:	
Massive dolomite	6
Thin-bedded dolomite	2
Massive dolomite	2

Dolomite	1
Laminated limestone	1
Yellow-weathering dolomite	6
Oölitic limestone	2
Covered interval	3
Limestone	2
Laminated shaly dolomite	11
Laminated limestone	12
Total Elbrook formation exposed; no exposure across anticlinal axis. East limb of anticline repeats section	48

ORDOVICIAN SYSTEM

The Lower Ordovician of Maryland includes the Beekmantown, Stones River (St. Paul), and Chambersburg limestones and the Upper Ordovician includes the Martinsburg shale and the Juniata formation.

More recently the Ordovician system has been subdivided differently and detailed studies of some of the formations and units made the introduction of additional group names necessary (Fig. 16). In the left column of the legend on the geological map of the county, some of these regroupings have been indicated upon advice of C. K. Swartz. Accordingly, the Stones River (St. Paul) is the equivalent of the lower and middle Chazyan, the Chambersburg is equivalent to upper Chazyan, Lowville, Black River, and lower Trenton. The Martinsburg includes the Trenton, Utica, and Eden. The Medina group includes both Juniata and Tuscarora formations.

In the Cambro-Ordovician volume of the Maryland Geological Survey, Bassler (1919) divides the Ordovician into Beekmantown limestone, Stones River limestone, Chambersburg limestone, Martinsburg shale, and Juniata formation. This grouping has been followed on the geological map of Washington County and used in this report.

BEEKMANTOWN LIMESTONE

Name.—The type locality for the Beekmantown is in Beekmantown township, Clinton County, New York. The name was proposed by Clarke and Schuchert (1899) for a larger group of limestones between the Potsdam sandstone and the Chazyan.

Butts uses the term as group name, but since the individual members become difficult to distinguish toward Maryland and Virginia, the unit shown on Butts' geologic map of the Appalachian Valley of Virginia (1933) comprises the entire Beekmantown group just as on the geologic map of Washington County.

Character.—The Beekmantown limestone is rather pure and in thicker massive beds with very much less shaly layers than the Conococheague, but not as evenly-bedded and pure as the overlying Stones River (St. Paul) limestones. Some of the Beekmantown beds are highly fossiliferous, especially at a distance from South Mountain fold.

The basal member has been called the Stonehenge by Stose (1910, p. 47) and consists of minutely-laminated beds, pink and white marbles, and siliceous banded beds with edgewise conglomerates.

The Beekmantown as delimited by Stose and Ulrich (Stose, 1910, p. 48) consists

	Standard Section	E.O. Ulrich 1909	R.S. Bassler 1919	Washington County Geological Map 1941	Correlation suggested by Cooper & Cooper 1946 Neuman (thesis)
UPPER	Cincinnatian	Juniata formation; Martinsburg Shale	Juniata formation; Martinsburg Shale	Juniata formation; Martinsburg Shale	Not discussed
MIDDLE	Trenton	Martinsburg Shale	Martinsburg Shale	Martinsburg Shale	Not discussed
MIDDLE	Black River	Chambersburg Limestone	Chambersburg Limestone	Chambersburg Limestone	? Chambersburg Limestone
MIDDLE	Chazy	Stones River Limestone	Stones River Limestone ?	Stones River Limestone (includes T. Syringoporoides bs)	New Market Row Park ? / St. Paul Group equals Stones River
LOWER	Beekmantown	Beekmantown Limestone	Beekmantown Limestone	Beekmantown Limestone	Not discussed

FIGURE 16. Correlation Chart for the Ordovician System

of dolomite beds interbedded with limestones near the top below the Stones River (St. Paul). The bulk of the formation consists of light-colored dove, pink, gray limestones in heavier beds than the Conococheague below. The beds vary between 1 and 6 to 10 feet in thickness and are exposed at innumerable localities in the Hagerstown Valley. Chert is common and can frequently be seen in large irregular lumps in the field.

Bassler (1919, p. 92) calls attention to a lithological difference of the Beekmantown rocks in the eastern and western part of the valley. This difference is pronounced and particularly noticeable in the lack of fossils in the east in comparison with the highly fossiliferous beds in the west. The eastern facies is still partly under the influence of the South Mountain fold, shows intense cleavage, crenulated laminations, and bedding planes, and at many localities bedding is obscured. Deformation has changed the appearance of the limestone; quartz has been infiltrated and alteration of the limestone is considerable. Cleavage surfaces frequently dominate the shape of natural outcrops, bedding planes are obscured or wrinkled.

Thickness.—Stose (1910, p. 48) and Ulrich measured a section in the Chambersburg quadrangle, 20 miles northeast of Hagerstown, one mile east of Chambersburg. This section is 2,265 feet thick and includes the complete sequence between the Stones River and Conococheague. Another section near the mouth of Licking Creek in the Mercersburg quadrangle is 2,319 feet thick.

Bassler (1919, p. 93) has published a generalized section of 2,400 feet for Maryland and southern Pennsylvania.

A new section was measured by R. B. Neuman at Pinesburg Station along the C. & O. Canal, west of the quarry. It shows a thickness of 3,300 feet. The section is listed below.

Distribution.—The Beekmantown underlies an area about 7 miles wide between the Potomac River and the State Line and a smaller area west of Conococheague Creek which is frequently interrupted by other formations and generally somewhat more complicated than the eastern belt. Hagerstown is about the center of the eastern area. The eastern third of this area is within South Mountain fold, the western two-thirds and the western belt are in the large Valley syncline. These divisions and structures are described in some detail under structural geology.

Since the formation is only about 3000 feet thick, the width of exposure means that, in spite of many folds, the formation generally lies flat upon a probably equally flat underground.

The Beekmantown has been correlated with equivalent formations in Pennsylvania and New York and it has been recognized in Virginia by Butts.

No attempt was made on the county geologic map to differentiate small inliers within the Beekmantown complex because of the lack of detailed information. Toward the east, the underlying Conococheague limestone has been upfolded in anticlines or possibly faulted locally. Toward the west, the overlying Stones River (St. Paul) limestone rests on Beekmantown in synclines and along the margins of the large syncline of Martinsburg shale.

There is no lack of exposures in the Beekmantown limestone. Agriculture is restricted to those areas where soil has accumulated between limestone ridges. At many places the solid limestone reaches the surface as white-weathered ridges which indicate the regional trend. Larger areas occur where the limestone lies flat in crests of anticlines and synclines. In the limbs of folds, beds frequently stand up like tombstones. Only persistent removal of the ledges by the early settlers and persistent vigilance by the present farmers keeps larger fields in workable condition without loss of soil and rapid "growth" of ledges.

Sections.—Measured sections of the Beekmantown formation have been published by Stose (1910, pp. 48 and 50), Bassler (1919, pp. 93, 94, and 95), and Butts (1946, pp. 107–114), and are not repeated here.

The following three new sections and discussion of the Beekmantown, Stones River, and Chambersburg stratigraphy were taken from Neuman.

SECTION THROUGH BEEKMANTOWN ALONG CHESAPEAKE AND OHIO CANAL, AT PINESBURG STATION, MARYLAND

An excellent exposure of the Beekmantown and Stones River (St. Paul) formations is found along the old Chesapeake and Ohio Canal between Charlton and Pinesburg Station.

The section was first examined to locate the Beekmantown and Stones River contact. Measurements for the most part were made with a steel tape held perpendicular to the bedding. Frequent measurements were made of the attitude to detect structural anomalies and indications of folding or faulting and consequent repetition of beds. Other than a flattening of beds in the upper part of the section, no structures destroy the continuity. Although jointing and fracturing are present, no significant cleavage system was seen. Since the section is west of the Massanutten syncline and 15 miles WNW of South Mountain, strong development of cleavage would not be expected (Cloos, 1947). A profile of the section is given in Figure 17.

	Feet
6. Dove calcilutite with small calcite flecks (= *Tetradium syringoporoides* Ulrich?) and *Lophospira; Maclurites magnus* Leseur at top	75
Beekmantown Limestone (3300 feet)	
5. Dolomite, variable, from nearly white to dark-grey, medium to fine-grained, saccharoidal; sparse to abundant bedded and nodular white and black chert, wide horizontal distribution of "cauliflower" forms (see Bassler, 1919, p. 120); no fossils seen	380
4. Thick beds of dolomite with limestones interbedded; about 60 per cent dolomite, usually light-grey and thick-bedded; limestones light blue-grey to dove, fine-grained; poorly preserved gastropods, possibly related to *Hormotoma* and *Barnesella* rare, good fossils absent	740
3. Limestone about 90 per cent, with 1 to 2 foot beds of dolomite and magnesian limestones interbedded; contains many thin edgewise conglomerates and a few poorly-developed oölite beds; sparsely cherty; four sandy zones, none over 6 inches thick; base concealed by stream	1515+
Some significant horizons with distance from the observable base of the unit are:	
Grey argillaceous limestone with *Tritoechia* sp. 2	1150
Lecanospira rare or absent above this horizon	775
Light-grey argillaceous limestone with *Tritoechia* sp. 1 and simple ring-like to cylindrical cystid stem plates and stem fragments	583
Grey argillaceous limestone with *Lecanospira* sp. and possibly *Ophileta* sp.	498
Grey argillaceous somewhat cherty limestone with *Lecanospira* sp. and a calcareous algae, possibly related to *Girvanella*	478
Grey argillaceous limestone with *Bassleroceras* sp. (1)	405
Grey argillaceous limestone with calcareous algae as above	290
Grey argillaceous limestone with *Finkelnburgia virginica* Ulrich and Cooper and *Diaphelasma pennsylvanicum* Ulrich and Cooper	134
Dove limestone with calcareous algae as above, *Lecanospira* sp. and "*Orthoceras*"	86

	Feet
2. Covered; a conduit carries the canal over a stream and its valley	225
1. Light and dark-grey slightly-argillaceous limestone, no dolomite; *Finkelnburgia* sp. 35 feet above the lowest bed observed. The lower limit of this unit is the western end of the bluffs where folding of the beds in the upper part of the exposure indicates the proximity of the axial plane of an anticline	440+
Total	3375

Discussion of section.—The weathered surface of the argillaceous limestone in this section shows wrinkled looking clay seams which, though essentially parallel to the bedding, anastomose through the rock. They project slightly above the surface of the purer limestone. This feature is characteristic of the Beekmantown limestones and serves as a criterion in distinguishing them from the Stones River (St. Paul) where the clay seams appear differently.

Parallel laminations characterize the dolomites and dolomitic limestones that are interbedded with the limestones. In the thick-bedded dolomite, high in the section, laminations other than bedding may be absent.

Most of the fossils mentioned in this discussion were collected by Neuman and are in the collections of the Department of Geology, Mines and Water Resources. J. Brooks Knight and G. Arthur Cooper of the U. S. National Museum have seen most of the gastropods and brachiopods, respectively. Their kindness is here acknowledged.

Correlation on the basis of a preliminary study and limited collections must necessarily be tentative. The four lithologic units are readily apparent, however, and the lower two strongly suggest correlation with previously described units. A *Finkelnburgia* species, the only fossil found in the lower division, and the lack of magnesian beds suggest a correlation with the Stonehenge of the Chambersburg area (Stose, 1909, and Butts and Moore, 1936).

The following have been identified from the beds next above the lowest:

A calcareous algae, possibly *Girvanella*
Finkelnburgia virginica, Ulrich and Cooper
Diaphelasma pennsylvanicum, Ulrich and Cooper
Tritoechia sps.
Bassleroceras sp.
"*Orthoceras*" sp.
Lecanospira sps.
Ophelita sp.

All but the *Tritoechia* occur in the lower half of the unit. Correlation with the Nittany of the Bellefonte quadrangle and the Longview limestone to the south is suggested (Butts, 1940).

A rapid increase in the amount of dolomite sets off the upper divisions. Fossils are sparse, but in the thin limestones separating the thick dolomite units, *Hormotoma*-like gastropods and a poorly preserved form suggesting *Barnesella* occur rarely. The division containing 60 per cent dolomite and 40 per cent limestone may correlate with the Axemann limestone of the Bellefonte quadrangle. The percentage of dolomite increases rapidly so that the upper 380 feet is entirely dolomite. On lithologic grounds alone a correlation with the Bellefonte dolomite may be possible.

The total measured thickness of 3300 feet is somewhat greater than thicknesses given for Virginia and the Chambersburg-Mercersburg area in Pennsylvania. Butts (1940, p. 114) gives an approximate thickness of ±3100 for the Beekmantown northwest of Middletown, Frederick County, Virginia, but considers that this may be too thick due to minor folding. Unexposed minor thrusting may make this figure too small. Stose's (1909) thickness of 2310 feet at Licking Creek in the Mercersburg quadrangle also contains a considerable covered interval in which structural repetition is acknowledged. Since the section described above contains no percepitble evidence of structural repetition or subtraction, it may perhaps be too thin, for the lowest beds to the top of the Conococheague are not exposed.

STONES RIVER LIMESTONE (ST. PAUL GROUP)

Name.—The Stones River was named from Stones River in Nashville Basin of Central Tennessee by Stafford (1851, p. 354).

Stose (1910, p. 53) uses the term Stones River limestone for a sequence of very pure limestones overlying the Beekmantown. Bassler (1919, p. 117) also uses the term, but also refers to the Stones River Group (p. 118) and lists the following subdivisions from top to bottom: Lebanon limestone, Ridgeley dolomite, Pierce limestone, and Murfreesboro limestone. Butts (1946, p. 119) lists a Stones River Group under the heading Chazyan Series and subdivides it into the Lenoir, Mosheim, and Murfreesboro limestones.

Recent work by B. N. Cooper and G. A. Cooper and detailed studies by Neuman in Maryland indicate that it may be necessary to revise the application of the term Stones River to the Maryland rocks. Since the most recent work was not available in the compilation of the Washington County geologic map, the term Stones River still appears in the legend. Three new names have been suggested to substitute for the simple division of Stones River as follows:

Stones River = St. Paul group (new) { New Market (*Tetradium syringoporoides* beds)
Row Park (new) (*Maclurites magnus* beds) }

The New Market limestone was proposed by Cooper and Cooper (1946, p. 71) as a succession of calcilutite above the Beekmantown and below the dark gray limestones of the *Dinorthis atavoides* zone.

Character and correlation.—Row Park limestone consists of two sharply differing facies in Maryland: a dove calcilutite including beds of calcarenite, and a dark, granular, impure, locally cherty limestone. Below the *Maclurites magnus* beds is a thick series of siliceous dolomite and the contact is placed at the contact of dolomite with the limestone. Bassler (1919, p. 123) and Stose (1910) refer to cauliflower chert near the contact. Since the chert is found at several horizons, it is not a usable horizon marker. The New Market limestone varies greatly in Maryland. It consists of fine-grained, mostly dove and light-gray, and some dark limestones. It is laminated or mottled which permits distinction from the massive calcilutites below. The pure commercial rock of Martinsburg, West Virginia, and the old Pinesburg quarry, comes from the upper part of this formation, but the thickness of the chemically pure rock diminishes to the north of Pinesburg.

CHAMBERSBURG LIMESTONE

Name.—The Chambersburg limestone was named by Stose and Ulrich from Chambersburg, Franklin County, Pennsylvania. The type locality is along the South Branch of the Cumberland Valley Division of the Pennsylvania Railroad, 2 miles southeast of Marion. Butts (1940, p. 195) in emending the type section, placed the lowermost 150 feet of the original Chambersburg in a separate formation, the Lowville limestone.

Cooper and Cooper (1946, p. 55) and Neuman (1949, p. 85) agree with Butts that this lowermost 150 feet should be removed from the Chambersburg; Neuman thinks that the Lowville limestone of Butts is properly referred to the New Market which equals the upper part of the Stones River of the Washington County geological map since it is lithologically and faunally like this formation in other areas.

Character.—The Chambersburg limestone is a dark-gray, medium-grained, thin-bedded to nodular, frequently argillaceous limestone. It weathers cobbly and is easily recognized in the field for this appearance. It is overlain by the Martinsburg shale and thus readily identified and traced.

Distribution of Stones River and Chambersburg limestones.—

EAST LIMB OF THE MASSANUTTEN SYNCLINE

The syncline that forms the Massanutten Mountain of Shenandoah County, Virginia, extends through Maryland, forming the wide belt of Martinsburg shale that is occupied by the meanders of Conococheague Creek. The structural relations of the east limb are more complex than the map indicates. To the east of Worleytown, Pennsylvania, the sequence is repeated by a fault, and the Chambersburg limestone is partially covered by a nappe of Martinsburg shale. At Cearfoss, New Market dipping steeply to the west is faulted against Chambersburg that dips 40° eastward. The westward dipping rocks persist southward to a cross fault about $\frac{3}{4}$ mile south of Huyett, south of which Beekmantown is found faulted against Martinsburg shale. At the mouth of Opequon Creek, Berkeley County, West Virginia, this fault is excellently exposed with gently eastward dipping Beekmantown in contact with a thin remnant of vertical Chambersburg. No beds younger than Beekmantown have been found east of this belt in the Cumberland Valley in Maryland.

Faulting prevents exposure of the complete section on this limb in Maryland. About eight miles north of the State line, southeast of Marion, Pennsylvania, a section is described by Cooper and Cooper (1946, pp. 49 and 55) including beds from the base of the New Market through the type section of the Chambersburg. Chert, which is quite abundant in this section, becomes rare southward, and it is believed that much of the thickness of the dark-gray, medium- to fine-grained beds (Cooper's section 4, beds 6 through 9), including the largest amount of this chert, was not deposited in Maryland.

A dark-gray granular limestone with abundant *Maclurites magnus* immediately overlying the New Market limestone serves as an excellent key bed, both as a guide to stratigraphic position and as an indicator of top and bottom of beds. The large gastropod has been found to be oriented with its broad flat dorsal side stratigraphically downward in about 90 per cent of its occurrences.

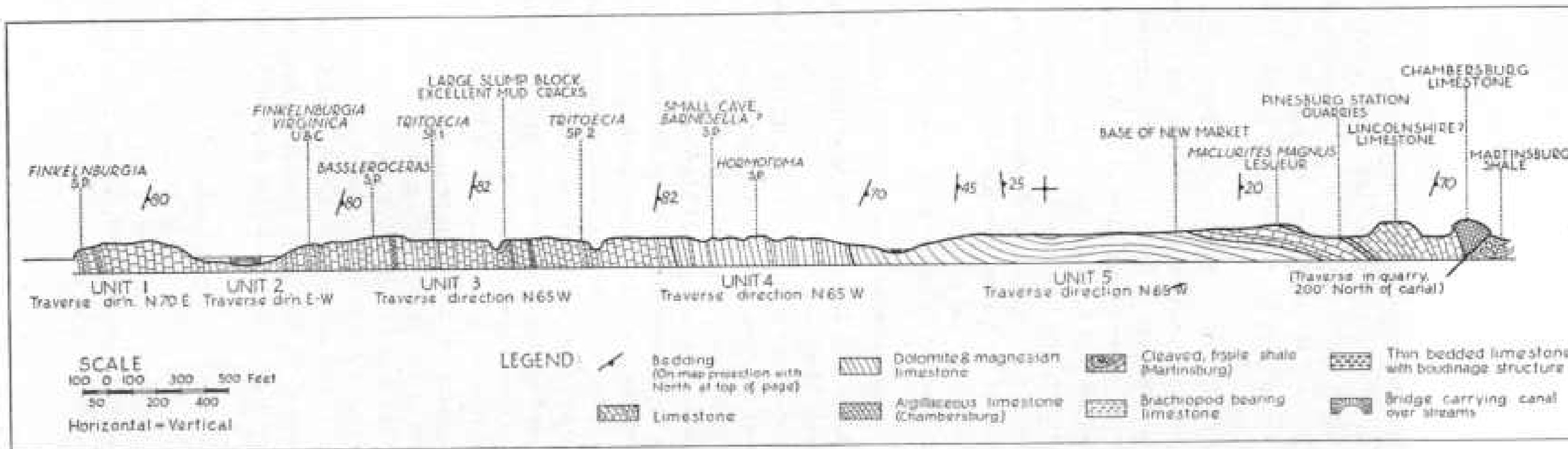

FIGURE 17. Section through Beekmantown along Chesapeake and Ohio Canal at Pinesburg Station (Measured by R. Neuman).

WEST LIMB OF THE MASSANUTTEN SYNCLINE

From about five miles south of New Market, Virginia, to Fairview, Maryland, the lower Middle Ordovician limestones are exposed along the west limb of the Massanutten syncline. Cooper and Cooper (1946, pp. 50 and 59) describe this belt as exposed along U. S. Highway 40 at Wilson, Maryland. A better exposure of the lower part of this section is found in the abandoned quarry south of Pinesburg Station along the Potomac River. The position of this section with respect to the underlying Beekmantown and the fault which truncates its upper part is shown in Figure 17.

POST-BEEKMANTOWN SECTION, PINESBURG
(The section was measured along the southern edge of the quarry.)

	Thickness in feet
Chambersburg limestone	
Dark-gray fine- to medium-grained argillaceous limestone in 2 to 6 inch irregular cobbly beds. *Nidulites pyriformis* and *Echinosphaerites*	100+
New Market limestone, 310 feet	
Light-gray fine-grained limestone, insoluble impurities virtually absent; evenly bedded in 2 to 6-inch beds; no fossils seen	15
Dove to dark-gray calcilutite, 1 to 1½-foot beds	35
Dove-gray calcilutite with a few beds of darker gray fine-grained limestone; tops of beds frequently grade into ½ to 1½-inch zone of buff-weathering clastic limestone; *Tetradium syringoporoides* and *Strophomena*	60
Gray to dark-gray mostly fine-grained limestone with a few parallel laminated magnesian beds; numerous clastic limestone beds; *Girvanella, Tetradium syringoporoides,* unidentified small gastropods, asaphid trilobites, ostracods, and orthocerid cephalopods	200
Row Park limestone, granular facies	
Light-gray granular limestone, chalky weathering, with abundant *Maclurites magnus,* more rarely *Multicostella, "Camarella" longirostra,* and *Dactylogonia*	27
Row Park limestone, calcilutite facies	
Dove calcilutite, beds about 2 feet thick, with *Maclurites magnus* and *Lophospira*	8
Dove calcilutite with a few clastic-textured beds, a few beds slightly magnesian; many small calcite-filled cavities; *Lophospira*	62
Beekmantown limestone, Bellefonte member	
Light gray, sugary dolomite. (See description of the Beekmantown section along the Chesapeake and Ohio Canal, p. 60)	

Discussion of section.—There are several points worthy of note in this section, some of which should be considered with Cooper and Cooper's section at Wilson:

(1) The Beekmantown and Row Park contact is not a sharp line as would be expected in the presence of a major erosional unconformity. Irregular dolomitic masses from 1 to 4 inches in diameter appear within the calcilutite in such a manner that their redeposition as dolomite fragments must be excluded. Moreover, the dolomite and limestone are interbedded through as much as a fifty foot thickness at some localities. Since there are no fossils in the thick series of dolomites, and, since the lithologic character of the dolomite and the limestone are readily distinguishable, this contact may be considered as the most reasonable one to use for mapping. Further work may indicate that the time boundary is within the dolomite beds which later gave way to the low-magnesian limestone or, perhaps, that there is no significant

erosional unconformity between the Beekmantown and the Row Park in this area and that gradual environment changes are reflected in a thin zone of variable deposits.

The New Market and Chambersburg contact appears on the eastern wall of the Pinesburg Station quarry as a very sharp line between light and dark evenly and unevenly bedded limestones. This line may be the most reliable datum for correlation of rocks in this vicinity, for it is equally recognizable at Marion and Wilson and can be traced for long distances along the strike.

Westernmost belt of outcrop.—A faulted syncline extending from the Shady Bower vicinity into Franklin County, Pennsylvania, furnishes a third and westernmost belt of exposure of the lower Middle Ordovician beds. Exposures over most of the belt are not good, but are excellent in a pasture 1,000 feet south of the National Pike (U. S. 40) at Shady Bower and in pastures in the vicinity of Hicksville and Rockdale Run. A summary of the Shady Bower section is given below. The beds strike N 30° E and are essentially vertical; no significant cleavage was observed except in the Martinsburg shale.

POST-BEEKMANTOWN SECTION, BOWERS FARM, 1000 FEET SOUTH OF U. S. 40, SHADY BOWER

	Thickness in feet
Martinsburg shale	
Pencil shale, weathering brown	50+
Chambersburg limestone, undifferentiated	
Dark-gray fine- to medium-grained argillaceous limestone, weathering cobbly; mostly covered, but top and bottom are exposed; *Nidulites pyriformis*	225
New Market limestone	
Dove to dark-gray calcilutite and fine-grained limestone, generally in beds ½ to 1½ feet thick; *Tetradium syringoporoides*	100
Dark-gray fine-grained limestone with a few calcilutite and light-gray, chalky, yellow-weathering magnesian beds; considerable evidence for shallow water deposition; *Cryptozoon*, *Fletcheria sinclairi*, orthocerid cephalopods, and ostracods	300
Row Park limestone, calcilutite facies	
Dove calcilutite in beds 1 to 2 feet thick with a few thin calcarenite beds; many calcite-filled cavities; *Lophospira* (lower contact like that at Pinesburg)	120
St. Paul Total	520
Beekmantown limestone, Bellefonte member	
Thick-bedded gray to white sugary dolomite	50+

MARTINSBURG SHALE

Name and Definition.—The Martinsburg shale was named by Geiger and Keith from Martinsburg, West Virginia, where it has a wide distribution. The present usage of the name includes Maysville, Eden, and Trenton strata.

Character.—The Martinsburg formation is essentially shale. The fresh shale is dark bluish, frequently black, slate and fissile shale. It weathers yellow, drab, and brownish. Some sandstone beds occur at several localities.

In Maryland, the shale is very intensely folded and sections cannot be measured due to the intense distortion. The only extensive good exposures of the shale are along the Western Maryland Railroad on the north side of the Potomac River Valley.

Here it can be seen how the beds curve up and down, and continuous sections cannot be observed.

Bassler (1919, p. 157) has published a generalized section which is reproduced below for lack of a more detailed section in order to show the character of the formation.

GENERAL SECTION OF MARTINSBURG SHALE

	Feet
Juniata formation—early Silurian or uppermost Ordovician.	
Martinsburg shale	
Upper Maysville division	
Unfossiliferous sandstone (Oswego sandstone). (Probably present under cover west of North Mountain in Maryland.)	150
Lower Maysville division	
Fossiliferous gray sandstone with *Orthorhynchula linneyi* bed at top. (Probably present west of North Mountain under cover.)	300
Eden division	
Interbedded yellow shale and calcareous sandstone with upper Eden fossils	500±
Greenish to yellow soft shaly limestone and shale with Eden fossils not uncommon at several horizons	500±
Trenton and Utica (?) divisions	
Dark-gray unfossiliferous shale breaking up into "shoe peg" fragments and often weathering into soft whitish clay	500
Black carbonaceous fissile unfossiliferous shale	500
Dark calcareous shale and thin limestone weathering gray containing graptolites (*Corynoides* fauna)	20–100
Granocrystalline fossiliferous limestone and shale holding the *Sinuites* fauna	2– 10
Total	2500±
Chambersburg limestone	

Distribution.—The Martinsburg shale in Maryland is limited to central Washington County. It occurs in the deepest portion of the Massanutten syncline and continues northward across the Chambersburg and Shippensburg quadrangles and to the northeast across the Susquehanna River.

In Washington County the Massanutten syncline is of particular interest, since Conococheague Creek and its beautiful meanders are restricted to it.

West of the syncline is another syncline which branches off the main syncline near the State line and extends to St. Pauls Church. Two additional areas of Martinsburg shale occur in the Bear Pond Mountains west of Clear Spring. Here it is faulted against Elbrook limestone along the eastern foothills of Powell Mountain, disappears below the Silurian strata of the syncline of Kasies and Gillians Knobs, and reappears in the Blairs Valley anticline. In the Polecat Hollow syncline the shale disappears again and reappears north of the State line in the Hearthstone and Cross Mountain anticline.

The close relationship of relative resistance of rocks against weathering and surface forms is well brought out in the relationship of the Martinsburg shale to its neighbors.

In the Massanutten-Conococheague syncline shale is less soluble than limestone and therefore forms highlands between St. Pauls Church and Fairview and along the east side of the syncline from Huyetts Crossroads to Cearfoss.

The much fractured shale is more readily eroded mechanically and the Conococheague therefore follows the syncline most carefully avoiding the limestone walls on either side.

West of Clear Spring the shale is less resistant to weathering than Silurian sandstones like the Tuscarora, Bloomsburg, Keefer, or Oriskany and is found in rather deep valleys.

Exposures and sections.—One generalized section has been listed above to show the character of the formation. Many small sections are exposed along the Conococheague and some of its tributaries. The Western Maryland section is long but folded and thus much repeated. Shale can always be recognized in fields due to the presence of many small weathered fragments. A large quarry operation is at the Cushwa brick plant at Williamsport. Small openings are plentiful because the County roads are frequently covered with shale which, if not too deeply weathered, provides a fairly good road bed.

JUNIATA FORMATION

Name and definition.—The Juniata formation was named by Darton (1896, p. 2) for the Juniata River in Pennsylvania. Butts (1946, p. 221) uses the term Juniata-Sequatchie formation since the same unit continues into Virginia and beyond under that name.

The Juniata is frequently assigned to the Silurian, but the U. S. Geological Survey and many of the State publications refer it to the Ordovician.

Character.—The formation differs from the Martinsburg below and Tuscarora above in consisting of massive sandstones, red mudstones, and coarse conglomerates. Since it is also very resistant to weathering, it is seen alongside the white Tuscarora sandstone wherever the latter forms ridges, cliffs, and road cuts. Frequently the Juniata sandstones and conglomerates form the highest crests as, for instance, at Cross Mountain where the Tuscarora is partly eroded.

The distinguishing features are its red color and the massive conglomerates and sandstones.

Distribution.—In Maryland the Juniata formation is limited to the central portion of Washington County where it accompanies the Tuscarora sandstone in many outstanding ridges such as Kasies and Gillians Knobs, Rickards Mountain, Fairview Mountain, Sword Mountain, Hearthstone Mountain, and Cross Mountain.

Thickness and sections.—The thickness of the formation is given by Butts (1946, p. 228) as from 200 to 725 feet in Virginia. Bassler (1919, p. 173) lists a general section for the McConnellsburg area in Pennsylvania as 400 feet.

A good section is exposed along the road from Clear Spring to Blairs Valley, where the road enters the mountains. This section is:

JUNIATA SECTION ALONG ROAD CUT FROM CLEAR SPRING TO BLAIRS VALLEY

Section begins at contact of white Tuscarora sandstone in west and continues eastward around the bend of the road. The section is overturned westward.

Feet	
0–66	White hard brittle massive Tuscarora sandstone beds: N 35 E, dip 60 SE
0–42.7	Red sandstone with 2-inch conglomerate at the top. Beds N 35 E, dip 60 SE
42.7–90.5	Concealed with loose red sandstone
90.5–92.5	Red sandstone
92.5–122.1	Gray sandstone N 35 E, dip 45 SE
122.1–128.7	Gray massive impure sandstone
128.7–178.7	Gray-green heavily bedded coarse sandstone. Bedding N 35 E, 70 SE
	Yellow weathered Martinsburg shale

Discussion of section.—The total thickness of Juniata formation at this locality is 179 feet. The Martinsburg is exposed just east of the last sandstone bed and contains trilobite fragments and crinoid stems. Since the Tuscarora is also readily recognized, the thickness of the formation cannot exceed 180 feet.

If the lower gray-greenish sandstone is Oswego sandstone, the boundary between the Martinsburg and Juniata would have to be placed at 92 feet, and the Juniata would thus be only 92 feet thick. The Juniata and Oswego sandstones seem to be thin at this locality in comparison with other areas to the north and south of Washington County.

SILURIAN SYSTEM

GENERAL REMARKS

The Silurian system in Maryland may be divided into three series on the basis of lithology. These are, in descending order: the Cayugan, the Niagaran, and the Medinan (Swartz, 1922, p. 25). The Cayugan is calcareous, the Niagaran arenaceous, and the Medinan sandy. For correlation see chart, Figure 18.

The underlying Juniata red sandstone is correlated by many as Ordovician, but this interpretation seems debatable. Swartz (1922 and 1941) designated it as Medinan but kept it in the Ordovician. For detailed description of the Silurian and its fossil content, see the Maryland Geological Survey systematic report on the Silurian.

DISCUSSION OF USAGE OF NAMES

The geologic map of the county shows the following units as suggested by Swartz except that the Keyser member is not mapped separately from the Tonoloway limestone.

Devonian: Helderberg limestone
Silurian: Cayuga Group
- Keyser member
- Tonoloway limestone
- Wills Creek shale
  - Bloomsburg red shale

Cayuga or Niagara
- McKenzie formation

Clinton shale
Medina
- Tuscarora sandstone

Ordovician: Juniata formation

Swartz and Others 1923

DEVONIAN	LOWER DEVONIAN		Helderberg Formation Keyser member at base
SILURIAN	CAYUGAN		Tonoloway Formation
			Wills Creek Formation (Bloomsburg Sandstone at base)
			Mc. Kenzie Formation
	NIAGARAN	CLINTON GROUP	Rochester Formation (Keefer Sandstone at base)
			Rose Hill Formation
	MEDINAN		Tuscarora Formation

Washington County Map 1941

DEVONIAN	LOWER DEVONIAN	Helderberg Limestone (includes Keyser member)
SILURIAN	CAYUGAN	Tonoloway Limestone
		Wills Creek Shale (Bloomsburg Sandstone member at the base)
	NIAGARAN CAYUGAN	Mc. Kenzie Formation
	NIAGARAN	Clinton Shale (Keefer Sandstone at top)
	MEDINAN	Tuscarora Sandstone

Silurian Correlation Chart Swartz and Others 1942

DEVONIAN			
SILURIAN	CAYUGAN		Keyser Limestone (Lower Devonian?)
			Tonoloway Limestone
			Wills Creek Shale.
			Bloomsburg red beds in east
	NIAGARAN		Mc. Kenzie Formation
		CLINTON GROUP	Rochester Shale
			Keefer Sandstone
			Rose Hill Shale
	ALBION		Tuscarora Sandstone

FIGURE 18. Correlation Chart for the Silurian System

The above usage does not quite coincide with that of Butts (1940) who lists the following Silurian subdivisions further south: Clinch-Tuscarora sandstone, Clinton formation, McKenzie limestone, Bloomsburg formation, Wills Creek shale and sandstone, and Tonoloway limestone. In the map of the Appalachian Valley in Virginia Butts shows the Cayuga Group, McKenzie, Bloomsburg, Wills Creek, and Tonoloway, as one unit and the Tuscarora-Clinch and Clinton formation as another.

TUSCARORA FORMATION

Name.—The Tuscarora formation was named by Darton (1896) from the Tuscarora Mountains in Pennsylvania where it is well exposed. The sandstone is the equivalent of the Clinch sandstone in Tennessee, and Butts suggests that the name Tuscarora be discontinued because the term Clinch was used first in 1856.

Character and thickness.—The Tuscarora sandstone consists chiefly of hard, massive, well-cemented and resistant white quartzite. At places it weathers into quartz sand and has been used commercially in the vicinity of Cumberland, Maryland. The individual grains are small. Due to recrystallization in the presence of percolating waters many grains have grown into quartz crystals so that the sand is sharp and the weathered surface is rather rough.

Joints are usually well developed and subdivide beds into large angular blocks. When weathered the blocky sandstone makes cliffs and picturesque summits. Cross bedding can be observed locally and is distinct on weathered surfaces.

The thickness of the sandstone varies according to Swartz from 60 feet in the Bear Pond area to 380 feet near Cumberland.

Distribution.—The Tuscarora sandstone forms the high ridges in the Bear Pond Mountain area and the county geologic map shows it winding as is characteristic of plunging folds. The first wooded ridge west of Hagerstown Valley—Johnson and Powell Mountains—are Tuscarora and Juniata sandstones in vertical walls which can well be seen through the trees, especially in winter. Kasies Knob is made of the Clinton, and the Tuscarora quartzite does not form the summit but appears along the northern slope. Rickard Mountain is the west limb of a syncline and the quartzite occurs along the western slope of the mountain. North of Gillians Knob the quartzite may be faulted out and outcrops are interrupted in the valley. Gillians Knob is a syncline and its summit is quartzite which strikes east-west and dips gently south. Fairview Mountain is an anticline, the two limbs and the crest having resisted erosion and standing out high above the valley floor which is underlain by shale. From Fairview Mountain to the northernmost turning-point the quartzite forms a long straight ridge and the bedding is vertical. In Two Top Mountain the quartzite turns back to the southwest in a syncline. Hearthstone Mountain and Cross Mountain are a wide anticline with the Tuscarora quartzite outcropping. At Cross Mountain the formation abruptly bends into a vertical position and continues northward for many miles forming the crest of Cove Mountain in the Mercersburg quadrangle, Pennsylvania.

The Tuscarora formation re-enters the map area but not the County about three miles west of Cross Mountain where it forms the cove of the Keefer Mountain anticline.

Few other formations are as consistent in forming the crests of the mountains as the Tuscarora quartzite. Its attitude is reflected in the topography of that area and determines all physiographic features.

The Tuscarora quartzite does not reappear in Washington County west of the southern slope of Cross Mountain.

Correlation.—The name Medina was first used by Vanuxem and Hall from a small village in western New York. H. D. Rogers recognized it in Pennsylvania and distinguished a lower Levant red sandstone and an upper Levant white sandstone. Lesley used the terms red and white Medina to which Darton gave the names Juniata and Tuscarora.

The Tuscarora of Maryland has been traced directly into Pennsylvania and West Virginia and Virginia. As it lies between a red sandstone below and the Clinton shale above, it is easily recognized.

Exposures and sections.—The Tuscarora is well exposed in the crests of all the ridges in the Bear Pond area. Good sections occur in all gaps which transect the formation, as for instance along the road from Clearspring to Blairs Valley, in the Johnson Mountain gap, and at Hanging Rock. Complete sections in which top and bottom are exposed are lacking, and Swartz (1923) lists no measured section in the Silurian report.

CLINTON SHALE

Name and correlation.—Usage of the term Clinton is discussed by Swartz (1923 p. 27) who followed the U. S. Geological Survey and committed on geologic names. The name Clinton was used by Conrad in 1839 for beds below the Niagara shale. Vanuxem (1842, pp. 79–90) defined Clinton group for the strata at the type locality Clinton, Oneida County, N. Y. Later Hall (1843) and others correlated the Clinton with strata that lie between the Medina sandstone below and the Rochester shale above. Ulrich (1911) showed that "the term Clinton had been applied to different units in different areas, embracing the pre-Rochester-Clinton in western New York and both the Rochester and pre-Rochester—Clinton at the type locality."

The term Rose Hill formation was then suggested for that portion of the group which was not included at the type locality. The name was chosen for the locality near Cumberland, Maryland. This formation was defined as including the section between the top of the Tuscarora and the bottom of the Keefer sandstone which is at the base of the Rochester formation in Maryland.

Butts (1940) follows Ulrich (1923) and includes the Rochester and Rose Hill in the Clinton formation with the Rochester and Keefer as members.

On the county geologic map the section between the top of the Tuscarora sandstone and the top of the Keefer sandstone has been included in the Clinton shale but the Keefer sandstone is indicated by a special pattern. This arrangement follows the original Paw Paw-Hancock folio with the exception of placing the Keefer sandstone with the Clinton shale and not at the bottom of the McKenzie, following a suggestion of Swartz who advised on the stratigraphic column for the Silurian and Devonian. The mutual relations of terminology and usage are shown in Figure 18.

Character and thickness.—The Clinton shale is composed of shales and sandstones in various proportions and a few limestone layers. Laterally there is a change of facies and thickness described by Butts (1940) as Cumberland facies in Maryland and Iron Gate facies to the south.

At the north end of Rose Hill, Cumberland, Maryland, the section consists of two parts: the McKenzie shale and fossiliferous limestone with the Keefer at the base and the Clinton formation consisting of 552 feet of olive or drab shale with purple layers and thin layers of sandstone and two beds of red ironstone, the Cresaptown iron sandstone member. The thickness of the Clinton is 598 feet at Rose Hill and about 300 feet in the Bear Pond area.

The Clinton consists of three distinct zones: an upper shale with purple bands, an iron sandstone in the center, and a lower shale with some sandstone beds near the base.

The lower shale beds are fissile, olive-green, and arenaceous and contain sandstone layers near the base. This portion of the section is 175 feet thick near Cumberland.

The Cresaptown iron sandstone consists of a purple sandstone bed in which the quartz grains are cemented by a matrix of hematite. It is particularly well exposed at Cresaptown 6 miles southwest of Cumberland and was named there by Swartz (1923, p. 29). It includes oölite beds and several layers of shale. The iron content reaches 24 per cent, but the presence of over 50 per cent silica renders the beds commercially useless as iron ore.

The purple sandstone is much more resistant against weathering than the shale and thus makes ridges and can become rather prominent topographically. Large and small blocks of purple sandstone cover the hillsides and travel downhill on the underlying shale. It can easily be distinguished from the Bloomsburg red shale by its deep purple color, its hardness, and the quartz grains, which are in part white.

The thickness of the ironstone is 30 feet at Pinto, 10 feet at Cumberland, and about 20–30 feet in the Bear Pond area.

The uppermost division of the Clinton is the Keefer sandstone member. The Keefer sandstone was named from Keefer Mountain a few miles northeast of Hancock where it is exposed in thick and massive beds. Here it is a pure quartzitic sandstone but grades into calcareous sandstone toward the west. Ledges of Keefer sandstone are prominent in the Bear Pond area where they can be distinguished from the Tuscarora sandstone by their yellowish color and the absence of the red Juniata below.

The thickness of the Keefer is 11 feet at Cumberland, 20 feet near Hancock, and 20 to 30 feet in the Bear Pond area.

Distribution.—In Washington County the Clinton shale is exposed only in the Bear Pond Mountains area and southwest and west of Hancock. The formation parallels the prominent ridges at Fairview Mountain and Hearthstone Mountain and is generally covered by debris of the much more resistant Tuscarora sandstone.

The Keefer sandstone makes a distinct ridge in the southeastern and southern slope of Hearthstone Mountain and is cut through by the county road from Indian Spring to Blairs Valley through Stone Cabin gap. U. S. 40 cuts through the sandstone near its highest point on Fairview Mountain where a small shoulder is formed by the more resistant sandstone and is used by a tourist camp and scenic parking area. A good exposure is the road cut just west of the summit.

Sections.—Measured sections of the Clinton formation were published by Swartz

(1923) from Hanging Rock, the gap through Johnson Mountain northwest of Clear Spring, and from Keefer Mountain north of the State line in Pennsylvania. In the following the sections are condensed to show the general appearance of the formation.

Clinton Section at Hanging Rock 2½ Miles Northwest of Clear Spring

Traverse begins at Keefer sandstone and proceeds northeastward along county road to the top of the Tuscarora Sandstone (Hanging Rock).

	Feet
Keefer Sandstone:	
Massive conglomeratic sandstone	25
Rose Hill formation (Clinton):	
Ferruginous and gray sandstone with shale, 51 feet of section concealed	63
Four ledges of blue ferruginous sandstone inbedded with gray shale (iron sandstone)	21
Gray, fissile, argillaceous shale with some thin-bedded argillaceous sandstone; hard sandstone in thin layers at 98.1 feet and 6 feet above base	225
Total	309

Clinton Section in Johnson Mountain Gap One Mile Northwest of Clear Spring

	Feet
Rochester Formation (basal McKenzie):	
Keefer sandstone member:	
Massive gray or greenish-gray sandstone stained mottled pink or brown, somewhat ferruginous at base. 94 feet of section concealed	40
Rose Hill formation:	
Gray shale with interbedded ferruginous and gray sandstone. Sandstone in thin beds scattered through section	152½
Base: Tuscarora sandstone	

In this section the Rochester formation consists only of Keefer sandstone with the upper portion missing and the Rose Hill formation is thinner than farther west and the Cresaptown ironstone seems to be missing. Swartz (1923, p. 104) suggested faulting may be responsible for the thin section.

Clinton Section West of Keefer Mountain One Mile North of State Line

	Feet
Rochester Formation:	
Keefer sandstone member:	
Massive sandstone	25
Rose Hill Formation (Clinton)	
Largely concealed, consists mostly of shale with interbedded sandstones and arenaceous limestones	93
Red ferruginous sandstone	50
Largely concealed consists mostly of shales	90
Olive shale with few thin bands of sandstone	180
Rose Hill total	413

Other sections are described by Swartz from the Baltimore and Ohio Railroad cuts east of Great Cacapon, West Virginia. These sections contain shales and thin sandstone beds which are absent above the Keefer sandstone farther to the east.

MCKENZIE FORMATION

General remarks.—The McKenzie formation belongs to the Cayuga group named from Cayuga County, New York. There the group comprises in ascending order

Pittsford shale, Vernon red shale, Camilla shale and Bertie waterlime. These are well known and best developed between Rochester and Buffalo. In Maryland the group contains in ascending order the McKenzie formation, the Wills Creek shale with Bloomsburg red shale at the base, and the Tonoloway limestone. Butts (1940, p. 251) uses the term Mackenzie limestone, thus indicating its character as mainly limestone.

The McKenzie can be recognized readily by interbedding of limestone beds and shale; the Wills Creek by the red heavy-bedded shale at the base (Bloomsburg) and yellow-weathering massive shale beds; and the Tonoloway by its cobbly very fossiliferous limestone beds. The series is enclosed between the Keefer sandstone at the base and the Helderberg limestone at the top, both readily recognizable.

Name and correlation.—The name McKenzie was taken from McKenzie station on the Baltimore and Ohio Railroad 9 miles southwest of Cumberland, Maryland (Stose and Swartz, 1912).

Originally the McKenzie formation included the Keefer sandstone and its top was marked by the red beds of the Bloomsburg (Ulrich and Stose, 1912). Subsequent work by Prouty and Swartz established the presence of the Rochester fauna in and above the Keefer sandstone and this part of the sequence was therefore included in the Clinton Group by the Maryland Geological Survey.

The boundary between Rochester and McKenzie is not readily determined by lithology and the two formations grade into each other. The lower limit of the McKenzie is therefore drawn on paleontological evidence. In the geological map of the Hancock folio the boundary was established on the basis of distance above the Keefer sandstone which served as reference horizon.

For correlation and terminology see chart, Figure 18.

Character and thickness.—The formation consists chiefly of interbedded shale and argillaceous limestone. The shale is gray, drab, calcareous and breaks into thin flat pieces at some localities as thin as cardboard. The limestone beds are much more resistant and break into gray-bluish rounded blocks or stand out in heavy ridges between shale. The difference between the competency of limestone and shale gives rise to a typical and easily recognized type of folds (see under structures).

Layers of limestone containing limestone pebbles have been reported by Swartz (1923, p. 36).

Swartz recognized and described the following subdivisions:

Arenaceous shale and interbedded limestone, forming the top of the formation. Some redbeds are present in the eastern part of the area.
Upper calcareous shale and argillaceous limestone.
Rabble Run red sandstone member.
Lower calcareous shale and argillaceous limestone, becoming dark and thicker-bedded near the bottom of the formation.

The thickness of the McKenzie formation near Cumberland is about 240 feet; opposite Great Cacapon it is 160 feet; and at Grasshopper Run about 130 feet thick. In Virginia at Crabbottom, 90 miles southwest of Pinto, Maryland, it is 165 feet and at Great North Mountain only about 100 feet thick.

The lower arenaceous shale and argillaceous limestone can be distinguished from the underlying Rochester only on faunal evidence or if the Keefer sandstone is the only representative of the Rochester formation.

Of special interest is the Rabble Run red sandstone member which is present about 100 feet from the top of the formation. This member is up to 100 feet thick in the Bear Pond area and thins westward and disappears before reaching Cumberland. It appears first in the Cacapon section southeast of Hancock and replaces gray shale and limestone toward the east in Washington County. The beds resemble closely the overlying Bloomsburg red sandstone and shale member of the Wills Creek formation and are hard to distinguish from that member in the easternmost exposures.

Distribution.—The McKenzie formation follows the Keefer sandstone as a band of variable thickness in the Bear Pond Mountains, at Keefer Mountain and Dickey Mountain just north of the State line, and in the anticlinal axes of Great Cacapon Mountain and Round Top Mountain.

Sections.—Excellent sections of the formation have been carefully described by Swartz (1923). Those in Washington County are condensed below.

An intensely folded and dislocated section of McKenzie strata occurs opposite Great Cacapon along the Western Maryland Railroad. Parts of the section are also exposed at Round Top.

McKenzie Section at Grasshopper Run

Two miles southwest of Hancock on the West Virginia side of the Potomac River is a well-exposed section near the mouth of Grasshopper Run. This section was measured by Swartz and is of interest because it shows a change in facies indicated by the redbeds which become more prominent farther to the east.

	Feet
Bloomsburg formation:	
Red sandstone and shale	
McKenzie formation:	
Argillaceous greenish-gray sandstone and some interbedded shale	4
Drab to olive fissile shale with numerous thin beds of dark bluish-gray crystalline limestone beds, largely very fossiliferous	83
Red sandy shale (McKenzie redbeds)	5
Olive very fissile shale, becoming mottled on weathering. Dark impure limestone at base	30
Shale and limestone bands, partly concealed	32
Concealed in valley	90
Total McKenzie formation	244

Swartz (1923, p. 95) measured a partly concealed section along a small tributary of Licking Creek, beginning between Dickey Mountain and Keefer Mountain, as 224 feet thick with 24 feet of McKenzie red beds.

A much more complete section is described on Rabble Run in the Bear Pond Mountains area in the Maryland Geological Survey Silurian volume. In the following the section is condensed.

McKenzie Section on Rabble Run

Wills Creek formation, Bloomsburg member
Red sandstone and shale

	Feet
McKenzie formation	
Fissile shale with fossiliferous crystalline blue limestone beds (6 beds)	67.7
Red shale	.7
Fissile gray shale and highly fossiliferous blue crystalline limestone interbedded	35.5
Red shale and red sandstone with some gray or greenish shale interbedded (McKenzie redbeds)	69.4
Concealed to bottom of formation, mostly fissile gray shale	100
Total McKenzie formation	272.8

In a section across Hearthstone Mountain anticline along Lanes Run the redbeds have thickened to 96 feet, and the total thickness of the formation is 300 feet. The top and bottom consists mostly of fissile yellowish-gray or dark shale.

The easternmost section of McKenzie formation is in Johnson Mountain gap 1 mile northwest of Clear Spring. This section is rather thin, probably due to faulting, and the redbeds take up almost the entire thickness which is 48.2 feet (Swartz p. 102). This section continues to the Tuscarora sandstone and is peculiar also in that the Keefer sandstone and McKenzie formation are in direct contact.

BLOOMSBURG FORMATION

General remarks.—Swartz (1923, p. 40) includes the Bloomsburg sandstone under Wills Creek formation as a member at the base of the formation. Butts (1940, p. 253) uses the term Bloomsburg formation and separates it from the Wills Creek. The Washington County geologic map shows the Bloomsburg with a special pattern, but as a member of the Wills Creek.

Name.—The Bloomsburg formation is a part of the Cayuga group. It was named by I. C. White in 1883 after the town of Bloomsburg, Columbia County, Pennsylvania.

Character and thickness.—The formation consists of bright-red sandstones and shales and can be recognized readily by its color. Almost all beds are red, except some thin shale layers and one dark sandstone. The lower beds are more massive than the upper ones. All beds show a strong fracture cleavage which is approximately perpendicular to the bedding and has been referred to as fan cleavage (Gair, 1949). The beds disintegrate into irregularly-bounded pieces and some of the cleavage planes are bleached, resulting in lighter streaks at a large angle to the beds. The red color of the formation is due to the presence of hematite. Thin green shales are interbedded with the red layers. Between the uppermost and lower redbeds occurs a limestone which thins toward the east where it seems represented by the normal red layers.

The name Cedar Cliff limestone has been suggested by Swartz because the limestone occurs most typically near Cedar Cliff southwest of Cumberland.

The thickness of the Bloomsburg formation varies between 20 feet in the west and 200 feet in the eastern sections.

WILLS CREEK SHALE

Name.—The Wills Creek formation was named by Stose and Swartz (1912) because it was well exposed on the banks of Wills Creek in Cumberland, Maryland.

The city has expanded since 1912 and the section is now covered. At Cumberland the shale has been quarried and used for cement making. The name had previously been used by Uhler (1905) for rocks that outcropped at that locality.

Character and thickness.—The Wills Creek formation rests unconformably above the Bloomsburg and the contact can be well observed at the Cacapon and Roundtop sections. It consists mainly of calcareous shales, calcareous mud rocks, and argillaceous limestones with several sandstone beds. Some of the heavy-bedded shales weather yellow and can be readily identified by their massive appearance. Green shales and finely laminated calcareous shales occur in several layers.

The Wills Creek formation displays some of the most beautiful folds and other structures in the Appalachian region.

Mud cracks, corrugations, ripple marks, and salt crystal imprints occur in many layers.

The thickness of the formation varies from 450 feet to 500 feet in Maryland. In the Bear Pond Mountains region it may reach 600 feet. In Virginia it seems to thicken also from west to east (Butts, 1940, p. 254).

Subdivisions.—The following subdivisions have been recognized.

Upper shale and limestone beds with imprints of salt crystals near the top
Upper sandstone
Middle shale and limestone beds
Lower sandstone
Lower shale and limestone beds with some interbedded sandstone

The two sandstone beds of the Wills Creek formation are persistent and are found in all exposures of the formation. Since they are rather competent beds they form very prominent folds, but the shale beds are much more contorted and irregular in thickness due to deformation. The green shale beds seem to have furnished a lubricant in the folding process which is most conspicuously displayed at Round Top and Great Cacapon along the tracks of the Western Maryland Railroad.

The calcareous argillaceous beds in the upper portion above the Bloomsburg have been used for natural cement at Round Top where the remnants of the factory can still be seen. Several tunnels are still visible along the railroad tracks.

Distribution.—The Wills Creek formation is restricted to the Bear Pond Mountains area, Dickeys Mountain anticline, and the Cacapon Mountain anticline. The latter exposes a belt of Silurian strata about 2 miles wide that crosses the county between Tonoloway Ridge and Cove Mountain west of Hancock. Several excellent exposures of the formation are accessible in that anticline north of Great Cacapon and east of Roundtop. Other good exposures are along Tonoloway Creek west of Hancock, along Licking Creek where it transects the Dickeys Mountain anticline just north of the State line, and in the Bear Pond Mountains area south of Cross Mountain and Hearthstone Mountain. The latter region does not furnish as complete a section as the Great Cacapon or Roundtop sections.

Sections.—The best section in the county is at Round Top along the Western Maryland Railroad and the Chesapeake and Ohio Canal. When the section was measured by Swartz and Leibensperger (Swartz, 1923, p. 152) the canal was still in use and the outcrops more readily accessible. Today only the upper portion of the section is easily seen. Since there are many folds and thrusts in the section it is pieced together from fragments. The great care taken by Swartz, however, assures accuracy of the measurements.

An equally complete and larger section with a number of folds similar to those at Round Top is exposed along the Western Maryland Railroad tracks north of Great Cacapon. This section is shown as a drawing in Figure 28. It includes almost the complete sequence between the upper McKenzie formation and the Oriskany sandstone.

TONOLOWAY LIMESTONE

Name.—The Tonoloway formation was named by Stose and Swartz (1912, p. 55) from Tonoloway Ridge west of Hancock. As suggested by Swartz, the type section should be at Pinto, but that name was already preoccupied.

Character and thickness.—The formation consists of finely-laminated fine-grained limestone of dark-gray to dove or bluish color. The fine lamination can be well seen where the surface is weathered and white. The laminae are thin shale partings which weather out as sharp ridges. When freshly exposed the limestone appears massive and hard. Some dolomite beds are fine-grained, not laminated, break with conchoidal fracture, and weather to a buff color. A sandstone bed occurs about 120 feet above the base of the formation in the eastern exposures.

The Tonoloway is nearly 600 feet thick at Potomac, Maryland, but seems to thin out toward the east. At Grasshopper Run it is 400 feet thick and farther southwest at Crabbottom, Virginia, the formation was computed to be 450 feet thick (Butts, 1940, p. 262).

Subdivisions.—The following subdivisions were recognized in the Silurian volume of the Maryland Geological Survey (p. 46):

Upper argillaceous limestone
Upper calcareous shale with interbedded limestone
Middle purer limestone beds
Indian Spring sandstone
Indian Spring redbeds
Lower calcareous shale and limestone with few imprints of salt crystals in the eastern exposure
Lower limestone, very massive

The base of the formation has been placed below the very massive lower limestone. The shale and limestone above it differ but little from the upper Wills Creek below the limestone. Salt crystal imprints were found in the Grasshopper Run section in West Virginia southwest of Hancock. The Indian Spring sandstone is a conspicuous bed which is very thin at Pinto, increases to about 5 feet at Hancock, and is very hard and dense in the easternmost exposures. There it can be recognized as irregular blocks that are strewn about.

The purest limestone occurs above the sandstone bed. It is a dense fine-grained rock which was burned for lime at many localities. The limestone quarries near Cumberland are located in this bed. Above the purer limestone occur nearly 100 feet of shale which is rather prominent in the western exposures. Also restricted to the western exposures is the upper argillaceous limestone.

Distribution.—The Tonoloway formation is associated with the Helderberg limestone as the Juniata is associated with the Tuscarora sandstone. The latter are prominent ridge makers in the Bear Pond Mountains area, and the Helderberg and Tonoloway also form the backbone of ridges despite their calcareous character.

Tonoloway Ridge is made up and supported by the Helderberg and Tonoloway formations. Elbow Ridge is the south-plunging axis of the Keefer Mountain anticline. In the vicinity of Indian Spring and in the plunging axis of Fairview Mountain anticline the two formations stand out as breaks in the topography, particularly the area south of Fairview Mountain shows a series of low but distinct hills which follow the strike of the formations.

Excellent exposures are in the cut of the Western Maryland Railroad north of Great Cacapon about 1¼ miles east of Woodmont station. Other outcrops are found along the road north from Hancock, at Elbow Ridge where Licking Creek transects the formation, and in some scattered openings in the ridge south of Fairview Mountain.

Sections.—The Round Top section exposes only 33 feet of Tonoloway limestone which indicates that a substantial portion of the formation is missing there. On the other side of the river, 1½ miles west of Hancock, a more complete section has been measured and described by Swartz (1923, p. 162). The following is a condensed sequence to show the general composition of the formation.

SECTION AT GRASSHOPPER RUN NEAR ROUND TOP

	Feet
Helderberg formation, Keyser limestone member	
Very massive, nodular, highly fossiliferous limestone	
Tonoloway formation	
Hard dark-gray limestone, argillaceous limestone, and thick-bedded calcareous breccia	24
Calcareous shale with platy limestone interbedded, and shaly limestone with some yellow dolomitic layers	175
Heavy-bedded partly-laminated blue or yellowish limestone	36
Calcareous shale and laminated argillaceous limestone interbedded	40
Limestone, blue or gray, crystalline, laminated and some thicker beds, few shale layers	203
Massive sandstone	5
Interbedded calcareous shale and shaly limestone	100
Hard blue limestone, oölitic limestone with some calcareous shale in center	14
Total Tonoloway formation	597
Wills Creek formation	

In the Bear Pond Mountains area a good section was measured by Swartz (1923, p. 173–177). This section is similar to the one above with the exception of the sandstone which is 24 feet thick in this locality. The locality is on Lanes Run north of Indian Spring and includes 277.6 feet of Tonoloway.

KEYSER LIMESTONE

Name.—The name Keyser was given to the basal portion of the Devonian by Ulrich and was included in the Devonian by Swartz. It does not yet appear in the Paw Paw-Hancock Folio. The type locality is at Keyser, West Virginia, where the limestone is well exposed in a quarry on the Baltimore and Ohio Railroad about $\frac{3}{4}$ mile east of the town.

Recently the Keyser has been included in the upper Silurian as shown in the correlation charts (Figs. 18 and 19).

Character and thickness.—The Keyser member comprises the largest part of the Maryland Helderberg. It consists of massive and very nodular limestones in the lower part and is shaly in the upper part. Chert layers occur at several intervals.

The thickness of the Keyser varies from 270 to 290 feet west of Hancock. To the east the section has not been accurately measured due to lack of complete exposures. In Virginia it reaches a thickness of about 600 feet according to Butts (1940, p. 270).

Distribution.—In Washington County there are several good exposures of Keyser limestone and the entire Helderberg formation. As mentioned above, it forms Tonoloway Ridge and Cove Ridge west of Hancock. In the Keefer Mountain anticline it forms Elbow Ridge just south of the State line. In the Bear Pond Mountains area it is exposed in a few scattered outcrops in the plunging axes of Hearthstone and Fairview anticlines. Where the dip of all formations is steep and the Tuscarora sandstone forms the crest of ridges, all other formations are covered by sandstone debris. At many localities it is covered by the more resistant overlying Oriskany sandstone.

DEVONIAN SYSTEM

GENERAL INTRODUCTION

The Devonian of Maryland has been described in three volumes published by the Maryland Geological Survey in 1913. The lithology and fauna are carefully described and many measured sections are listed. The system is subdivided downward into the Catskill, Jennings, Romney, Oriskany and Helderberg formations. Each of these is subdivided into members which are recognizable lithological units.

In the Paw Paw-Hancock folio the same general subdivisions were used but a transition zone was included between the two uppermost formations.

In the county geologic map of 1941 the Paw Paw-Hancock folio was reprinted with very slight changes except for the omission of the transition zone between the Catskill and Jennings formations.

SUBDIVISIONS

The subdivisions of the Devonian system are shown in the correlation chart (Figure 19).

A somewhat different usage, including some names not used in the Devonian volume is shown by Butts (1940, p. 23) in a table of all the Paleozoic formation.

The total thickness of the Devonian of Maryland is about 11,000 feet. The Silurian measures about 2400 feet and the Carboniferous 3200.

HELDERBERG LIMESTONE

Introduction

The name Helderberg comes from the Helderberg Mountains in Albany County, New York. It was first used by Conrad in 1839, but his formation does not coincide with the present usage.

Devonian Volume Maryland Geological Survey 1913			Devonian Correlation Chart (Cooper and Others) 1942 (Generalized)		
Upper Devonian	Catskill Formation		Upper Devonian	"Catskill" Red Beds	
	Jennings Formation	Chemung Member		Jennings Formation	Chemung Sandstone
		Parkhead Member			Parkhead Sandstone
		Woodmont Member			Woodmont Shale
		Genesee Member	Middle Devonian		Genesee Shale
Middle Devonian	Romney Formation	Hamilton Member		Romney Formation	Hamilton Formation
		Marcellus Member			Marcellus Shale
		Onondaga Member	Lower or Middle Devonian		Onondaga Shale
Lower Devonian	Oriskany Formation	Ridgely Member	Lower Devonian	Ridgely Sandstone	
		Shriver Member		Shriver Chert	
	Helderberg Formation	Becraft Member		Mandata Shale	
		New Scotland Member		New Scotland Limestone	
		Coeymans Member		Coeymans Limestone	
		Keyser Member	Upper Silurian	Keyser Limestone	

FIGURE 19. Correlation Chart for the Devonian System

The Helderberg consists mostly of limestone. Its lithology varies somewhat laterally and vertically. The limestone is blue or gray and rather hard and massive in the upper part and contains several chert horizons. Many of the beds are profusely fossiliferous.

Some of the more massive beds have been burned for lime and are now used for crushed stone, particularly in the vicinity of Cumberland.

The total thickness of the formation varies between 290 feet in the eastern exposures to 350 in the Cumberland area.

Since the Keyser limestone is now placed in the Silurian the Lower Devonian begins with the Coeymans member of the Helderberg formation.

Coeymans member

Name.—The Coeymans member or Coeymans limestone (Wilmarth, 1938, p. 481) was named by Clarke and Schuchert in 1899 to designate the lower *Pentamerus* of New York and to substitute a regional for a paleontological name. Coeymans is a village in Albany County, New York.

Character and thickness.—This member of the Helderberg formation consists of blue massive crystalline and very fossiliferous limestone, a small amount of chert, and a sandstone bed near the base. Toward the east the sandstone becomes more prominent and at Elbow Ridge the Coeymans is a sandstone.

In some localities in Virginia portions of the limestone are mottled pale-red or pink and resemble marble due to their coarse texture. The crystalline appearance is due to the presence of large quantities of crinoid stem fragments.

The Coeymans is rather thin. It varies from 8 to 13 feet in Maryland and may reach 50 feet in Virginia (Butts, 1940, p. 275).

New Scotland member

Name.—The New Scotland member was named by Clarke and Schuchert in 1899 after the village of New Scotland in Albany County, New York. This designation replaced the term *Delthyris* shaly limestone.

Character and thickness.—The New Scotland of Maryland consists of a lower limestone containing several layers of white chert which replace the limestone, and an upper bed of drab soft fissile shale. In road cuts and natural exposures the chert is in loose blocks and fossils weather out and are found abundantly in the soil. A particularly good exposure of this portion of the Helderberg is east of Licking Creek bridge on U. S. 40, west of Indian Spring.

In Virginia the New Scotland is a cherty or siliceous limestone.

In Maryland the thickness varies between 12 feet at Tonoloway and 43 feet at Keyser. In Virginia it reaches 150 feet or more in the gorge of the Jackson River.

Becraft member

Name.—The Becraft member was named by Darton in 1875 to replace the earlier name *Scutella* limestone or upper *Pentamerus* limestone by a locality designation. Becraft Mountain is in Columbia County, New York.

Character and thickness.—In Maryland the Becraft is an arenaceous limestone interbedded with much black chert. It occurs only in Washington County where it is 85 feet thick. In the Cumberland and Keyser sections this member is lacking, but it continues to the south into Virginia where it is described by Butts (1940, p. 279).

Sections in Helderberg formation.—A composite section of the Helderberg formation in the Lower Devonian volume (p. 89) is condensed in the following table:

COMPOSITE SECTION, HELDERBERG FORMATION

			Feet
Becraft member	Cherry Run, W. Va.	Dark blue arenaceous limestone with lumps of black chert (absent west of Hancock)	85
New Scotland member	Twenty-first Bridge, W. Va.	Soft, bluish argillaceous limestone with some harder layers and occasional manganese phosphate nodules	20
	Devils Backbone, Cumberland, Md.	Massive, gray limestone, with chert bands becoming thin above with partings of shale	29
Coeymans member	Devils Backbone, Cumberland, Md.	Massive, regular-bedded blue-gray limestone	9
Keyser member (Silurian)	Keyser, W. Va.	Massive, very nodular limestone, shaly and thin-bedded above	281

An excellent section is exposed in the Western Maryland Railroad cut east of Woodmont, formerly called Tonoloway Station. Here the bedding is nearly vertical and every layer is well exposed.

The following is a condensation of the measurements by Ulrich and Stose as published in the Lower Devonian volume (p. 161) and by Stose and Swartz (1912, p. 7).

SECTION EAST OF WOODMONT

	Feet
Oriskany formation	
Shriver chert member	
Helderberg formation	
New Scotland member	
Residual clay with white chert fragments, very fossiliferous	12
Coeymans member	
Hard, blue-gray limestone, mottled and fine black-speckled, full of fossil fragments	9
Keyser member (Silurian)	
Mostly cobbly dark limestone with shaly layers very fossiliferous	146
Subcrystalline, thick-bedded, mostly massive limestone, thinner-bedded in the lower portions	147

To reach this section one takes the road south from U. S. 40 to the Woodmont Gun Club and the Wild Life Preserve to the railroad and turns east along railroad to a pond where there is a parking space. The section begins near the parking space with Oriskany sandstone and continues for several miles into the McKenzie formation.

The locality of the Hancock section described in the Lower Devonian volume is now altered greatly, due to construction of the New Potomac River bridge. Part of the section is exposed in the road cut leading from U. S. 40 to the bridge from the west but neither top nor bottom are included. Fossils are abundant and the locality is favorable for collecting.

SECTION NEAR WARREN POINT

Warren Point is just north of the State line in Pennsylvania and is a prominent point formed by the Keefer sandstone in the Keefer Mountain anticline. Licking Creek transects the anticline and exposes a good section of Tonoloway, Helderberg, and Oriskany.

A rapid change in conditions of sedimentation is indicated between Hancock and Warren Point. The Oriskany is greatly reduced to only 52 feet, the Becraft is much thicker, the New Scotland and Keyser are thin, and the Coeymans is a sandstone.

The section as described in the Lower Devonian volume begins at the center of the bridge across Licking Creek and continues westward along the south bank of the creek. A quarry has been opened since and the bridge has been changed, but the section is still excellently exposed. The section can be reached along a highway leading north from U. S. 40 just west of Millstone.

The following section is condensed from pages 176–177 of the Lower Devonian volume.

SECTION AT WARREN POINT

	Feet
Oriskany formation	
Cherty arenaceous limestone	
Helderberg formation, Becraft member	
Light gray limestone with chert layers	127
New Scotland member	
Light gray limestone with numerous layers of light chert at bottom	25
Coeymans member	
Light gray quartzitic sandstone with crinoid stems	10

Other sections.—Another prominent section is described in the lower Devonian volume (p. 179) from Cherry Run, West Virginia, on the south side of the Potomac River about opposite Big Pool. Here the lower Devonian beds form a cliff along the south side of the Railroad tracks. The New Scotland and Becraft members are exposed and the contact with the Oriskany.

Another section described in the same volume is on the Maryland side of the river opposite Ernstville in an old quarry which is now not accessible. It showed only a portion of the Becraft member.

ORISKANY FORMATION

Introduction.—The name Oriskany was introduced by Hall in 1839 because the formation was first described from Oriskany Falls, Oneida County, New York.

In Maryland the formation consists of black cherty shale in the lower portion and calcareous sandstone or arenaceous limestone in the upper portion.

The Oriskany does not quite equal the Tuscarora sandstone as a ridge maker, but where it is thick it usually stands out in relief.

The thickness of the formation varies from 350 feet at 21st Bridge in West Virginia to 417 feet at Tonoloway. Fourteen miles to the northeast it has shrunk to 14 feet. In Virginia the thickness varies between 5 and 50 feet.

The Oriskany has been subdivided into two members: the Shriver chert and the Ridgely sandstone.

Shriver Chert member

Name.—The name Shriver chert was proposed in the Lower Devonian volume for its exposures at Shriver Ridge near Cumberland, Maryland. Schuchert had previously called this portion of the formation Lower Oriskany.

Character and thickness.—The Shriver chert member consists of dark siliceous shale and large quantities of black impure chert as nodules or beds of nodules. It weathers to buff or yellow and the chert may become spongy. Where it crops out the surface may be covered with gravel-like fragments.

The thickness reaches about 100 feet in the western area. In Washington County it may be absent.

Ridgely Sandstone member

Name.—This conspicuous and well-known sandstone was originally called Monterey sandstone by Darton in 1892. Schuchert called it upper Oriskany in 1903. It was named the Ridgely sandstone member in the Lower Devonian volume because of good exposures near Ridgely, West Virginia at the north end of Knobbly Mountain, opposite Cumberland, Maryland.

Character and thickness.—The sandstone is a coarse-grained, pure quartz sandstone with calcareous matrix. At some places it becomes an arenaceous limestone due to the increasing amount of calcareous cement. The quartz grains attain a diameter of from $\frac{1}{2}$ to 5 millimeters and locally beautiful euhedral grains are found. Conglomeratic beds may be found near the top with pebbles resembling "grains of wheat". In fresh exposures the rock is bluish-gray, calcareous, and quite hard, but it weathers readily due to its weak cement.

At some localities the sandstone is pure enough to be quarried and washed for glass sand as between Berkeley Springs and Hancock.

The thickness of the sandstone member varies from 250 feet in the western exposures to 50 feet or less in the Bear Pond Mountains area. It thins also southward and is missing in Virginia.

Oriskany sections.—A composite section published in the Lower Devonian volume (p. 95) is repeated below in condensed form.

COMPOSITE SECTION OF ORISKANY

Ridgely sandstone member 258 feet	Heavy-bedded arenaceous limestone gradually changing downward into black chert or siliceous shale. Fossils are generally rare below about 100 feet above the base.
Shriver Chert member 100 feet	Bedded nodular black chert and siliceous shale. In eastern sections there is no black chert, the time interval being occupied by the typical more sandy Oriskany.

The Oriskany is exposed typically at Twenty-first Bridge, West Virginia. Another excellent and complete section is about 1 mile east of Woodmont Station, north of Great Cacapon, West Virginia.

ROMNEY SHALE (MIDDLE DEVONIAN)

Name.—The type section of the Romney shale is at Romney, West Virginia. The name was suggested by Darton in 1892.

Subdivisions and correlation.—As originally described by Darton, the Romney shale included the section between the top of the Oriskany sandstone and the greenish shale of the Jennings. It consists largely of dark or black shale. Later Stose and Swartz (1912, p. 11) named the uppermost black shale the Genesee and included it in the Jennings. Butts recognized the lower half of the Jennings as Brallier shale and made it a separate formation. He also removed the Onondaga from the Romney. Since the upper portion had been separated by Stose and Swartz, the name Romney was left only for the middle portion. Butts (1940, p. 306) suggested, therefore, that the term Romney be abandoned but retained it in a restricted sense.

In the Devonian report of the Maryland Geological Survey three members are recognized: the Onondaga shale, the Marcellus black shale, and the Hamilton. The same units appear in the text of the Paw Paw-Hancock folio. Since the geological map of that folio has been included in the geologic map of Washington County without revision, the legend of the latter carries the same designations. The whole middle Devonian is shown on the maps as Romney shale.

Onondaga shale member

Name.—James Hall named this member after Onondaga County, New York. The member was previously called Corniferous limestone.

Character and thickness.—The Onondaga member consists of thick-bedded dark shales which alternate with thin-bedded fissile black shales. The thick-bedded shale weathers into yellow or greenish irregular fragments; the fissile shale becomes whitish or ashen gray. Several beds of dark argillaceous limestone occur about 100 to 150 feet above the base.

Locally a coarse conglomerate occurs at the base of the Romney.

Between the Oriskany sandstone and the Romney an erosional unconformity is suggested by the irregular surface of the former, by the local presence of conglomerate, and by the lack of transition beds.

The thickness of the Onondaga shale is from 100 to 150 feet.

Marcellus black shale member

Name.—The Marcellus black shale member was named by Hall in 1839 after Marcellus village, Onondaga County, New York.

Subsequently the name has been used variously by Vanuxem (1840) who described upper lighter shales and a lower darker division. Hall in 1843 applied the name to the shales which overlie the Hamilton Group. J. M. Clarke and Luther (1904) divided the Marcellus of New York into 50 to 100 feet of Cardiff shale at the top, Stafford limestone 8 inches, and 50 feet of black shale. They recommended the name Marcellus be restricted to the lower black shale. The Cardiff shale has been included in the Marcellus by some authors and excluded by others. Most workers favor restricting the Marcellus to the black shale

The U. S. Geological Survey considers the Marcellus shale and Hamilton distinct formations. The New York Survey, however, followed Cooper (1930) who included the Cardiff in the Marcellus and the Marcellus in the Hamilton

Butts (1940) eliminated the names Marcellus and Hamilton.

Character and thickness.—The Marcellus member is composed largely of black fissile carbonaceous shale which becomes yellowish to buff when weathered. Nodules of very dark limestone occur near the base.

The thickness of the Marcellus is about 500 feet $3\frac{1}{2}$ miles southeast of Cumberland along the Williams Road.

Hamilton member

Name.—The name Hamilton is derived from West Hamilton in New York. It was first used by Vanuxem in 1840 as a group name. Hall (1843) also used Hamilton for a group which included amongst others the Marcellus, Portage, and Chemung.

The Hamilton has had various usages and there has been little agreement as to what should be included and excluded.

Most geologists have excluded the Marcellus from the Hamilton. Swartz (Middle and Upper Devonian, p. 99) calls attention to the continuity of the Hamilton strata from Virginia to New York and lists a considerable array of fossils to substantiate the correlation.

Character and thickness.—The Hamilton member consists of bluish to gray arenaceous to fine argillaceous shales and sandstones. The latter are mostly less than one foot thick. A lower thicker sandstone occurs from 850 to 1050 above the base of the formation and an upper one near the top.

A conglomerate bed is about 175 feet below the top of the formation in exposures east of Hancock.

Large exposures of the Hamilton show most intense alternation of more and less resistant shale layers which emphasize the bedding because hard layers stand out as ribs against softer ones. The layers are thin and mostly less than one or two inches thick. The Hamilton is a very monotonous looking formation with very few visible breaks. Some of the beds are very fossiliferous, especially between the two sandstones.

Distribution of the Romney formation

The Romney occurs adjacent to the Cacapon-Roundtop anticline in a belt west of Hancock and in one which runs through Hancock. A broad curved area occurs in the Keefer anticline and Cross Mountain and Fairview Mountain anticlines.

Sections and exposures of Romney

SECTION AT TONOLOWAY (EAST OF WOODMONT)

Tonoloway was a station on the Western Maryland Railroad one mile east of what is today Woodmont station. The section begins at Oriskany sandstone and proceeds from here westward (upward). The contact is above the old lock on the north side of the canal.

	Feet
Shales partly concealed, drab, 1–1½ inches thick layers, blue to black shales above....	328
Bluish sandy shale and thin-bedded sandstone..................................	479
Good section along canal bank and in mail road along pond on top of the hill:	
Shales and thin-bedded sandstone with Hamilton fossils..........................	225
Lower sandstone zone, bluish thin-bedded sandstone..............................	57
Arenaceous shales with occasional sandstone beds. Very fossiliferous.............	505
Massive gray to greenish gray sandstone..	59
	1653
Greenish shale with some sandstone layers—probably Jennings	

The above section is the only complete one of the Romney formation in the Middle and Upper Devonian volume. Scattered outcrops are abundant. At McCoys Ferry south of the east end of the railroad bridge are very fossiliferous exposures in green slightly sandy shale. At the west end of the same bridge is a cut with deeply weathered slaty shale. Along the road from Big Pool to Big Spring are several outcrops showing slaty shale with sandstone beds and very intense slaty cleavage. Cuts along the new highway after leaving the Conococheague area to the east are continuous for one-half mile. Fairly good outcrops occur along Licking Creek from where it crosses the State line to where it enters the State again. Occasional good outcrops are made when highways are widened or scraped, but these rarely expose more than a fraction of the section.

JENNINGS FORMATION

General introduction.—The geologic map of Washington County shows one subdivision for the entire Jennings, but one rather outstanding horizon—the Parkhead sandstone—is marked.

The name Jennings formation was introduced by Darton in 1892 and originally applied to the middle series of Devonian sediments in Virginia. Later the Jennings was correlated with Portage and Chemung and with separation of the Genesee from the Romney formation also included that formation. Butts (1933) did not recognize unquestioned Genesee beds and named the upper portion Brallier shale and the lower black shale Romney. In 1940 Butts used the term Millboro shale for a group of shales between the Romney (restricted) and the Brallier shale. The Chemung is a separate formation above the Brallier formation. The relation between the Brallier to the Portage and Big Stone Gap shales is illustrated by Butts on plate 45 of his report on the Appalachian Valley (1940).

Swartz in the Paw Paw-Hancock folio included the following divisions in the upper Devonian:

- Catskill formation
  - Jennings-Catskill transition zone; contains Chemung fauna
    - Beds above the Parkhead, contain Parkhead fauna
- Jennings formation
  - Parkhead sandstone
    - Beds between Genesee and Parkhead contain Ithaca and Naples fauna
  - Genesee black shale; contains Genesee fauna

The same general divisions were adopted in the Devonian report and are shown in Figure 19. The shale below the Parkhead has been named Woodmont shale and the beds above the Parkhead were correlated with the Chemung. A rather complete discussion on pages 341 to 346 in the Middle and Upper Devonian volume need not be repeated here.

Name.—The Jennings formation was named for exposures at Jennings Gap and on Jennings Branch, Augusta County, Virginia.

Character and thickness.—The formation consists of alternating sandstone and shale with shale predominating in the lower part and sandstone in the upper. The thickness of the formation varies from about 4000 to 4800 feet.

Genesee member

The Genesee was named for the exposures along Genesee River and Valley, New York. The name was first used by Vanuxem in 1842.

Character and thickness.—The member consists of black fissile argillaceous shale, which breaks into large flat sheets and weathers into thin flat plates. It is carbonaceous and turns chocolate-brown when weathered.

The lower limit is distinct against the massive sandstones of the Romney. The upper limit against the less carbonaceous and olive-green shales with the Naples fauna is less distinct.

This member is 90 to 100 feet thick west of Wills Mountain near Cumberland and thins eastward and disappears before it reaches Washington County.

Woodmont shale member

Name.—Woodmont is a station on the Western Maryland Railroad north of Great Cacapon and almost three-quarters of a mile west of Tonoloway Ridge. The section exposing the shale is about one-half mile east of Woodmont Station.

Character and thickness.—The Woodmont shale overlies the Genesee shale conformably, or where the latter is lacking it rests on the Romney.

The shales are olive-green and interbedded with thin fine-grained flaggy sandstone. The shale is fissile and breaks into smooth thin fragments with parallel sides. It weathers greenish or yellow and a few beds are reddish brown. The sandstone is micaceous and breaks into platy fragments.

The thickness of this member varies between 1600 feet in the eastern and 1200 to 1300 feet in the western sections.

Subdivisions.—On paleontological grounds the Woodmont shale has been further subdivided into lower beds containing the Naples fauna and upper beds containing the Ithaca fauna. The lower beds consist of olive-green hard fissile argillaceous shale alternating with thin fine-grained sandstone beds. The thickness varies from 500 to 600 feet in the east to 1200 to 1300 feet in the western sections.

The upper beds are lithologically similar, but the shale tends to be softer and the proportion of sandstone is less. East of Sideling Hill there is a bright red bed at the top that resembles the Catskill formation. The Ithaca fauna ranges through a thickness of 1000 to 1100 feet near Hancock.

Lower boundary.—In Washington County the Woodmont member rests on Romney shale and can be distinguished by the difference in the shape of the fragments produced by weathering. The Romney yields very irregularly bounded pieces, whereas the Woodmont shale weathers into smooth thin plates whose larger surfaces are nearly parallel. Another difference is the abundance of brachiopods in the Romney and their almost complete absence in the Woodmont shale.

Parkhead sandstone

Name.—The Parkhead sandstone was named for its excellent exposures near Parkhead, 7 miles east of Hancock. The name was introduced by Stose and Swartz in 1912.

Character and thickness.—The member consists of shale interbedded with massive frequently conglomeratic sandstone. Some of the latter beds are very fossiliferous. The shale is more arenaceous than the Woodmont. The beds become yellowish, buff, and reddish when weathering.

The thickness varies from 400 feet in the east to 800 feet west of Green Ridge.

Conglomeratic sandstone.—Conglomerates make up the largest portion of the Parkhead member. There are usually three conglomerate horizons in the east—at the base, in the middle, and near the top. The conglomerate is bluish-black when fresh and alters to buff-yellow or red when weathered. The lower sandstone is highly fossiliferous and the upper one is very massive near Parkhead. The exposures have recently been considerably improved by relocation of U. S. 40.

Toward the west the sandstones grade laterally into shales which can hardly be distinguished from the underlying Woodmont shales.

The upper part of the Parkhead consists mostly of shales with interbedded sandstones. The shales at the top have been included in the Chemung on the map because the boundary is easier drawn at the top of the upper Parkhead conglomerate.

The total thickness of the Parkhead varies between 300 and 400 feet.

Chemung sandstone

Name.—Hall used the name Chemung for a group of sandstones, shales, and conglomerates which are very different from the underlying Ithaca group and which occur abundantly in the valley of the Chemung River near the town of Chemung, in Chemung County, New York.

Wilmarth (1938, p. 411) devotes two pages to a discussion of the evolution of the term Chemung indicating the wide and varied usages and to a certain extent also the confusion that exists.

"*Chemung fm.* has been employed in Pa., Md., and northern Va. as the name of a series of marine sss. and shales, of gray, green, and brown colors and upper Dev. age, which are in part older and in part grade laterally into the continental red beds long known as *Catskill fm.* and which overlie sss. and shales containing what has been known as *Portage fauna* and commonly designated as *Portage fm.*" (Wilmarth, p. 413)

Character and thickness.—The Chemung formation consists of a series of alternating shales, sandstones, and conglomerates with the amount of sandstone increasing upward. The shale is more arenaceous than that of the lower Jennings members.

Colors are gray, olive-green, yellow, and brown, frequently iron-stained. The red component also increases upward. The thickness varies from 2000 to 2300 feet.

Sections.—Several sections have been measured in Washington County. One section is east of Hancock along former "National Road." The present U. S. 40 has been straightened and even the old still visible road may show a much altered section. Another section east of Woodmont Station is probably unchanged. A third section west of Tonoloway Ridge on the "National Road" may also be hard to identify now. Two good sections were measured just north of the State line: one on the Hancock-Harrisonville road about 2 miles northeast of Hancock and the other along a road leading from Great Tonoloway Creek to Timber Ridge about 1.9 miles north of the Maryland line. The latter section is especially complete.

CATSKILL FORMATION

Name.—The name Catskill was suggested by W. W. Mather in 1840 for a series of white, gray, and red conglomerates with gray, red, olive, and black grits, slates, and shales. The Catskill Mountains are in Green County, New York.

Variations in the use of the name are discussed by Wilmarth (pp. 373–375).

Butts (1940, p. 333) uses the term "Hampshire (Catskill) formation" after Darton (1892, pp. 13, 17, 18). The Hampshire is thought to be the westward extension of the red Catskill of eastern New York.

The Catskill red continental beds seem to be the non-marine equivalent of the upper Devonian contemporaneous and intertonguing with marine sediments ranging from Hamilton to Chemung and in part post Chemung beds.

Character and thickness.—The lower Catskill rocks consist of brownish-red in part arkosic sandstones alternating with red argillaceous shale including occasional bands of greenish shale. In the upper part of the formation there is more greenish-gray sandstone and shale alternating with red rocks. The sandstones are micaceous, rarely cross-bedded, and barren. The thickness of the formation is about 3800 feet in Washington County.

Distribution.—The Catskill formation occupies two broad areas which follow the general trend. The western area is a syncline about 2½ miles wide that reaches from the Potomac River to the State line. In its center is Sideling Hill in which Carboniferous sandstone forms a long ridge. The eastern area about 1 mile east of Hancock is also in the center of a syncline. In both areas the colorful sandstones and shales are readily recognized.

Excellent new exposures of Catskill rocks are along the relocation of U. S. 40 across Sideling Hill and along U. S. 40 east of Hancock.

CARBONIFEROUS SYSTEM

In Washington County Carboniferous rocks occur only in the westernmost portion in Sideling Hill and include only the lowest strata of the system, the Rockwell formation and the Purslane sandstone.

Carboniferous rocks of Washington County:

Mississippian	Pocono Group	Purslane sandstone
		Rockwell formation

POCONO GROUP

Rockwell formation

Name.—The formation was named by Stose and Swartz for the exposures in Rockwell Run, Morgan County, West Virginia.

Character and thickness.—The formation is composed of coarse arkosic sandstones, fine conglomerates, dark and buff shales, and locally some coal seams. It grades downward into the Catskill, and the appearance of the first distinct quartzose conglomerate or sandstone has been taken as the lower boundary.

A partial section of the formation measured by Stose and Swartz (1912) on the north side of the Potomac River in the Sideling Hill syncline is:

SECTION OF ROCKWELL FORMATION, SIDELING HILL, NORTH BANK OF POTOMAC RIVER

	Feet
Flaggy cross-bedded sandstone stained reddish, base of Purslane sandstone	
Poorly exposed buff to brown shale and tough hackly greenish sandstone, with some reddish shale containing small quartz pebbles and grains	400±
Hackly dark shale with thin coal bed at base	10
Hackly dark shale and thin concretionary sandstone	50
Dark shale weathering to splintery fragments	15
Hard shale	10
Thin ripple-marked sandstone and shale	5
Hard dark shale weathering into splintery fragments	6
Granular sandstone	5
Dark-gray crumbly hard shale	5
Hard massive greenish-yellow cross-bedded arkosic sandstone, containing a few quartz pebbles, and two ledges of vitreous quartzose gray sandstone	35
Base not exposed	541±

Several small openings have been made in the coal seams in Sideling Hill, but the coal is too thin and impure to be used.

Purslane sandstone

Name.—The formation was named by Stose and Swartz (1912, p. 13) for Purslane Mountain, Morgan County, West Virginia.

Character and thickness.—In Washington County the Purslane sandstone makes the summit of Sideling Hill and is well exposed in the new road cut of the relocated U. S. 40 near the summit. It is composed of thickly bedded coarse white sandstone with interbedded conglomerate. Stose and Swartz report also thin coal seams and red shale between the harder sandstones.

South of the Potomac River the formation consists of three hard ledges which form rather massive outcrops.

In the new road cuts at Sideling Hill the rough, heavily bedded sandstones and conglomerates are vertical and seem to indicate the approximate center of the syncline.

The Purslane sandstone is at the top of the Pocono Group and is the youngest Paleozoic formation in Washington County. Higher Mississippian and Pennsylvanian formations have been eroded.

TERTIARY AND QUATERNARY DEPOSITS

Above the folded Paleozoic rocks are much younger deposits which have been laid down by the Potomac River and its tributaries. In addition, the slopes of the mountains are strewn with boulders and debris derived from the more resistant formations which make up the mountains. Most of the area is covered also with soils which are described in another chapter.

STREAM DEPOSITS

Along the Potomac River and its larger tributaries are gravel and sand deposits of considerable extent. At many places they are high above the present stream level and indicate former position of the streams.

The present stream beds also carry many sand and gravel beds which are still shifting and in the process of deposition.

The Quaternary terrace deposits are shown on the geological map of the County (1941).

The terrace gravel beds are unconsolidated accumulations of well-rounded boulders and pebbles of from 1 or 2 to 2 or more feet thick. The matrix is largely impure clay and sand. The pebbles and boulders are derived from the resistant beds in the drainage areas of the individual streams. The size of the pebbles and boulders ranges from less than one inch to several feet in diameter.

The terrace gravels occur only in the vicinity of the streams. Beyond a mile erosion has removed all traces of terrace deposits. No gravels are preserved on any of the higher peneplains.

Excellent terrace deposits can be seen in the various river bends west of Sharpsburg and southwest of Williamsport. The course of the river has changed considerably since they were deposited. Southwest of Grimes gravel was found about 160 feet above the present river level, and at many places terraces occur at 100 to 140 feet.

No detailed information is available on the river deposits. Their systematic study would furnish interesting physiographic results.

MOUNTAIN WASH

Wherever resistant rocks make up the summit of mountains, block streams and fans of debris are formed. The Tuscarora sandstone is scattered widely on the slopes of the adjacent shales. Weverton quartzite in the South Mountain area covers the slopes down to the valleys. Large block streams occur west of Black Rock, Quirauk Mountain, and lesser elevations and all along the South Mountain front. These block streams are unstable and still in motion and are constantly supplied anew from the Weverton outcrops above. As the blocks gradually weather and vegetation takes hold the ground becomes stabilized. The large debris-strewn slopes make geologic mapping difficult because the opportunity to find rocks in place is slim.

IGNEOUS ROCKS

BY

ERNST CLOOS

INTRODUCTION

Igneous rocks occur only within the South Mountain anticlinorium between Elk Ridge and South Mountain and in the summit of the mountain where the County line swerves to the east. East of Smithburg they are of two ages: pre-Weverton (possibly pre-Cambrian) and Triassic. The pre-Weverton igneous rocks are of two kinds: gneissic granitic rocks and volcanics.

In the geologic map of Washington County only volcanic rocks are shown and the granitic rocks have erroneously been omitted.

The age relationship between granitic rocks and volcanics has been under discussion for some time and it is not clear whether the granitic gneisses underlie the volcanics as a basement or intrude them. The author had thought that the evidence proved the latter (Cloos 1941, p. 81) but new evidence seems to indicate that some meta-diabase intrudes the gneisses. Stose and Stose (1946, pp. 17 and 25) showed that diabase intrudes the gneisses and concluded that the dikes may be the feeding channels for the greenstones and volcanics which overlie the gneisses. There seems little doubt that this view is essentially correct.

An excellent outcrop showing mutual relations of dikes and gneiss is at the southern end of the Potomac River bridge below Harpers Ferry where a metadiabase dike cuts across gneiss, provides its independent foliation, and spreads out about 100 feet above the road level along the foliation of the gneiss. It is not yet proven, however, that all gneisses are of the same age and that all dikes and greenstones belong to the same generation.

GRANODIORITE GNEISS

The granodiorite gneiss was described by Stose and Stose (1946, p. 16) as granodiorite. It is well exposed in the river islands below the highway bridge at Sandy Hook and along the cliff at the south end of the bridge. These are probably the only tolerably fresh outcrops of this rock in the County. In all road cuts and most natural exposures the granodiorite weathers brownish and rusty and fresh specimens are hard to find.

Near the contact with the greenstones above the highway bridge the granodiorite is very schistose and shows a prominent lineation which consists of an orientation of spindle-shaped accumulations of dark minerals and quartz. The longest spindle axes are parallel to the lineation of the overlying rocks as high as the Conococheague limestone. Their orientation is shown in Figure 21. In the exposures at the south end of the bridge the lineation is hard to see in the north end of the outcrop but very much more distinct at the southern end. A distinct foliation parallels the cleavage of the greenstones and the Paleozoic rocks above and some of the metadiabase dikes follow it.

The uniformity of all these structures shows that the granodiorite has been deformed along with the overlying Paleozoics.

BIOTITE GRANITE GNEISS

Stose and Stose (1946, p. 16) describe a second granitic rock type of the basement complex, but the author is not certain whether he has recognized this type in Washington County. In some of the river islands between Elk Ridge and South Mountain two granitic rocks seem evident, but their mutual relation could not be ascertained. A coarse pegmatitic rock includes fragments of augengneiss which is strongly lineated and foliated. It contains biotite and is probably the equivalent of the biotite granite gneiss of Stose and Stose. Its structures parallel those of the adjacent granodiorite and greenstone.

VOLCANIC ROCKS

Between the granitic gneisses and the Loudon and Weverton formations is a series of volcanic rocks of tuffs and flows partly interbedded with quartzites and slates. In the Potomac River gorge the interval between gneiss and Weverton is only a few hundred feet. At Weverton the gneiss is faulted against the Harpers and the volcanics are absent. East of South Mountain the volcanics are thin. In the Middletown Valley the volcanics occupy the northern and higher portion of the area, the gneisses the lower portion near Potomac River. The volcanics thus always occupy the same stratigraphic position: between a granitic basement and the overlying Paleozoic sediments.

In the small area of volcanic rocks in Washington County no attempt has been made to subdivide them into smaller units.

Essentially two types of volcanics are evident: a greenstone and a purple slate and tuffaceous rock. The greenstone is well exposed in the vicinity of the Potomac River where it forms islands and in the lower portions of Pleasant Valley. Some fair greenstone outcrops occur also near Rohrersville at the north end of the valley and east of South Mountain in the northern area.

The greenstone is schistose, strongly lineated, frequently amygdaloidal, and intersected by numerous quartz and epidote veins. It is thought to be the equivalent of what Stose and Stose have described as Catoctin metabasalt (1946, p. 20). Cleavage in the greenstone parallels that in the granitic rocks below and the Paleozoics above. Lineation is distinct at many places and strictly parallels that in the sequence above and below. It becomes distinct due to the alinement of elongated blebs of chlorite which may be up to 6 inches long, an inch or less wide, and very thin. These blebs are not visible on every cleavage plane but some surface with blebs occurs in almost every outcrop of any size. They are also visible in highly weathered greenstone.

Small areas of purple volcanics are exposed near Rohrersville, but mostly in loose pieces in the fields. They are considered the equivalent of the aporhyolites of Stose and Stose (1946, p. 22).

AGE RELATIONSHIPS

As indicated by Stose and Stose (1946, p. 28) the granitic gneisses are most likely the oldest rocks in Washington County and constitute the basement upon which all other rocks were deposited. Evidence of unconformity with younger rocks is not exposed. Intrusives of granitic rocks into younger ones have also not been found. It is significant that the volcanic cover is at many places only a few hundred feet thick, but that the granitic rocks have never penetrated the Weverton or other Paleozoic rocks above.

Above the granitic gneisses are volcanics of various composition, in part interbedded with some sedimentary rocks. Stose and Stose (1946) distinguished Swift Run tuff, Catoctin metabasalt, and aporhyolites. All of these units may be represented in Washington County.

According to Stose and Stose (1946) the Paleozoic sedimentary rocks rest unconformably on the volcanics. The author has failed to see such an unconformity, but instead has seen many indications of transition which are described on page 27. It seems more probable that the volcanics are not pre-Cambrian but were deposited upon a surface of pre-Cambrian granitic rocks and grade upward into the sedimentary rocks of Paleozoic age. A great deal more detailed work will be needed to satisfactorily answer that question.

TRIASSIC DIKES

The Triassic is represented only by a few diabase dikes in Washington County. They are much more numerous in Frederick County to the east (Stose and Stose 1946, p. 98).

The dikes are discordant steeply dipping bodies of diabase that cut all earlier formations. A number of these dikes are shown on the geologic map between South Mountain and Elk Ridge and one in the area of Tomstown dolomite northwest of Boonsboro. Some of these dikes can be traced for several miles.

The Triassic dikes are easily distinguished from the early metadiabase due to their freshness, discordant relationship, lack of cleavage and lineation, absence of subsequent alteration phenomena, and frequent frozen borders. The diabase dikes are dark, medium to fine-grained with typical diabase texture. They consist of dark feldspar, labradorite, augite and hornblende and chlorite as secondary constituents and apatite and magnetite as accessories. An analysis of diabase from Frederick County is given by Stose and Stose (1946, p. 47). In the field the dikes can readily be detected due to the distribution of round weathered boulders which can be followed across country for some distance. The only fresh outcrops in place are along the B. & O. Railroad between Weverton and the highway bridge at Sandy Hook (U. S. 340) where several Triassic dikes occur next to metadiabase.

PALEONTOLOGY

BY

THOMAS W. AMSDEN

INTRODUCTION

No one publication deals specifically with the paleontology of the Paleozoic formations in Washington County. The available literature is widely scattered and it seems desirable to present a summary of what is known on this subject. Most of the material in the following pages has been extracted from the literature, although wherever possible the generic assignments are brought into accord with modern studies. An inclusive and exhaustive faunal analysis would be beyond the scope of this report and only the more common and better known species are listed. Those who wish more detailed information should consult the literature.

Some of the best places for collecting fossils are listed in the text and these may be easily located by consulting the Washington County geological map. An abbreviated faunal list is presented in table 4. Text references to fossil illustrations in Plates 1 to 6 are enclosed in square brackets.

The writer thanks Professor H. E. Vokes who read the manuscript and made many valuable suggestions.

CAMBRIAN SYSTEM

The Cambrian faunas of Maryland are rather poorly known. This is due in part to the fact that in most of the formations fossils are relatively uncommon and poorly preserved and in part to the fact that many of these faunas have never been adequately collected or studied.

One of the earliest workers on the Cambrian System was C. D. Walcott (1896) who did some collecting in Maryland. He included a brief discussion on the Cambrian strata of Washington County and listed a few fossils. Bassler (1919) published the results of a somewhat more extended study of the Cambrian of Maryland, but the usefulness of this volume is somewhat impaired by the fact that many of the fossils which were described and illustrated came from areas rather far removed from Maryland. The most recent publication on this subject is by Resser (1938) on the Cambrian of the southern Appalachians. This includes a short discussion on the Maryland fauna, but most of this study is devoted to areas farther south where the faunas are larger and better known.

In the last few years J. L. Wilson has done intensive work on the stratigraphy and paleontology of the Upper Cambrian (Conococheague) of Maryland and Pennsylvania but his results are not yet published.

Although most of the Maryland Cambrian has not been very intensively studied, a sufficient number of fossils have been collected and identified to show that all three series, Lower, Middle and Upper Cambrian, are present. Cloos refers the Catoctin, Loudon, Weverton, Harpers, Antietam, Tomstown and Waynesboro formations to

TABLE 4

ABBREVIATED FAUNAL LIST OF PALEOZOIC FORMATIONS

System	Series	Formation	Member	Fauna
MISSISSIPPIAN		Pocono	Purslane sandstone	Lepidodendron sp.
MISSISSIPPIAN		Pocono	Rockwell formation	Eskdalia sp., Lepidodendron sp.
DEVONIAN	Upper	Catskill formation		Fragmentary plants and pelecypods.
DEVONIAN	Upper	Jennings formation	Chemung member	Cyrtospirifer disjunctus [*Pl. 6, figs. 17, 20*], Cariniferella tioga [*Pl. 6, figs. 21, 22*], Douvillina cayuta [*Pl. 6, fig. 19*], Nervostrophia nervosa, Atrypa hystrix, Grammysia subarcuata, Leptodesma medon [*Pl. 6, fig. 18*], Tropidoleptus carinatus.
DEVONIAN	Upper	Jennings formation	Parkhead member	Camarotoechia congregata parkheadensis [*Pl. 6, fig. 16*], Leiorhynchus mesacostale, Tropidoleptus carinatus, Nucula corbuliformis [*Pl. 6, figs. 14–15*], Nuculana diversa, Loxonema hamiltoniae, Phacops rana.
DEVONIAN	Upper	Jennings formation	Woodmont member	Lingula ligea [*Pl. 6, fig. 13*], Pterochaenia fragilis [*Pl. 6, fig. 11*], Buchiola retrostriata.
DEVONIAN	Upper	Jennings formation	Genesee member	Buchiola retrostriata [*Pl. 6, fig. 12*], Pterochaenia fragilis.
DEVONIAN	Middle	Romney shale	Hamilton member	Mucrospirifer mucronatus [*Pl. 6, fig. 8*], Spinocyrtia granulosa [*Pl. 6, figs. 9, 10*], Athyris spiriferoides, Tropidoleptus carinatus [*Pl. 6, figs. 5–6*], Megastrophia concava, Chonetes coronatus, Camarotoechia congregata, Heliophyllum sp., Cystiphyllum americanum, Grammysia bisulcata, Orthonota undulata [*Pl. 6, fig. 7*], Modiomorpha concentrica [*Pl. 6, fig. 4*], Loxonema hamiltoniae [*Pl. 6, fig. 3*], Phacops rana [*Pl. 6, fig. 2*], Greenops boothi [*Pl. 6, fig. 1*].
DEVONIAN	Middle	Romney shale	Marcellus member	Leiorhynchus limitare [*Pl. 5, figs. 15–16*], Styliolina fissurella.
DEVONIAN	Middle	Romney shale	Onondaga member	Coelospira acutiplicata [*Pl. 5, fig. 14*], Nucleospira concinna, Nuculites modulatus, Loxonema hamiltoniae, Phacops cristata.
DEVONIAN	Lower	Oriskany sandstone	Ridgely sandstone	Costispirifer arenosus [*Pl. 5, fig. 12*], Acrospirifer murchisoni [*Pl. 5, fig. 5*], Rhipidomella musculosa [*Pl. 5, figs. 7, 13*], Costellirostra pecularis [*Pl. 5, figs. 8–10*], Leptostrophia magnifica, Beachia suessana, Favosites conicus, Edriocrinus sacculus [*Pl. 5, fig. 11*], Technocrinus ? lepidus [*Pl. 5, fig. 6*], Orthonychia tortuosa [*Pl. 5, fig. 4*], Platyceras ventricosum.
DEVONIAN	Lower	Oriskany sandstone	Shriver chert	Probably absent in Washington County.
DEVONIAN	Lower	Helderberg limestone	Becraft member	Nanothyris subglobosa [*Pl. 5, figs. 2, 3*], Rhipidomella assimilis [*Pl. 5, fig. 1*], Favosites conicus.

TABLE 4—*Continued*

DEVONIAN—*Continued*	Lower—*Continued*	Helderberg limestone—*Continued*	New Scotland member	Delthyris perlamellosa [*Pl. 4, figs. 15–16*], Eospirifer macropleurus [*Pl. 4, fig. 19*], Rhipidomella oblata [*Pl. 4, figs. 20–21*], Isorthis perelegans [*Pl. 4, figs. 12–13*], Rhytistrophia beckii, Costellirostra singularis, Schuchertella woolworthana, Favosites conicus [*Pl. 4, fig. 14*], Pleurodictum lenticulare [*Pl. 4, fig. 18*], Edriocrinus pocilliformis [*Pl. 4, fig. 17*], Platyceras ventricosum.
			Coeymans member	Gypidula coeymanensis [*Pl. 4, fig. 11*], Isorthis perelegans, Tentaculites elongatus.
SILURIAN	Cayugan	Keyser		Favosites helderbergiae praecedens [*Pl. 4, fig. 7*], Stromatopora constellata, Tentaculites gyracanthus [*Pl. 4, fig. 8*], Leperditia alta Chonetes jerseyensis [*Pl. 4, fig. 1*], Meristella praenuntia [*Pl. 4, figs. 2, 3*], Rhynchospirina globosa [*Pl. 4, figs. 4–6*], Gypidula coeymanensis prognostica, Sphaerocystites multifasciatus [*Pl. 4, fig. 10*], Pseudocrinites gordoni [*Pl. 4, fig. 9*].
		Tonoloway		Leperditia mathewsi [*Pl. 3, fig. 28*], Hindella ? congregata [*Pl. 3, figs. 25, 26*], Howellella vanuxemi, Camarotoechia litchfieldensis, Hormatoma rowei [*Pl. 3, fig. 27*], Tentaculites gyracanthus marylandicus.
		Wills Creek		Hughmilleria cf. H. shawangunk, Dolichopterus cumberlandicus. Leperditia elongata willsensis [*Pl. 3, fig. 23*], Bollia pulchella, Fardenia ? interstriata [*Pl. 3, fig. 24*], Camaroteochia litchfieldensis, Howellella vanuxemi, Calymene camerata [*Pl. 3, figs. 21, 22*].
		Bloomsburg		Leperditia sp (Cedar Cliff limestone member).
	Niagaran	McKenzie		Whitfieldella marylandica, Parmorthis elegantula, Camarotoechia andrewsi, Hormatoma marylandica, Beyrichia moodeyi [*Pl. 3, fig. 18*], Dizygopleura swartzi [*Pl. 3, fig. 20*]. Calymene macrocephala.
		Clinton	Rochester	Drepanellina clarki [*Pl. 3, fig. 19*], Whitfieldella marylandica [*Pl. 3, figs. 11–13*] Schuchertella ? elegans [*Pl. 3, figs. 16–17*], Parmorthis elegantula [*Pl. 3, figs. 14–15*] Eospirifer radiatus, Tentaculites niagarensis, Howellella crispa [*Pl. 3, figs. 4, 5*], Dalmanites limulurus [*Pl. 3, figs. 9, 10*]
			Keefer sandstone	Dalmanites limulurus [*Pl. 3, figs. 9, 10*].
				Coelospira hemispherica [*Pl. 3, figs. 2, 3*], Chonetes novascoticus [*Pl. 3, fig. 7*], Calymene macrocephala [*Pl. 3, fig. 8*], Mastigobolbina typus [*Pl. 3, fig. 6*], Tentaculites minutus.
	Medinan	Tuscarora		Arthrophycus alleghieniensis [*Pl. 3, fig. 1*].

TABLE 4—*Continued*

ORDOVICIAN	Upper	Juniata	None.
	Upper	Martinsburg	Orthorhynchula linneyi.
			Climacograptus bicornis, Resserella multisecta, Zygospira modesta, Cryptolithus bellulus [*Pl. 2, figs. 1, 2, 4, 5*], Flexicalymene sp. [*Pl. 2, fig. 3*].
	Middle		Corynoides calicularis. Sinuites cancellatus, Cryptolithus tesselatus, Triarthrus becki.
		Chambersburg	Echinosphaerites aurantium [*Pl. 2, figs. 9–11*], Nidulites pyriformis [*Pl. 2, figs. 15, 16*], Dinorthis cf. D. transversa [*Pl. 2, fig. 14*], "Sowerbyella" pisum [*Pl. 2, fig. 12*], Strophomena sp. [*Pl. 2, fig. 13*], Christiania trentonensis, Bimuria lamellosa, Reuschella "edsoni", Isotelus sp. [*Pl. 2, fig. 8*].
		Stones River (St. Paul): New Market	Tetradium syringoporoides [*Pl. 1, figs. 9, 10*].
		Stones River (St. Paul): Row Park	Maclurites magnus [*Pl. 1, fig. 8*], Mimella cf. M. vulgaris [*Pl. 1, figs. 11–13*], Camerella plicata, Isotelus sp.
	Lower	Beekmantown	Isochilina seelyi, Hormatoma gracilens, "Turritoma acrea", Cryptozoon steeli, Lecanospira compacta [*Pl. 1, fig. 3*], Ophileta complanata, Diaphelasma pennsylvanicum, Finkelnburgia virginica [*Pl. 1, figs. 4–7*], "Orthoceras".
CAMBRIAN	Upper	Conococheague	Cryptozoon proliferum, C. undulatum [*Pl. 1, fig. 1*], Prosaukia stosei [*Pl. 1, fig. 2*], Eoorthis sp., Tellerina sp.
	Middle	Elbrook	Glossopleura bassleri.
	Lower	Waynesboro	Lingulella sp.
		Tomstown	Olenellid fragments, Kutorgina sp., Salterella sp.
		Antietam .	Olenellus sp., Obolella minor, Hyolithes communis.
		Harpers	Scolithus linearis.
		Weverton	None.
		Loudon	None.
		Catoctin	None. —

the Lower Cambrian; the Elbrook to the Middle Cambrian; and the Conococheague to the Upper Cambrian.

LOWER CAMBRIAN

Catoctin, Loudon, Weverton and Harpers formations

No fossils have been recorded from the Catoctin, Loudon, or Weverton formations (Bassler 1919, pp. 54–57; Stose and Bascom 1929, p. 6). The overlying Harpers shale has yielded only the supposed worm boring, *Scolithus linearis* Haldemann (Walcott 1896, p. 25; Stose 1906, p. 205; Bassler 1919, p. 58). The reference of these units to the Lower Cambrian is based upon their stratigraphic and structural relationships to the overlying Antietam.

Antietam quartzite

The Antietam quartzite has yielded a few fossils from localities in Maryland and adjacent areas of southern Pennsylvania. Fragmentary remains of the Lower Cambrian trilobite *Olenellus* have been recorded as well as the brachiopod *Obolella minor* Walcott and *Hyolithes communis* Billings (Walcott 1896, p. 25; Bassler 1919, p. 59; Resser 1938, p. 5). An Antietam collecting locality in Washington County is on the road leading south from Keedysville, about three-quarters of a mile west of Eakles Mills (see fossil locality on Washington County geological map).

Tomstown dolomite

The Tomstown dolomite is poorly fossiliferous but Resser states (1938, pp. 6–7) that in Maryland it carries fragmentary remains of olenellid trilobites, the brachiopod *Kutorgina* and the mollusk *Salterella*, thus indicating a Lower Cambrian age. Farther south the equivalent Shady formation is much more fossiliferous. Many Archaeocyathid reefs and a fairly large fauna of trilobites and other groups occur in the vicinity of Austinville, Virginia (Resser 1938, pp. 24–25).

Waynesboro formation

No fossils have been reported from the Waynesboro formation in Maryland, but a few fragmentary specimens of the inarticulate brachiopod *Lingulella* have been recorded from southern Pennsylvania (Bassler 1919, p. 71). Beds of equivalent age in Virginia (Rome formation) carry the brachiopod *Acrotreta buttsi* Resser and the *Olenellus* trilobite fauna.

MIDDLE CAMBRIAN

Elbrook limestone

No fossils have been described from the Elbrook limestone of Maryland, but just north of the State line, near Waynesboro, Pennsylvania, the trilobite *Glossopleura bassleri* Resser has been found. Bassler (1919, p. 338, pl. 26, figs. 1–9) referred this to *Dolichometopus*; Resser (1938, p. 79) described it as the new species, *Glossopleura bassleri*. In the southern part of the Appalachians the Elbrook is divisible into three formations, the Rutledge, Rodgerville and Maryville; from these Resser described a rather large Middle Cambrian fauna.

UPPER CAMBRIAN

Conococheague limestone

The most common fossils in the Conococheague limestone are the calcareous algae, *Cryptozoon proliferum* Hall and *C. undulatum* Bassler [Pl. 1, fig. 1] which make reef-like masses in many places. Bassler (1919, p. 82) also records the trilobite *Prosaukia* *stosei* (Walcott) [Pl. 1, fig. 2] and a species of the brachiopod *Eoorthis*, and Resser states that the *Tellerina* fauna has been found in southern Pennsylvania. J. L. Wilson who has recently made a detailed faunal study of the Conococheague has collected a sizeable fauna, representing the Trempealeau, Franconia, and Dresbach stages of the standard Cambrian section. The equivalent strata farther south have also yielded large faunas.

ORDOVICIAN SYSTEM

INTRODUCTION

The Ordovician strata of Maryland are referable to five formations representing the Lower, Middle and Upper epochs of this period. The upper two, the Juniata and the Martinsburg, are composed of shale and sandstone whereas the underlying Chambersburg, Stones River (St. Paul), and Beekmantown are largely limestone.

These lower limestones are relatively fossiliferous, although it is usually difficult to collect good specimens. This is especially true of the Beekmantown and Stones River (St. Paul) because the limestones of these formations are fairly pure and consequently the fossils do not weather out, but appear only as sections on the rock surfaces. It is somewhat easier to collect fossils from the more argillaceous Chambersburg as the fossils tend to weather into relief.

The Beekmantown limestone has been considered to be of Lower Ordovician age by almost all workers. The overlying Stones River (St. Paul) and Chambersburg limestone have been referred to the Middle Ordovician, but their exact position within this series has been a matter of some debate. The Correlation Chart, figure 16, presents a summary of the various opinions as to the exact age of these units.

The Martinsburg formation is said to carry fossils ranging in age from high Middle to Upper Ordovician. No fossils have been found in the Juniata of Maryland, but it is placed in the Upper Ordovician on the basis of its stratigraphic position and relationships in other areas.

It should be emphasized that these age assignments, especially for the Middle Ordovician formations, are only tentative. The stratigraphy, faunas, and age relationships of the Ordovician strata, not only in Maryland, but for the entire Appalachian region, present a complex problem. There appear to have been significant facies changes both in an east-west and a north-south direction. Further complications are presented by unconformities within the sequence. The final answer to the exact age of the Ordovician strata in Maryland must wait upon further stratigraphic and faunal studies in this State and in the areas to the north and south.

Ulrich did considerable work on the Ordovician faunas, studying the collections of a number of field geologists including G. W. Stose and Butts. His publication that bears most closely on Maryland faunas deals with the Ordovician section of the Mercersburg-Chambersburg quadrangles in southern Pennsylvania only a short distance north of the Maryland line (Ulrich in Stose 1909). In this folio Ulrich gives faunal lists for all of the Ordovician formations.

Bassler's (1919) discussion of the Ordovician sequence in the Cambrian and Ordovician volume of the Maryland Geological Survey contains much information but many of the species which are described and illustrated came from other areas.

In recent years G. A. Cooper and B. N. Cooper have been studying the Ordovician strata and faunas. Most of this work has been done in the states south of Maryland but in a paper titled *Lower Middle Ordovician Stratigraphy of the Shenandoah Valley, Virginia* (1946) they have included a brief discussion on the Chambersburg and Stones River of Maryland and southern Pennsylvania. During 1947 and 1948, Neuman made a careful investigation of the Stones River (which he proposes to call St. Paul) of Maryland, and presented detailed information on the stratigraphy, fauna, and possible age. Kay and Craig have worked extensively on the Middle Ordovician strata in Pennsylvania.

LOWER ORDOVICIAN

Beekmantown limestone

The Beekmantown limestone in Maryland is composed mainly of a fairly pure limestone, although there are some dolomites present, especially near the top. The dolomite beds are usually poorly fossiliferous, but many of the limestone beds have an abundant fauna. It is generally difficult, however, to collect satisfactory specimens because the fossils have about the same degree of resistance to weathering as the enclosing matrix and do not weather into relief [Pl. 1, fig. 3.]. Enough fossils have been obtained to assign a Lower Ordovician age to these strata.

The fauna of the Beekmantown differs in some respects from that of the underlying Cambrian. In the latter the trilobites are the dominant element, although other types are present. In the Ordovician the trilobites continue to be important, but other groups such as the gastropods and articulate brachiopods show a marked increase. The oldest known corals (*Lichenaria? simplex*) appear in the Lower Ordovician and the nautiloid cephalopods become common for the first time.

North of Maryland, in the Bellefonte quadrangle of central Pennsylvania, the Beekmantown has been divided on lithologic grounds into four formations, each characterized by its own faunal assemblage (Butts and Moore 1936, pp. 20–32). In Maryland and southern Pennsylvania such a lithologic division is not possible, although both Ulrich and Bassler have recognized several faunal zones. Ulrich studied the fossils from the Mercersburg-Chambersburg quadrangles of southern Pennsylvania (in Stose 1909, p. 7) and recognized four faunal zones. Bassler in 1919 also recognized four zones in the Beekmantown of Maryland which agree in a general way with those of Ulrich. The following paragraphs present a summary of Bassler's faunal discussion (1919, pp. 96–105) but more detailed paleontological and stratigraphic work is necessary before either the zones or the generic and specific identification can be regarded as final.

The four units recognized by Bassler are, in ascending order, Stonehenge member, *Cryptozoon steeli* zone, *Ceratopea* zone, and the *Turritoma* zone.

Seventeen species are recorded from the Stonehenge member. One of the most common is the brachiopod *Finkelnburgia* [Pl. 1, figs. 4–7]. Several species of gastropods are said to be present, including the low-spired *Ophileta complanata* Vanuxem. One species of a straight nautiloid cephalopod and three cyrtoconic species are listed as well as several trilobites, including *Bellefontia collieana* (Raymond). This fauna is similar to that found in the Stonehenge limestone of the Bellefonte area (Butts and Moore, 1936, p. 21).

The next higher zone was called the *Cryptozoon steeli* zone by Bassler because of the abundance of this fossil. The supposed coral *Tetradium? simplex* Bassler (*Lichenaria? simplex*) was described from this zone as well as several species of gastropods, including *Lecanospira compacta* (Salter) [Pl. 1, fig. 3], and one trilobite, *Hystricurus conicus* (Billings). This fauna has some similarities to that of the Nittany dolomite at Bellefonte (Butts and Moore, 1936, p. 26).

The third faunal zone was said to be characterized by *Ceratopea keithi* Ulrich, the presumed operculum of a gastropod. According to Bassler, there are also a few species of gastropods, fragments of trilobites, and one brachiopod associated with *Ceratopea*. In addition, he lists one species of the ostracod genus *Isochilina*.

The highest faunal zone recognized was said to be characterized by a number of gastropod species, the most common being *Turritoma acrea* (Billings). This species, the genotype of *Turritoma*, has been recently restudied by Knight (1941, pp. 375–376) who states that the type specimens are so poorly preserved that they are of little value. Another high-spired gastropod, *Hormotoma gracilens* (Whitfield) and the ostracod *Isochilina seelyi* (Whitfield) are also recorded.

Neuman collected fossils from a measured section of Beekmantown strata near Pinesburg station in Washington County. This section, as well as the fossils and their stratigraphic position, is given in the chapter on stratigraphy. He identified the following species:

- brachiopods
  - *Finkelnburgia virginica* Ulrich and Cooper[1] [Pl. 1, figs. 4–7]
  - *Diaphelasma pennsylvanicum* Ulrich and Cooper
  - *Tritoechia* sp.
- gastropods
  - *Lecanospira* sp. [Pl. 1, fig. 3]
  - *Ophileta* sp.
  - *Hormotoma* sp.
- cephalopods
  - "*Orthoceras*"
  - *Bassleroceras* sp.
- calcareous algae

Several of Bassler's important zone fossils, such as *Ceratopea keithi* and *Turritoma acrea*, were not found by Neuman so that it is difficult to fit Bassler's faunal succession into the section measured by Neuman.

MIDDLE AND UPPER ORDOVICIAN

The Middle and Upper Ordovician series are represented in Maryland by the Stones River (St. Paul), Chambersburg, Martinsburg, and Juniata formation. The lower

[1] This may be the species which Bassler records as *Dalmanella wemplei* (*Finkelnburgia wemplei*).

two are referred to the Middle Ordovician, the Martinsburg is considered to range from high Middle to Upper Ordovician, and the Juniata to the very late Upper Ordovician. (See chart, p. 58.)

Stones River limestone

The limestones of the so-called Stones River (St. Paul) present the same problem to the collector as do those of the Beekmantown; that is, fossils are not uncommon, but they are difficult to extract from the rock.

Bassler in his study of the Stones River (St. Paul) recognized three divisions and correlated all of these with the Chazy beds of New York (1919, pp. 121–126). Neuman's detailed stratigraphic and faunal study of this formation led to conclusions which are somewhat different from those of Bassler. The writer spent some time in the field with Neuman and is convinced that his interpretation is essentially correct.

The name Stones River has been applied to a group of strata in the Appalachian region which are not equivalent in age to those of the type Stones River in Tennessee (Cooper 1945, pp. 262–275; Neuman manuscript). To avoid this confusion, Neuman has proposed that the strata in Maryland which have been called Stones River be renamed the St. Paul group. He subdivided the St. Paul group into two units on lithologic and faunal grounds. The lower of these two he gave the new name Row Park limestone, and the upper he called the New Market limestone. The name New Market was proposed by Cooper and Cooper (1946, p. 71) for strata exposed in the vicinity of New Market, Virginia. Neuman has presented adequate evidence to show that these strata are present in Maryland.

The Row Park limestone carries a moderately large fauna of which the most common and conspicuous species is the large gastropod *Maclurites magnus* [Pl. 1, fig. 8]. In addition, Neuman describes the following:

Girvanella sp.
Beatricea sp.

bryozoa
Nicholsonella sp.

brachiopods
Hesperorthis cf. *H. costalis* (Hall)
Ptychopleurella sp.
Multicostella sp.
Mimella cf. *M. vulgaris* (Raymond) [Pl. 1, figs. 11–13]
Camerella plicata (Schuchert and Cooper)
Camerella cf. *C. varians* Billings
"*Camerella*" *longirostris* Billings
Rostricellula pristina (Raymond)
Rostricellula plena? (Hall)
Dactylogonia cf. *D. incrassata* (Hall)

gastropods
Bucania sp.
Lophospira sp.
Maclurites magnus Leseur [Pl. 1, fig. 8]

trilobites

Lonchodomas sp.

Isotelus sp.

On the basis of this fauna Neuman has tentatively correlated the Row Park limestone with the middle and possibly upper Chazy of New York state. He discusses also possible correlation with strata found in areas to the south of Maryland.

The fauna of the New Market is rather limited and is dominated by primitive corals, *Tetradium syringoporoides* Ulrich being the most common. This species has a small corallum which usually does not exceed four corallites. Naturally weathered specimens showing the characteristic cross section are common in the New Market limestone. The following New Market species are listed by Neuman:

corals

"Fletcheria" sinclairi Okulitch

Lichenaria n. sp.

Tetradium syringoporoides Ulrich [Pl. 1, figs. 9, 10]

Prismostylus n. sp.

brachiopods

Ancistrorhyncha? sp.

gastropods

Eotomaria sp.

Neuman discusses the difficulties in correlating the New Market with strata in the New York area. On the basis of the common occurrence of *Tetradium syringoporoides* he suggests that the New Market may be equivalent to the lower Black River (Pamelia) in New York.

There is a complete exposure of the Stones River (St. Paul) at an abandoned quarry on the north side of the Potomac River near Pinesburg Station. The lower part of this carries numerous specimens of the characteristic Row Park fossil, *Maclurites magnus*, and the overlying New Market has abundant *Tetradium syringoporoides*. (See chapters on Stratigraphy and on Structure for further discussion of this locality.)

Chambersburg limestone

In 1919 Bassler (pp. 131–144) discussed the Chambersburg fauna and gave extended lists of species. It is necessary, however, to point out that Bassler's concept of the Chambersburg is not exactly the same as that held by most recent investigators. He included as a basal member of this formation a series of dove to bluish-colored, non-argillaceous limestones, which he claimed carried a large fauna, the lower part being characterized by *Caryocystites* and the upper part carrying numerous "*Tetradium cellulosum*." In this respect, he followed Stose who included these "*T. cellulosum*" beds in the Chambersburg. Bassler thought these beds were present only in Pennsylvania, wedging out and disappearing before they reached the Maryland line (1919, p. 131; also reproduced in his generalized chart, p. 49).

In 1932 Butts (p. 16) removed these "*Tetradium cellulosum*" beds from the Chambersburg and placed them in a separate "Lowville" formation. Cooper and Cooper (1946, p. 55) examined these strata in the vicinity of Marion, Pennyslvania, (type locality of the Chambersburg, about 15 miles north of Hagerstown) and agreed with Butt's emendation, noting that these so-called "*T. cellulosum*" strata were both lithologically and faunally similar to the underlying Stones River but different from the overlying Chambersburg. These authors were not, however, certain that the correlation with New York Lowville was justified. Craig (1949, p. 717) also accepted the view that the "*T. cellulosum*" beds should be removed from the Chambersburg.

Neuman examined the section near Marion and found that the strata below the cobbly Chambersburg were lithologically and faunally like the New Market limestone. He found *Tetradium syringoporoides* ranging up to the base of the Chambersburg, but no *T. cellulosum*. Therefore, it would appear that these "*T. cellulosum*" (= *T. syringoporoides*) and *Caryocystites* beds of Bassler are equivalent to the New Market of Maryland and Virginia; the fauna listed by him on pp. 135–137 is presumably incorrectly ascribed to the Chambersburg.

Bassler recognized the following faunal zones in the Chambersburg (above his "*T. cellulosum*" beds) and gave extended species lists for each of them.

Greencastle beds (recurrent *Nidulites* and *Echinososphaerites*; not present in Maryland)
Christiania zone
Nidulites zone
Echinosphaerites zone

Cooper and Cooper (1946, p. 55) agreed with the above, but Craig recognized a somewhat different faunal succession. The latter believes that the Chambersburg at its type locality near Marion should be divided into three formations, each characterized by a distinctive lithology and fauna. The following presents a summary of his ideas on the Chambersburg as seen at Marion (1949, chart on p. 713 plus following text discussion).

Oranda (Greencastle) formation	*Christiania* zone Upper *Echinosphaerites* zone
Mercersburg formation	Upper *Nidulites* zone
Shippensburg formation (includes 3 members of which the upper is not present at Marion; p. 728 and pl. 6)	*Caryocystites* zone Lower *Nidulites* zone Lower *Echinosphaerites* zone

The above formations were divided into a number of members and faunal lists were given.

The writer is not in a position to evaluate the merits of these faunal zones or their possible application to strata exposed in Washington County. Furthermore, in a report of this scope it is not feasible to repeat the complete species lists given by Bassler or Craig. Therefore, only a few of the more common species are listed below:

brachiopods
Reuschella "edsoni" (Bassler)
"Sowerbyella" pisum (Ruedemann) [Pl. 2, fig. 12]

Christiania trentonensis Ruedemann
Bimuria lamellosa (Bassler)[2]
Dinorthis cf. *D. transversa* Willard [Pl. 2, fig. 14]
Strophomena sp. [Pl. 2, fig. 13]
"*Leptobolus*" *ovalis* Bassler

cystoids
Echinosphaerites aurantium (Gyllenhal) [Pl. 2, figs. 9–11]

trilobites
Isotelus sp. [Pl. 2, figs. 7, 8]
Cryptolithus tesselatus Green
Lonchodomas sp. [Pl. 2, fig. 6]

corals
Lambeophyllum profundum (Conrad)

bryozoa
Many genera and species, including species of *Prasopora*, *Helopora* and *Rhinidictya*.

Nidulites pyriformis Bassler (biological relationship uncertain) [Pl. 2, figs. 15, 16]

There is a good exposure of Chambersburg limestone in a road cut on U. S. Route 40 near Wilson, about 7 miles west of Hagerstown. The exposed strata are fossiliferous and many of the species listed above can be collected, including specimens of *Nidulites* and *Echinosphaerites*.

Martinsburg shale

The Martinsburg shale is rather poorly fossiliferous. In Washington County this formation is usually much deformed, thus increasing the difficulties of obtaining good specimens. However, several fossil localities are indicated on the Washington County geological map; the writer recently visited one located about 2 miles north of Clear Spring, on the road leading south from Union Bethel Church. This yielded molds of the trilobites *Cryptolithus* and *Flexicalymene* as well as a few poorly preserved brachiopods [Pl. 2, figs. 3–5].

Bassler found that the Martinsburg carries fossils which range in age from Trenton in the lower beds to Eden and Maysville in the higher beds. Thus the Martinsburg shales represent a time interval ranging from late Middle Ordovician through most of the Upper Ordovician.

Two faunal zones of Trenton age were recognized by Bassler. The lowest is characterized by abundant specimens of the gastropod *Sinuites canellatus* (Hall). This "*Sinuites* zone" carries a number of other gastropods as well as 3 species of inarticulate and 2 species of articulate brachiopods. About a dozen trilobites are listed, including *Eoharpes ottawaensis* (Billings), *Cryptolithus tesselatus* Green, and *Triarthrus becki* Green. According to Bassler, the best localities for obtaining collections of this fauna are just north of the Mason-Dixon line in southern Pennsylvania.

[2] Bassler records this from the basal Martinsburg; Cooper and Cooper (1946, p. 55) and Craig (1949, p. 740) place it in the Upper Chambersburg.

About 30 feet above the *Sinuites* beds is a second faunal zone which carries many specimens of the small graptolite *Corynoides calicularis* Nicholson (probably var. *americana*: see Ruedemann 1947, p. 359); this zone also has other graptolites such as *Climacograptus spinifer* Ruedemann and the trilobites *Cryptolithus tesselatus* Green and *Triarthrus becki* Green.

Above these Trenton zones Bassler found a horizon which carried a large Eden fauna consisting of some 40 species; an abbreviated list is given below:

graptolites
- *Climacograptus bicornis* (Hall)

asteroid
- *Hudsonaster clarki* Bassler

brachiopods
- *Resserella multisecta* (Meek)
- *Plectorthis plicatella* (Hall)
- *Strophomena* sp.
- *Zygospira modesta* (Hall)

gastropods
- *Sinuites cancellatus* (Hall)
- *Hormotoma gracilis* (Hall)

trilobites
- *Cryptolithus bellulus* (Urlich) [Pl. 2, figs. 1, 2, 4, 5]
- *Flexicalymene* sp. [Pl. 2, fig. 3]

ostracods
- *Dicarnella bivertex* (Ulrich)

The highest beds assigned to the Martinsburg consist of sandstones which carry specimens of *Orthorhynchula linneyi* (James). There are also specimens of *Rafinesquina alternata* (Emmons) and *Zygospira modesta* (Hall) as well as a number of pelecypod species.

Juniata formation

The Juniata sandstone of Maryland is unfossiliferous. Stratigraphic studies in other areas have shown that this formation is equivalent to the Richmond division of the Upper Ordovician.

SILURIAN SYSTEM

INTRODUCTION

The Silurian system is well represented in Maryland by strata referable to the Medinan (Lower), Niagaran (Middle) and Cayugan (Upper) epochs. Seven formations (see chart, page 70) are included in the Silurian. The fauna of these units has been treated at considerable length in the Silurian volume of the Maryland Geological Survey. The non-ostracod portion of the fauna was prepared by C. K. Swartz and Prouty and the ostracods were studied by Ulrich and Bassler. Most of the following discussion has been taken from this source, although some additional information has been obtained from publications by F. M. Swartz.

MEDINAN SERIES[3]

Tuscarora sandstone

The only Maryland formation referred to the Medinan series is the Tuscarora sandstone. This formation is very sparingly fossiliferous, the most common species being *Arthrophycus alleghaniensis* (Harland) [Pl. 3, fig. 1]. This fossil is of uncertain biologic position; it was originally described as a seaweed, but later workers have suggested that it might be the trail of an arthropod or perhaps some kind of worm boring. Swartz also records a species of rhynchonellid brachiopod, *Camarotoechia neglecta* (Hall), from shale beds near the top of the formation.

The age of the Tuscarora and its relation to the Juniata is fully discussed by Swartz (1923, pp. 184–185) and need not be repeated here beyond noting that most workers are agreed that it should be placed in the Medinan or Lower Silurian series.

NIAGARAN AND CAYUGAN SERIES

In this report the Niagaran and Cayugan series are divided into the following formations:

Keyser
Tonoloway
Wills Creek
Bloomsburg
McKenzie
Clinton

As shown in the chart on page 70 not all workers have defined the Clinton and McKenzie formations as they are here used. (See also discussion under McKenzie formation.)

There is also some question regarding the age to be assigned to some of these stratigraphic units. In 1923 Swartz, Ulrich and Bassler referred the Clinton group (including the Rochester formation) to the Niagaran series, placing the overlying McKenzie, Wills Creek and Tonoloway formations in the Cayugan series. The Rochester formation represents the lower part of the McKenzie formation as used in this report; see chart, page 70. These same authors drew the Silurian-Devonian contact at the top of the Tonoloway formation, referring the overyling Keyser member (of the Helderberg group) to the Lower Devonian.

More recent studies by C. K. Swartz and F. M. Swartz have suggested a somewhat different age assignment. As shown in the Silurian Correlation Chart (C. K. Swartz and authors, 1942, p. 538) the McKenzie formation is removed to the Niagaran with the Bloomsburg formation in Maryland probably largely Cayugan in age (in Pennsylvania the McKenzie grades into beds of Bloomsburg lithology). The Keyser formation is removed from the Helderberg and provisionally regarded as the youngest Silurian formation in Maryland. A summary of these different interpretations is given in the chart on page 70.

The problems involved in these age assignments have been ably discussed at considerable length in the literature (see the following: C. K. Swartz 1923, pp.

[3] Sometimes called the Albion series; see Wilmarth 1938; C. K. Swartz and authors 1942.

203–206; Ulrich and Bassler in C. K. Swartz 1923, pp. 243–249; F. M. Swartz 1935, pp. 1190–1192; C. K. Swartz and authors 1913, p. 118; F. M. Swartz 1939, pp. 47–50; C. K. Swartz and authors 1942, chart p. 538).

These Cayugan and Niagaran formations are, with the exception of the Bloomsburg (which is largely non-marine), on the whole fairly fossiliferous. They include a large ostracod fauna and many brachiopods, mollusks, and trilobites.

Clinton shale

The Clinton formation as used in this report includes the strata extending from the top of the Tuscarora sandstone to the top of the Keefer sandstone. As thus defined it is almost equivalent to the Rose Hill formation of Swartz with the exception that the latter does not include the Keefer sandstone, this being referred by Swartz to the overlying Rochester formation (see chart, p. 70). The Clinton shale (Rose Hill) and the Keefer sandstone have been regarded by almost all workers as Niagaran in age.

The Clinton shale (excluding the Keefer sandstone) carries a varied fauna. A total of 58 species are described in the Silurian volume of the Maryland Geological Survey, of which 26 species are ostracods and 32 species belong to other biologic groups.

The most common non-ostracod species in the pre-Keefer part of the Clinton (Swartz 1923, p. 30) is the brachiopod *Coelospira hemispherica* (Sowerby) [Pl. 3, figs. 2, 3] which ranges throughout these beds. Other important forms are:

- brachiopods
  - *Camarotoechia neglecta* (Hall)
  - *Chonetes novascoticus* Hall [Pl. 3, fig. 7]
- trilobites
  - *Calymene macrocephala* Prouty [Pl. 3, fig. 8]
  - *Calymene crespensis* Prouty
  - *Liocalymene clintoni* (Vanuxem)
- *Tentaculites minutus* Hall
  - (The biological position of *Tentaculites* is uncertain; most authors refer it to the phylum Mollusca, but others have suggested that it is a worm tube)

Ulrich and Bassler (Swartz 1923, pp. 349–384) have described a large ostracod fauna from these Clinton strata. The more common species are:

- *Mastigobolbina typus* Ulrich and Bassler [Pl. 3, fig. 6]
- *Mastigobolbina lata* (Hall)
- *Zygosella postica* Ulrich and Bassler
- *Zygobolbina emaciata* Ulrich and Bassler

Several zones of both the ostracod and the non-ostracod faunas are recognized by Swartz, Ulrich and Bassler.

The Keefer sandstone which is here included as the highest member of the Clinton is a rather pure quartz sand in the eastern belt of outcrops and in this area largely unfossiliferous. Toward the west it becomes calcareous and carries the trilobite *Dalmanites limulurus* (Green) [Pl. 3, figs. 9, 10] and other fossils which Swartz

(1923, p. 35; F. M. Swartz 1935, p. 1168) thought closely allied it with the fauna of the lower part of the McKenzie formation (Rochester formation; see chart p. 70 and also the following discussion on the McKenzie formation).

According to Swartz (1923, pp. 68–74) one of the best localities for collecting from the Clinton, Keefer and lower McKenzie (Rochester formation) strata is at the north end of Rose Hill, Cumberland, Maryland, where the strata are well exposed in a cut along the Western Maryland Railroad.

McKenzie formation

The McKenzie formation of this report includes the beds between the top of the Keefer sandstone (upper member of the Clinton) and the base of the Bloomsburg formation. As shown in the chart on p. 70, this is the way Stose and Swartz (1912, pp. 5–6) defined the formation, except that they included the Keefer sandstone as a basal member of the McKenzie. According to these authors, Ulrich believed that the fauna of the Keefer and McKenzie was equivalent to that of the Salina formation of New York and therefore these strata were placed in the Cayugan series. However, in the Silurian volume of the Maryland Geological Survey (Swartz and authors, 1923, pp. 25, 245–246) it was proposed that the lower 20 or 30 feet of the McKenzie shales be removed and placed, together with the Keefer sandstone, in a separate Rochester formation. This subdivision was based entirely upon paleontological studies; the fauna of the Rochester was considered to be Niagaran in age while that of the overlying McKenzie was referred to the Cayugan. The evidence for this age assignment was based primarily upon Ulrich's and Bassler's studies of the ostracods because Swartz (1923, p. 204) noted that the non-ostracod McKenzie faunas had strong Niagaran affinities.

F. M. Swartz in 1935 made a careful faunal study of these strata and recognized both Rochester and McKenzie formations. He differed, however, in his age assignments, placing not only the Rochester but also the lower part of the McKenzie formation in the Niagaran series. In the Silurian Correlation Chart (C. K. Swartz and authors 1942, p. 538) the entire McKenzie formation was placed in the Niagaran (see chart, p. 70).

It is most convenient to discuss the faunas of the lower McKenzie shales (Rochester formation) separately from the middle and upper portions since this is the way it has been approached by C. K. Swartz, Ulrich, Bassler and F. M. Swartz.

C. K. Swartz (1923, p. 35) drew the upper limit of the Rochester shale at the top of the *Whitfieldella marylandica* zone, but F. M. Swartz has pointed out that the upper limits of this formation might be equally well drawn at the upper limit of the *Drepanellina clarki* or *Schuchertella elegans* zones. For the purpose of this paper, it can be defined as extending from the top of the Keefer sandstone to the top of the *Whitfieldella marylandica* zone.

These strata carry a rich fauna of ostracods and of non-ostracod types. The non-ostracod forms include about 60 species. A few of the more common are:

brachiopods

Parmorthis elegantula [Pl. 3, figs. 14, 15]

Whitfieldella marylandica Prouty [Pl. 3, figs. 11, 12, 13]

Schuchertella tenuis [*Fardenia? tenuis*] (Hall)
Schuchertella elegans [*Fardenia? elegans*] Prouty [Pl. 3, fig. 16, 17]
Camarotoechia neglecta (Hall)
Howellella crispa (Hisinger) [Pl. 3, figs. 4, 5]
Eospirifer radiatus (Sowerby)

trilobites
Dalmanites limulurus (Green) [Pl. 3, figs. 9, 10]
Homalonotus delphinocephalus (Green)

gastropods
Bucanella trilobata (Conrad)

Tentaculites niagarensis Hall

These Rochester strata also carry a large ostracod fauna of which the most common form is *Drepanellina clarki*, Ulrich and Bassler [Pl. 3, fig. 19]. This species occupies a zone immediately overlying the Keefer sandstone.

The part of the McKenzie formation lying above the Rochester formation also carries a considerable fauna of both ostracod and non-ostracod types (Swartz 1923, pp. 37–38; F. M. Swartz 1935), many of these species being present in the Rochester. Below is an abbreviated list of species from these strata:

brachiopods
Whitfieldella marylandica Prouty [Pl. 3, figs. 11, 12, 13]
Howellella [?] *bicostata* (Vanuxem)
Parmorthis elegantula (Dalman) [Pl. 3, figs. 14, 15]
Leptaena rhomboidalis [?] (*Wilckens*)
Camarotoechia andrewsi Prouty
Schuchertella elegans [*Fardenia ? elegans*] Prouty

gastropods
Hormatoma marylandica Prouty

trilobites
Calymene macrocephala Prouty [Pl. 3, fig. 8]

Tentaculites niagarensis Hall

ostracods
Beyrichia moodeyi Ulrich and Bassler [Pl. 3, fig. 18]
Kloedenia normalis Ulrich and Bassler
Dizygopleura swartzi Ulrich and Bassler [Pl. 3, fig. 20]
Leperditia sp.

Bloomsburg formation

The Bloomsburg is here treated as a formation, but in some publications, as in the Silurian volume and the Washington County geologic map of the Maryland Geological Survey, it is regarded as the basal member of the Wills Creek formation.

According to C. K. Swartz (1923, p. 43) no fossils have been found in the redbeds of the Bloomsburg except for a few specimens of a linguloid brachiopod and some fragments of fish scales. There is, however, a limestone lens in the central part of the formation, called by Swartz the Cedar Cliff limestone, which was found to carry ostracods of the genus *Leperditia*.

As noted on page 111, the Bloomsburg formation is now considered to be the oldest Cayugan strata in Maryland. These redbeds thicken considerably as they are traced north into Pennsylvania where they seem to represent a greater time interval. This facies change that takes place between Maryland and Pennsylvania has been fully discussed by C. K. Swartz and F. M. Swartz (C. K. Swartz and F. M. Swartz 1931; F. M. Swartz 1934).

Wills Creek shale

The Wills Creek shale has a fairly large ostracod fauna with these small shells so abundant in some layers that they form a coquina. Ulrich and Bassler (C. K. Swartz and authors, 1923, pp. 207, 222–231) described 16 species of ostracods from this formation, including the following:

Leperditia elongata willsensis Ulrich and Bassler [Pl. 3, fig. 23]
Bollia pulchella Ulrich and Bassler
Zygobeyrichia incipiens Ulrich and Bassler
Dizygopleura affinis Ulrich and Bassler

The non-ostracod fauna of the Wills Creek is less well developed, only 7 species being recorded by Swartz from exposures in Maryland. The most common species are given below (all of these species range into the Tonoloway).

Howellella vanuxemi (Hall) [ranges into Keyser]
Camarotoechia litchfieldensis (Schuchert)
Fardenia ? interstriata (Hall) [Pl. 3, fig. 24]
Calymene camerata Conrad [Pl. 3, figs. 21, 22]

Near the top of the Wills Creek formation is a zone which carries numerous fragments of eurypterids; Swartz (1923, pp. 44, 716–718) records two species, *Hughmilleria* cf. *H. shawangunk* Clarke and Ruedemann, and *Dolichopterus cumberlandicus* Swartz

Tonoloway limestone

The Tonoloway limestone contains an even larger ostracod fauna than does the Wills Creek; about 30 species are recorded by Ulrich and Bassler including:

Leperditia mathewsi Ulrich and Bassler [Pl. 3, fig. 28]
Zygobeyrichia modesta Ulrich and Bassler
Welleria obliqua Ulrich and Bassler
Dizygopleura subovalis Ulrich and Bassler

A total of 39 species other than ostracods have been recorded from the Tonoloway of Maryland by Swartz (1923, pp. 47, 212). The middle portion of this formation carries many specimens of the brachiopod *Hindella* (?) *congregata* Swartz [Pl. 3, figs. 25, 26]; other common species are:

brachiopods
    Stenoscisma (?) *lamellata* (Hall)
    Camarotoechia litchfieldensis (Schuchert)[4]
    Howellella vanuxemi (Hall)[4]
    Schuchertella [?] *rugosa* Swartz
gastropods

[4] Also recorded from the Wills Creek formation.

Hormatoma rowei Swartz[4] [Pl. 3, fig. 27]
Tentaculites gyracanthus var. *marylandicus* Swartz (also recorded from the Keyser)

Almost all investigators have referred both the Tonoloway and Wills Creek formations to the Cayugan (Upper Silurian) series.

Keyser formation

The fauna of the Keyser formation has for many years presented a problem to paleontologists since it seems to contain transitional elements between typical Silurian and typical Devonian faunas. In this report the usage of the Silurian Correlation Committee (C. K. Swartz and authors 1942) is followed by placing the Keyser as the youngest of the Silurian formations. As is shown in the correlation chart on page 70 many workers in the past have treated this unit as the basal member of the Lower Devonian Helderberg formation (Swartz 1913, pp. 96–123). F. M. Swartz (1939, pp. 47–50) has given a very good analysis of this problem.

The Keyser formation includes some 200 feet of strata with a rich fauna of brachiopods and corals. Two rather well-defined lithologic-faunal groups have been recognized (C. K. Swartz and authors 1913, pp. 98–99). The lower of these consisting of nodular limestones has been termed the *Chonetes jerseyensis* [Pl. 4, fig. 1] zone because of the abundance of that brachiopod; the upper, consisting of more shaly limestones which carry reefs of corals and stromatoporids, has been termed the *Favosites helderbergiae* var. *praecedens* [Pl. 4, fig. 7] zone.

The *Chonetes jerseyensis* zone carries a fairly large fauna dominated by brachiopods. Some of the more common species are:

brachiopods
Chonetes jerseyensis Weller [Pl. 4, fig. 1]
Meristina praenuntia Schuchert [Pl. 4, figs. 2, 3]
Rhynchospirina globosa (also recorded from the Tonoloway) [Pl. 4, figs. 4–6]
Schuchertella [?] *prolifica* Schuchert & Maynard
Camarotoechia litchfieldensis (Schuchert)
Howellella [?] *plicatus* Schuchert & Maynard
Gypidula coeymanensis var. *prognostica* Schuchert & Maynard

corals
Favosites pyriformis Hall

bryozoa
Diplostenopora siluriana (Weller)

In addition to the above, a number of well preserved cystoids have been collected from this part of the formation near Keyser, West Virginia. Among the more common species are *Jaekelocystis hartleyi* Schuchert, *Pseudocrinites gordoni* Schuchert [Pl. 4, fig. 9], and *Sphaerocystites multifasciatus* Hall [Pl. 4, fig. 10].

The fauna of the *Favosites helderbergiae praecedens* zone is made up largely of corals and stromatoporoids with the brachiopods much reduced in numbers. A partial list of species from this zone is:

corals
Favosites helderbergiae praecedens Schuchert [Pl. 4, fig. 7]

Cyathophyllum [?] *schucherti* Swartz

Halysites catenulatus (Linne)

Stromatopora constellata Hall[5]

Tentaculites gyracanthus (Eaton) [Pl. 4, fig. 8].

brachiopods

Meristina praenuntia Schuchert [Pl. 4, figs. 2, 3]

ostracods

Leperditia alta Conrad

A well-exposed section of fossiliferous Keyser limestone is exposed in a cut of the Western Maryland Railroad about a mile east of Woodmont in southwestern Washington County.

DEVONIAN SYSTEM

The Devonian section in Maryland is reasonably complete, including representatives of the Lower, Middle and Upper epochs of Devonian time. Five formations have been recognized, the Helderberg limestone and Oriskany sandstone comprising the Lower Devonian, the Romney shale the Middle, and the Jennings and Catskill formations the Upper Devonian series. These formations have been further subdivided into members as is shown in the chart on page 82, this being the same division as that used in the Devonian volumes of the Maryland Geological Survey. In this report, however, one change has been made in the age assignments: the Keyser is removed from the Lower Devonian (Helderberg limestone) and placed in the Cayugan or Upper Silurian series (see chart and discussion on pages 70, 116). However, more recent work by the Committee on Devonian Stratigraphy (Cooper and authors 1942) has suggested that the Genesee shale (lower member of the Jennings formation) should be moved from the Upper to the Middle Devonian and that the Onondaga member (of the Romney formation) may be Lower Devonian. These changes are summarized in the chart on page 82.

In this report the older classification is retained since it keeps the terminology more nearly in accord with the Washington County geologic map and other publications of the Maryland Geological Survey.

With the exception of the Catskill formation which is almost barren, the Maryland Devonian formations are quite fossiliferous, although the preservation is not always of the best. Fossils from the Romney shale and Jennings formation have commonly lost the original shell and occur as casts and molds. In most localities this is also true of the Oriskany, although there are a few places which have yielded complete specimens. Some of the best collecting in the Maryland Devonian comes from the New Scotland member of the Helderberg where the fossils are often silicified and weather out free.

The fauna of the Maryland Devonian has been described and illustrated in considerable detail in the Devonian volumes and most of the following data have been abstracted from those volumes.

[5] The biological position of the stromatoporoids is uncertain; many workers regard them as an extinct group of the phylum Coelenterata, possibly related to the class Hydrozoa.

LOWER DEVONIAN SERIES

Two formations, the Helderberg limestone and Oriskany sandstone, are included in the Lower Devonian of Maryland. Both of these carry large and distinctive faunas and furnish some of the best fossil collecting in Washington County.

Helderberg limestone

The authors of the Lower Devonian volume of the Maryland Geological Survey divided the Helderberg into the Keyser, Coeymans, New Scotland, and Becraft members. Only three of these are here included in the Helderberg, the Keyser limestone being removed to the Silurian (see chart p. 70; also discussion under Keyser limestone p. 116).

In Maryland the Coeymans is a thin crinoidal limestone ranging from 8 to 13 feet in thickness (Lower Devonian volume, p. 86). It is moderately fossiliferous with many of the species ranging up into the New Scotland. The New Scotland member in Maryland consists of two distinct lithologic units; the lower is a cherty limestone and the upper is a shale which represents a southern extension of the Mandata shale of Pennsylvania. The limestone and at least the lower portion of the shale carry *Eospirifer macropleurus* (Conrad) and other fossils characteristic of the New Scotland in its type area (New York). According to C. K. Swartz (1913, p. 88) the overlying Becraft member is a cherty limestone with a very restricted development in Maryland. It is possible that in those areas where this cherty limestone is absent the Becraft horizon may be represented by the upper part of the New Scotland shale beds (F.M. Swartz 1939, chart opp. p. 51). The exact relation of the New Scotland to the Becraft and overlying Shriver chert (basal member of the Oriskany sandstone) is still uncertain. F. M. Swartz (1939, pp. 50–73) has presented an extended discussion of this problem.

The most distinctive fossil in the Coeymans member is the pentameroid brachiopod, *Gypidula coeymanensis* Schuchert [Pl. 4, fig. 11]. A very similar variety, *Gypidula coeymanensis* var. *prognostica* Schuchert and Maynard, is found in the Keyser. Several other brachiopods are recorded from this member, including *Isorthis perelegans* (Hall), *Rhipidomella oblata* Hall, and *Schuchertella woolworthana* (Hall) (These species also occur in the New Scotland member). In addition, *Tentaculites elongatus* Hall and the coral *Favosites helderbergiae* are present; for a complete faunal list, see the Lower Devonian volume (pp. 124–132).

The New Scotland member is richly fossiliferous. One of the most common species is *Delthyris perlamellosa* (Hall) [Pl. 4, figs. 15, 16] and many of the early workers in New York referred to these beds as the *Delthyris* shaly limestone due to the abundance of this brachiopod. Another distinctive brachiopod is *Eospirifer macropleurus* (Conrad) A much abbreviated faunal list is:

brachiopods

- *Orthostrophia strophomenoides* (Hall)
- *Isorthis perelegans* (Hall) [Pl. 4, figs. 12, 13]
- *Rhipidomella oblata* Hall [Pl. 4, figs. 20, 21]
- *Leptaena rhomboidalis* (Wilckens)
- *Rhytistrophia beckii* (Hall)

Schuchertella woolworthana (Hall)
Costellirostra singularis (Vanuxem)
Atrypa cf. *A. reticularis* (Linne)
Eospirifer macropleurus (Conrad) [Pl. 4, fig. 19]
Nucleospira ventricosa (Hall)
Meristella arcuata Hall

corals

Enterolasma strictum (Hall)
Favosites helderbergiae Hall
Favosites conicus Hall [Pl. 4, fig. 14]; ranges into the Oriskany
Pleurodictyum lenticulare (Hall) [Pl. 4, fig. 18]

crinoids

Edriocrinus pocilliformis Hall [Pl. 4, fig. 17]

gastropods

Platyceras ventricosum Conrad[6]

trilobites

Phacops logani Hall

In addition, this horizon has yielded a number of species of bryozoans and pelecypods. For a complete faunal list see Lower Devonian volume, pages 124–132.

An easily accessible collecting locality which yields a large number of well preserved New Scotland fossils is on the north side of U. S. 40, just east of Licking Creek (see Washington County geologic map).

The Becraft member of the Helderberg has a fauna similar to that of the New Scotland, although more restricted in number of species. One of the most common fossils is the terebratuloid brachiopod *Nanothyris subglobosa* (Weller) [Pl. 5, figs. 2, 3]. An abbreviated faunal list is:

corals

Favosites conicus Hall

brachiopods

Nanothyris subglobosa (Weller) [Pl. 5, figs. 2, 3]
Rhipidomella assimilis (Hall) [Pl. 5, fig. 1]
Plethorhyncha praespeciosa Schuchert

Oriskany sandstone

The Oriskany consists of two members, a lower called the Shriver chert and an upper termed the Ridgely sandstone. According to Swartz the Shriver chert, which was named for exposures near Cumberland, thins toward the east and is absent in Washington County. The fauna will not be discussed here but a list of species may be obtained from the Lower Devonian volume (pp. 124–132).

The Ridgely member has yielded a large fauna of corals, echinoderms, brachiopods and mollusks. In most of the outcrop in Maryland, as well as in other states, the fossils are usually preserved as molds or internal cores. There are, however, quarries in Cumberland, Maryland, which have yielded some excellent Oriskany fossils.

[6] Ohern (Lower Devonian volume, p. 471) considers this species probably identical with *P. gebhardi* Conrad.

There the shells and other hard parts have been replaced by silica and the sandstone matrix has disintegrated sufficiently so that the fossils weather out free (Lower Devonian volume, p. 93).

One of the distinctive features of the Ridgely fauna is the presence of several fairly large brachiopods such as *Costispirifer arenosus* (Conrad) [Pl. 5, fig. 12], *Acrospirifer murchisoni* (Castelnau) [Pl. 5, fig. 5], *Rhipidomella musculosa* (Hall) [Pl. 5, figs. 7, 13], and *Hipparionyx proximus* Vanuxem. Other common fossils are:

corals
- *Favosites conicus* Hall [Pl. 4, fig. 14]

crinoids
- *Technocrinus ? lepidus* Ohern [Pl. 5, fig. 6]
- *Edriocrinus sacculus* Hall [Pl. 5, fig. 11]

brachiopods
- *Leptostrophia magnifica* (Hall)
- *Plethorhyncha speciosa* (Hall)
- *Costellirostra pecularis* (Conrad) [Pl. 5, figs. 8, 9, 10]
- *Rensselaeria marylandica* (Hall)
- *Beachia suessana* (Hall)

gastropods
- *Platyceras ventricosum* Conrad (see footnote page 119)
- *Orthonychia tortuosa* (Hall) [Pl. 5, fig. 4]

The Oriskany sandstone is well exposed in the quarries near Berkeley Springs, a short distance south of Hancock, Maryland. Many of the species listed above can be collected there.

MIDDLE DEVONIAN SERIES

The Middle Devonian of Maryland is included within a single formation, the Romney shale, which is divided into the Onondaga, Marcellus and Hamilton members. This shale is moderately fossiliferous, especially in the Hamilton member, but the fossils are usually poorly preserved, occurring as molds or internal cores.

The Onondaga member consists largely of dark shales and is lithologically quite different from the Onondaga in its type area (Onondaga County, New York) where it is a limestone. On the basis of faunal studies the strata in the two areas are believed to be equivalent and therefore the name Onondaga has been carried into Maryland (Middle and Upper Devonian volume, pp. 88–97).

One of the most common species in this member is the brachiopod *Coelospira acutiplicata* (Conrad) [Pl. 5, fig. 14]. A number of other species are present, among which are the following:

brachiopods
- *Nucleospira concinna* Hall[7]
- *Elytha fimbiata* (Conrad)[7]

pelecypods
- *Panenka* cf. *P. dichotoma* Hall
- *Nuculites modulatus* Kindle

[7] Range higher in the Romney shale.

gastropods

Loxonema hamiltoniae Hall[7]

cephalopods

Bactrites ? sp.

Agoniatites expansus (Vanuxem)

trilobites

Phacops cristata Hall

The Marcellus member carries a meager fauna. The most common species are the brachiopod *Leiorhynchus limitare* (Vanuxem) [Pl. 5, figs. 15, 16] and the questionable mollusk *Styliolina fissurella* (Hall).

The shales of the Hamilton member are very fossiliferous, the fauna being dominated by brachiopods, pelecypods, and gastropods. Many of the characteristic species of the New York Hamilton are present, such as the brachiopods *Mucrospirifer mucronatus* (Conrad) [Pl. 6, fig. 8], *Spinocyrtia granulosa* (Conrad) [Pl. 6, figs. 9, 10], *Athyris spiriferoides* (Eaton), and *Tropidoleptus carinatus* (Conrad) [Pl. 6, figs. 5, 6], and the trilobite *Phacops rana* (Green) [Pl. 6, fig. 2]. Other common species are:

corals

Heliophyllum sp.

Cystiphyllum americanum Edwards and Haime?

brachiopods

Megastrophia concava (Hall)

Chonetes coronatus (Conrad)

Productella cf. *P. spinulicosta* Hall

Rhipidomella penelope (Hall)

Camarotoechia congregata (Conrad)

Cyrtina hamiltonensis (Hall)

pelecypods

Grammysia bisulcata (Conrad)

Orthonota undulata Conrad [Pl. 6, fig. 7]

Modiomorpha concentrica (Conrad) [Pl. 6, fig. 4]

gastropods

Loxonema hamiltoniae Hall [Pl. 6, fig. 3]

Bembexia sulcomarginata (Conrad)

trilobites

Greenops boothi (Green) [Pl. 6, fig. 1]

UPPER DEVONIAN SERIES

The Upper Devonian of Maryland has been divided into two formations; the lower, called the Jennings formation, consists of marine sediments with several fossiliferous horizons, and the upper, the Catskill formation, consists largely of non-marine redbeds that yield almost no fossils.

Jennings formation

In the Devonian volume of the Maryland Geological Survey the Jennings formation is divided into the Genesee, Woodmont, Parkhead, and Chemung members (see chart, p. 82; discussion, p. 117).

The black shales of the Genesee member are very poorly fossiliferous, but have yielded specimens of the pelecypods *Buchiola retrostriata* (V. Buch) and *Pterochaenia fragilis* (Hall) [Pl. 6, fig. 11] as well as the cephalopod *Bactrites aciculus* (Hall)?. According to Prosser (Middle and Upper Devonian volume, p. 412) the Genesee thins toward the east and appears to be absent east of Oldtown.

A rather meager fauna has been recorded from the Woodmont member. In the Middle and Upper Devonian volume of the Maryland Geological Survey this member has been broken down into two faunal zones, the Naples and the Ithaca. Six species of brachiopods are present, including *Lingula ligea* Hall ? [Pl. 6, fig. 13], *Cyrtina hamiltonensis* Hall, *Ambocoelia umbonata* Conrad, and a species of *Schizophoria*. Also, the pelecypods *Buchiola retrostriata* (von Buch) [Pl. 6, fig. 12] and *Pterochaenia fragilis* (Hall) [Pl. 6, fig. 11] have been found (*B. retrostriata* is also recorded from the Romney).

About 15 species have been recorded from the Parkhead sandstone with most of these distributed among the brachiopods, pelecypods and gastropods. According to Swartz (Middle and Upper Devonian volumes, pp. 415–417) this fauna shows strong affinities with that of the Hamilton. Among the more common of the brachiopods are *Tropidoleptus carinatus* (Conrad), *Camarotoechia congregata* var. *parkheadensis* Clarke and Swartz [Pl. 6, fig. 16], *Rhipidomella vanuxemi* (Hall), and *Leiorhynchus mesacostale*. The pelecypods include *Nucula corbuliformis* Hall [Pl. 6, figs. 14, 15] and *Nucluana diversa* (Hall). *Loxonema hamiltoniae* Hall occurs along with other gastropods. Only one trilobite, *Phacops rana* (Green), is recorded.

The most distinctive species in the Chemung member is the brachiopod *Cyrtospirifer disjunctus* (Sowerby) [Pl. 6, figs. 17, 20]. This species is commonly associated with *Cariniferella tioga* (Williams) [Pl. 6, figs. 21, 22] and *Douvillina cayuta* (Hall) [Pl. 6, fig. 19]. Other species described from this horizon include the following:

brachiopods

- *Nervostrophia nervosa* (Hall)
- *Schuchertella chemungensis* (Conrad)
- *Camarotoechia contracta* (Hall)
- *Atrypa hystrix* Hall

pelecypods

- *Grammysia subarcuata* Hall
- *Leptodesma medon* Hall [Pl. 6, fig. 18]

gastropods

- *Loxonema styliolum* Hall

According to Swartz (Middle and Upper Devonian volume, pp. 419–420) the lower part of the Chemung carries a recurrent Hamilton fauna with *Tropidoleptus carinatus* (Conrad) and *Rhipidomella vanuxemi* (Hall).

Catskill Formation

The Catskill formation in Maryland is almost barren of fossils, yielding only a few fragmentary plant remains and poorly preserved pelecypods. The relation of this formation to the Jennings formation is discussed at some length in the Middle and Upper Devonian volume of the Maryland Geological Survey.

MISSISSIPPIAN SYSTEM

The youngest Paleozoic strata in Washington County are Mississippian in age and referred to two formations, the Rockwell formation and the Purslane sandstone. These units which were named and described by Stose and Swartz (1912, pp. 13–14) are placed in the Pocono group and are thought to be Lower Mississippian in age. No marine fossils have been found in either, but a few plants were identified by David White (Stose and Swartz 1912, pp. 13–14). The Rockwell formation has yielded a few specimens of *Eskdalia* sp., *Lepidodendron* sp. and megaspores, and the overlying Purslane sandstone has furnished casts of *Lepidodendron* sp.

STRUCTURAL GEOLOGY OF WASHINGTON COUNTY

BY

ERNST CLOOS

INTRODUCTION

This chapter deals with the position of formations in the ground, their mutual relations, and the changes which the rocks have undergone since they were originally deposited. The description proceeds from east to west, from the bottom to the top of the sections, and from the older to the younger. Some rock groups have been treated together because they were deformed and dislocated as a group.

STRUCTURAL PROVINCES

Washington County straddles the Appalachian Mountains from the western slope of the Blue Ridge to the center of the Ridge and Valley Province.

Topographic features are a function of resistance of rocks against erosion and solution. Structures are the result of deformation and the resistance of rock layers against deformation. Erosion only carves out existing structures. Topographic provinces, therefore, do not necessarily coincide with structural ones.

The following are structural units and not directly related to topography (Fig. 20).

The *South Mountain Anticlinorium* reaches almost to Hagerstown and includes all folds that are clearly related to the folding of South Mountain. The small folds are overturned asymmetrically westward and show axial plane cleavage which dips uniformly east and a lineation within the cleavage planes that plunges very uniformly east and southeast. No other regions in Maryland show as uniform and dominating a deformation plan as South Mountain.

To the west, South Mountain anticlinorium grades into *Massanutten Synclinorium*. This broad synclinal area consists of many small synclines and anticlines and reaches its maximum depth in the Martinsburg shale belt at Conococheague Creek. Massanutten Synclinorium is bounded by two faults on the west. A reverse fault forms the boundary between Elbrook limestone and Martinsburg shale and may be a low angle thrust. Another fault transects the first and dies out northward. Along it Cambrian limestone is thrown against Silurian and Devonian strata, indicating a considerable displacement of the Massanutten syncline with respect to the Folz anticlinorium to the west.

The *Foltz Anticlinorium* was called Folz anticline by Stose (1909, p. 14) in the Mercersburg area. It consists of several large folds: the Gillians syncline, Blair Valley anticline, Bear Pond Hollow syncline, and the broad dome-shaped apex of the Cross Mountain-Foltz anticline.

The *Meadow Branch Synclinorium* to the west was called a syncline by Stose and Swartz (1912, p. 127), but it also consists of several smaller folds as the Dickeys

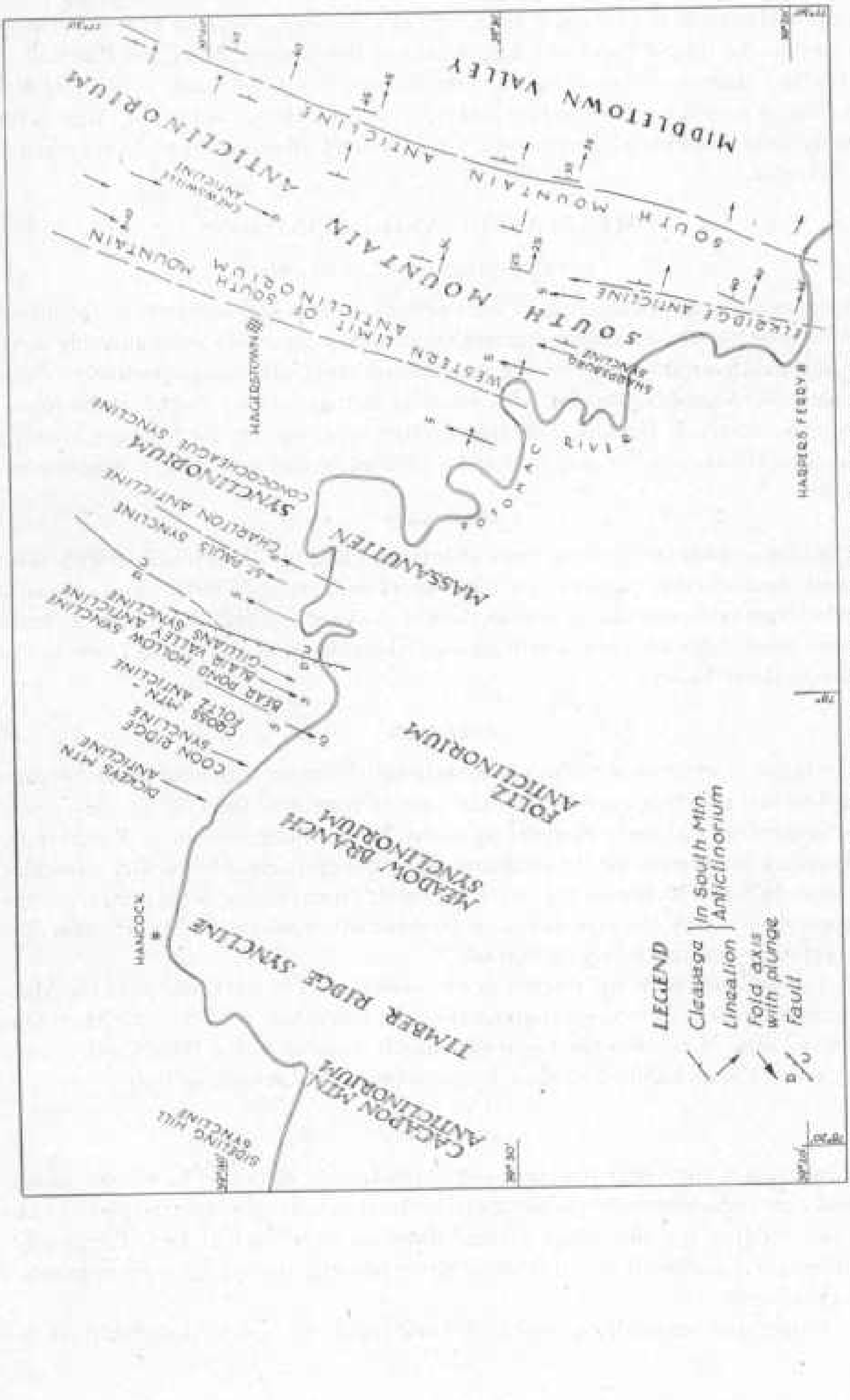

FIGURE 20. Structural Provinces of Washington County

Mountain anticline and Timber Ridge syncline at Hancock. West of Hancock is the *Cacapon Mountain anticlinorium*, consisting of a number of smaller folds beautifully exposed in the Round Top and Cacapon cuts of the Western Maryland Railroad.

The last large structure along the western border of the County is *Sideling Hill Syncline*, so named by Stose and Swartz (1912, p. 131). Here, the highest range in the County coincides with the deepest syncline in which Carboniferous rocks are exposed in its center.

NOMENCLATURE AND DEFINITIONS

ANTICLINORIUM-SYNCLINORIUM

Some of the above outlined units were called synclines and anticlines in the literature because the terms synclinorium and anticlinorium were then not commonly used. A synclinorium or anticlinorium is a synclinal or anticlinal area, respectively, which consists of a number of smaller folds much as corrugated iron sheets can be folded into larger domes or troughs. The Massanutten synclinorium, for instance, consists of at least twenty smaller synclines and anticlines of various orders of magnitudes.

FOLD AXES

The axes of folds are the hinge lines of anticlines and synclines. Their strike is their general trend and they plunge in the direction of their trends. The fold axes are easily seen in larger folds, and also as intersections of cleavage and bedding or axes of crenulations. Small folds are abundantly exposed along many of the railroad cuts in the Potomac River Valley.

CLEAVAGE

The major cleavage in the South Mountain anticlinorium is an axial plane cleavage that dips east and fans westward. In the western portion of the County, cleavage is also frequently axial plane cleavage as in the Martinsburg shale or at Round Top, and fanning is more intense. In sandstone beds, this cleavage is frequently a fracture cleavage. In South Mountain the cleavage in most formations is, as for instance in the Harpers shale, a flow cleavage due to an arrangement of minerals in its direction during beginning and partial crystallization.

Such crystallization is less distinct in the western part of the County. In the Martinsburg shale slaty cleavage is common, but the limestones west of South Mountain fold show little or no cleavage. Good cleavage is common in the Wills Creek shales, Romney shales, and almost all shale formations of the Paleozoic section.

LINEATION

A lineation is any linear structure and needs further definition to become useful.

Fold axes are a frequently visible lineation. Intersection between axial plane cleavage and bedding is a line whose general direction parallels fold axes. Frequently, the direction is paralleled by wrinkling of either bedding or cleavage surfaces in small crenulations (Pl. 16).

A distinct and regionally conspicuous lineation in the South Mountain fold lies in the axial plane cleavage. In the volcanics it is visible as an elongation of blebs and blotches, epidote or chlorite clusters, sericite accumulations, and other mineral arrangements. In the granodiorite gneiss the lineation is visible as accumulation of chlorite, biotite, hornblende, or quartz in spindle-shaped clusters. In the Cambro-Ordovician rocks the lineation becomes visible because of pebble-elongation, oölite elongation, rodding of cleavage surfaces, streaking of cleavage surfaces, or almost any combination of possibilities. No matter how this lineation may appear on a cleavage plane, its orientation in space is so constant and regular that a few symbols suffice to indicate its orientation over many square miles.

Slickensided surfaces are common in the entire area. They may be faults, bedding planes, cleavages, or joint surfaces. Slickensides are, however, not indications of large-scale movements, since very small displacements may result in handsomely striated and polished surfaces.

WORKING METHODS

Until comparatively recently, structural geology has been considered more or less the by-product of mapping, and the structural analysis of an area consisted in the listing of some of the major anticlines and synclines and faults. The latter were only very rarely directly observed.

Systematic observations of attitudes of beds and other structural elements were not always undertaken, but thought of as less important. Many maps have been published without structure symbols in spite of the fact that some of the workers gathered the information but buried it in their notebooks.

Geologic mapping should be the gathering of information for the use of others with subsequent presentation of facts to scientist and layman. It should be as accurate as possible and as complete as can be shown on a map of a given scale. To leave out some information or selective presentation of information is objectionable. Even if the author is unable to interpret his facts, he should present them as completely as possible. If another worker can later interpret the facts he has saved the time of remapping the region.

The problem of structural analysis can be approached from different viewpoints. In addition to the mapping of the distribution of formations, structures should be mapped and their attitudes noted fully for all exposures. Contacts between formations should be traced in the field and not from plotted points in the office.

This procedure guarantees a much higher degree of control and accuracy and leads the way to outcrops at critical localities. It shows position of strata in the field, top and bottom of beds, synclines and anticlines, plunging folds, and all the details which are essential for an interpretation of the history of an area. Such detailed work is only little more time-consuming and is worth the investment in additional accuracy and reliability. Much geology defies interpretation without the detail.

As an example of detailed mapping, attention is called to the discussion of the Potomac Gorge at Harpers Ferry and the determination of the lower Cambrian sequence along the South Mountain front. Determination of top and bottom of the sequence is essential for the interpretation of the sequence and the structure of the region.

It is strange how such important conclusions as the depth and configuration of the Appalachian geosyncline and the correlation of stratigraphic sequence within it have been so widely accepted in spite of the meager information that has been available.

Geology is frequently called an inexact science as compared with chemistry and physics. This, however, does not mean that the geologist should not measure wherever possible. Most of the sections on which correlations are based are given in feet, but were never measured. They are so given that it is impossible to locate them in the field. One frequently gains the impression that such data are an author's property and should not be visited by others. It would seem good scientific procedure to make data available and accessible to the co-worker and not to hide them in incomplete location and vague descriptions.

The detail into which one should go depends on the problem at hand. Mapping should generally be done on a larger scale and reduced for reproduction because accuracy decreases with the scale on which the work is done. Satisfactory scientific work does not thrive under pressure and should never suffer from lack of time. The times in which a quadrangle was mapped during one field season should have passed. It is preferable to follow the British method where the geologist lives on his quadrangle. Though less ground is covered, the product is superb. If the area is large, the solution is not less quality, but more geologists.

THE SOUTH MOUNTAIN ANTICLINORIUM

(Catoctin Mountain–Blue Ridge Anticlinorium)

LOCATION AND GEOLOGIC SETTING

South Mountain anticlinorium is essentially a large asymmetrical fold, overturned to the west, that begins south of Carlisle, Pennsylvania, crosses Maryland between Frederick and Hagerstown, and continues southward into Virginia and beyond. In Maryland, Catoctin Mountain and South Mountain are the eastern and western flanks of the fold with Middletown Valley in the center representing the core. South of Boonsboro, Elk Ridge rises from the valley floor and to the south becomes more prominent than South Mountain, which continues only a few miles south of the Potomac River. Elk Ridge becomes Blue Ridge to the south and is then the western margin of the topographically prominent uplift. Structurally, the western limit is in Hagerstown Valley.

Only a small portion of this large fold is in Washington County. Some of its core is exposed where the County line does not coincide with the boundary between the Weverton and the underlying rocks and in Pleasant Valley between Elk Ridge and South Mountain south of Rohrersville.

South Mountain uplift comprises volcanic rocks and gneisses of probably igneous origin overlain by Cambro-Ordovician sedimentary rocks.

One easily recognized and identified deformation plan dominates all parts of the uplift and all rocks in it.

STRUCTURES OF IGNEOUS ROCKS

Igneous rocks appear only in the easternmost portion of Washington County and have been described above.

Granodiorite

The granodiorite is schistose and in its schistosity planes is an intense lineation due to spindle-shaped bodies of dark minerals and quartz. Both the planar and linear structures are parallel to the equivalent structures in all overlying rocks which indicates deformation at one time and under identical stress conditions.

Volcanics

The volcanic rocks in Washington County are typical for the entire core of South Mountain uplift. Greenstones and rhyolitic tuffaceous layers rarely show primary banding or layering, but both have been described and pictured by Stose and Stose (1946, p. 20 and pl. 11).

Massive greenstones occur, but are not the rule. An intense and very uniformly oriented regional cleavage prevails. It can be seen in the islands in the Potomac River, at Rohrersville, and in the many large road cuts of the new U. S. 40 east of South Mountain Summit. A strong lineation invariably parallels the steepest dip of the cleavage and is uniform in the entire area from Potomac River to the Pennsylvania line. The structure is due to parallelism of lenticular thin blebs which are from $\frac{1}{2}$ to 8 inches long and about $\frac{1}{10}$ to 1 inch wide. Most of these blebs are black chlorite clusters, frequently with epidote or calcite. Some cleavage planes are covered with long black streaks which occur where blebs are connected. This lineation is not always seen immediately, but can be found in all exposures.

The purple rhyolites are also schistose due to a most intense cleavage. The orientation is identical with that in the greenstones. Still more intense lineation is frequent and consists in parallelism of elliptical, spindle-shaped, or lenticular clusters of sericite, frequently with feldspar grains. The structure may be so intense that the rock appears like a pencil schist. The best locality for observation of the structures in rhyolite tuff is east of South Mountain Summit to Wolfsville crossing along new U. S. 40 from Hagerstown to Frederick.

Though only a small portion of the igneous area in the uplift overlaps into Washington County, a study of the core area is essential for the understanding of the uplift.

THE SOUTH MOUNTAIN ANTICLINE

Introduction

Stose and Stose (1946, p. 102) describe the area here called an anticline as South Mountain syncline. Their figure 22 shows a schematical cross section through South Mountain east of Weverton. The synclinal character is supposedly best seen at Lambs Knoll to the north.

Detailed investigation of several sections across South Mountain and systematic observations of cross bedding and the relation between cleavage and bedding leave little doubt that South Mountain is an anticline and not a syncline. The significance of this observation with respect to the stratigraphic sequence has been discussed above.

B. L. Mather called attention to the reversed order of Weverton quartzite for the first time in 1938 when engaged in field work for a dissertation. He submitted a manuscript map which was used in preparation of the geologic map of the County (1941). All of Mather's observations have been verified and many additional ones added during recent field work. Mather did not use cleavage and bedding relations, but only cross bedding. The former observation, however, checked the latter at all points. The same results were obtained by different methods. The principal of cross bedding and of cleavage and bedding relationship has been explained on pages 18–24.

The key horizon is the Weverton quartzite and at almost all exposures cross bedding can be observed. Some cross bedding is inconclusive, but there are few outcrops where conclusive observations are impossible.

Cleavage is not visible in all beds of the Weverton; it is mostly restricted to some less competent beds, or to a portion of the formation. Since deformation is intense, however, elongated quartz grains are commonly observed and the orientation of cleavage can be seen by observation of the grains. If field observations fail, an oriented thin section perpendicular to the fold axis will show the orientation of cleavage beyond any doubt, as, for instance, the quartz orientation shown by Fellows (1943, p. 8, figs. 1 and 4) from the Weverton at Harpers Ferry.

Excellent cleavage is common in the adjacent Harpers formation which also shows excellent bedding at most points. Observations in the Harpers fully corroborate those in the Weverton. It may be argued that the position of the cleavage is accidental. This point is well answered by the uniformity of the cleavage throughout the uplift, of which at least 300 square miles are exposed in Maryland alone. In the entire area the cleavage strikes generally north-south and invariably dips to the east. The dip angle is strongly influenced by the competency of beds and the position of the locality in the fold. This axial plane cleavage has been measured in many thousand localities (E. Cloos, 1941, pl. 8). It is, with the lineation, the most dependable regional structure between Frederick and Hagerstown and remains constant in orientation and intensity in all formations.

Potomac River Section

East of Weverton South Mountain is transected by the Potomac River gorge. Exposures are excellent on both sides of the river and in the many islands in the river bed at low water. The author planetabled the river exposures from the greenstone contact east of Weverton up river to the new highway bridge across the Shenandoah River above Harpers Ferry at the scale of 1:200. Most of the area was traversed by boat and wading.

Exposures in the river are freshest and show cross bedding, graded bedding, and cleavage very well. In the Harpers formation cleavage and bedding are prominent and minor folds are common.

Figure 21 is the portion of the plane table map which includes the South Mountain anticline between the greenstone in the east and the granodiorite gneiss in the west. The Weverton quartzite is in normal position next to the greenstone. Upstream follow a number of small islands where observations were impossible. The largest group of continuous exposures near the western contact of the Weverton show overturned bedding dipping 40 degrees east.

This series of beds can be traced north to U. S. 340 where the beds dip 50 east in an

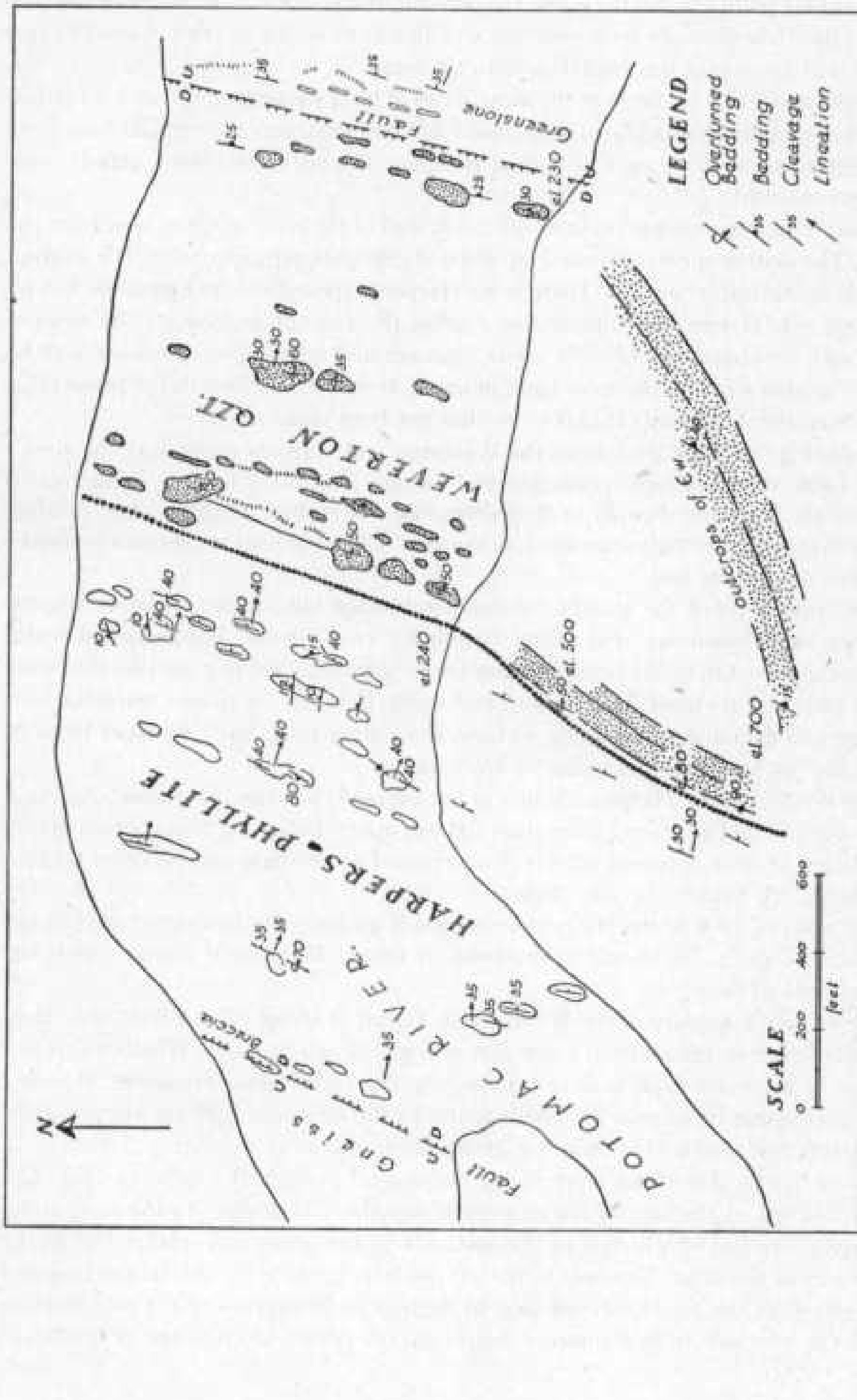

FIGURE 21. Plane Table Map of Potomac River Gorge at Weverton. Difference in elevation on south side is 470 feet (compare Fig. 10).

old quarry in which there is a small house. Stose and Stose also show a dip of 50 degrees at that point. Above the house the beds rapidly steepen to 90 degrees at the top of the cliff. Here cleavage is very intense and dips 25 to 30 degrees east. Cross bedding shows that the top of the formation is to the west.

On the south side of the river the same series of beds steepens uphill and is vertical near the summit. Here a gap of only about 300 feet separates the vertical beds from the gently east dipping ones in normal position. The anticline is here almost completely preserved.

Figure 22 is a generalized view of the north wall of the river gorge as seen from the south. The eastern slope is almost a dip slope of gently dipping quartzite. The western slope is considerably steeper. There is no Harpers exposed on the east slope but on the west side Harpers phyllite almost reaches the summit and covers the western slope with an abundance of cliffs where cleavage and bedding relations can well be seen. The area south of the river bank in figure 21 has been added to the plane table sheet from the Army map 1:25,000, but has not been plane tabled.

Ascending the mountains from the Weverton and Harpers contact at the river's south bank the beds rapidly steepen and become vertical. Cleavage is distinct in some of the beds and dips 20 to 30 degrees east. At several localities cross bedding shows that the top of the formation is to the west. Cleavage near the summit is steeper and dips 40 degrees east.

The upper limb of the anticline shows no cleavage but an extraordinary display of large scale boudinage and many prominent cross joints. Boudinage indicates stretching down dip of the beds. Tension joints normal to bedding parallel the strike of the beds and are filled with thick quartz veins. Between the quartz veins the beds thicken and thin and the bedding surfaces show large rolls (boudins) from 10 to 20 feet wide cut into 20-foot lengths by cross joints.

The Weverton and Harpers contact is not exposed, but the two formations come close together and are rarely more than 100 feet apart. Following that contact uphill, it becomes at once apparent that it is overturned at the base and becomes vertical approximately halfway up the slope.

The western limit of the Harpers formation is an intensely brecciated zone in the granodiorite gneiss, evidently a fault which brings Harpers in contact with the granodiorite gneiss.

The eastern boundary of the Weverton in Figure 21 seems to be a fault also. Here normal Weverton rests within a few feet of schistose greenstones. Whether this is a normal or a reverse fault is uncertain despite the rather good exposures. It seems quite reasonable to assume that both faults to the west and east are steep normal faults and that South Mountain is a graben structure at this point.

On the north side of the river valley are several prominent exposures (Fig. 22): one to the left at the base of the mountain, one above this offset to the east, and a long quartzite bed which dips to the east. Above the latter is a smaller bed in the lower part of the slope. The beds to the left dip 50 degrees to the east at the base and are vertical at the top. Cleavage dips 20 degrees to 40 degrees east. Cross bedding shows the west side to be the top of the formation. About 150 feet east of the top of

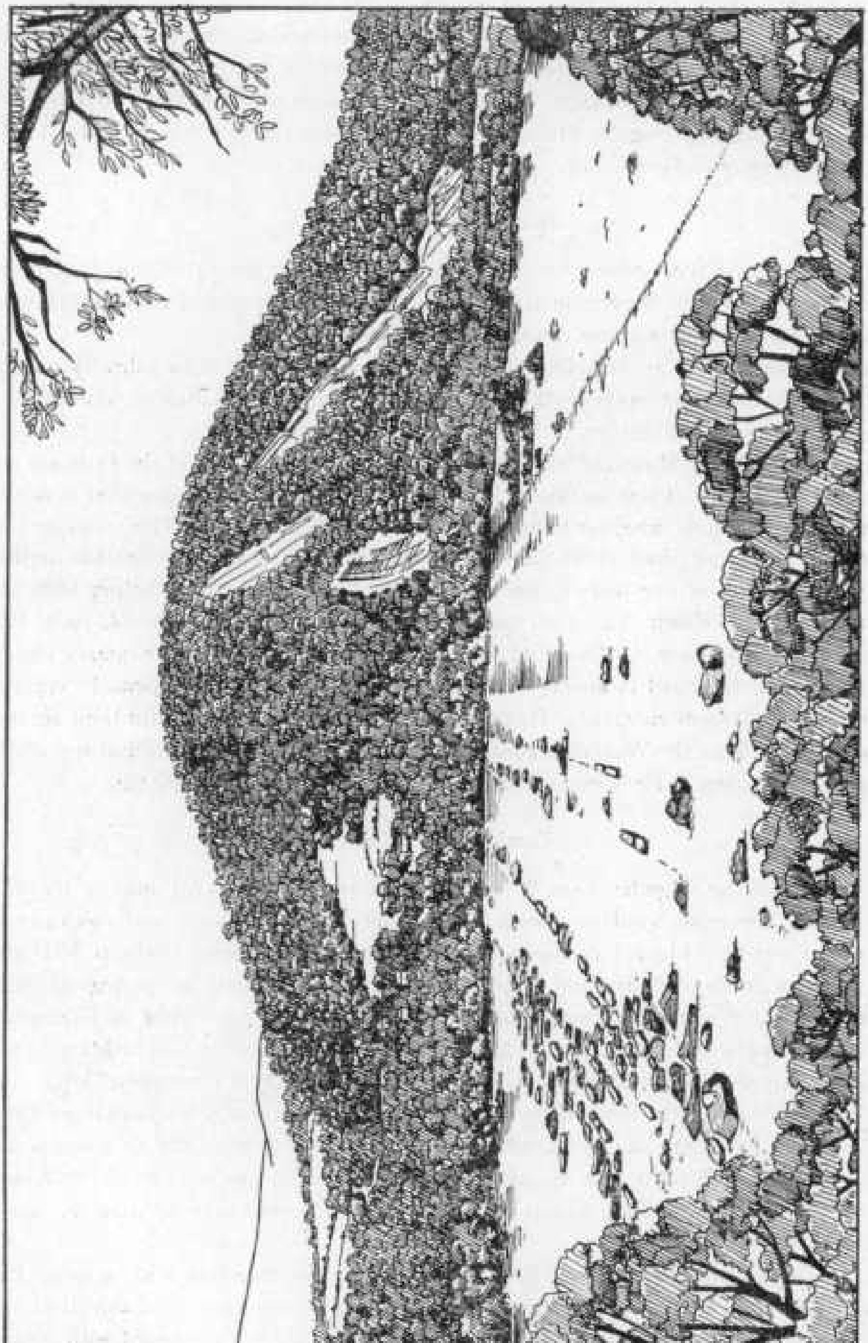

FIGURE 22. View across Potomac River at Weverton, South Mountain Gap. Cliffs in forest are Weverton quartzite.

the cliff are beds which dip 10 to 20 degrees to the east and may be the equivalent beds in normal position with the crest of the anticline broken. The long hard quartzite bed dipping east is right side up as the same bed is on the south side (Fig. 21).

To the west of the old quarry are almost continuous exposures of Harpers shale showing cleavage dipping 20–30 degrees east to the intersection of U. S. 340 with the concrete highway to Boonsboro.

Discussion of section

The Potomac River section has been described in some detail because it contains the type section of the Weverton and has been the starting point of views which were not substantiated by a more detailed investigation.

South Mountain is an anticline. The anticline is faulted on both sides by normal faults which may show upon further investigation that the anticline occurs now in a longitudinal graben structure.

As pointed out by Stose and Stose "The structure and relations of the beds are not clear" (1946, p. 37). Their section is an interrupted one and so vague that it would seem highly doubtful whether it has any value as a type section. The cross section shown by Stose and Stose (1946, p. 103) is diagrammatic and pays attention neither to the actual dip of the beds in the outcrop nor to the question whether beds are normal or upside down. The two easternmost beds shown in figure 22, page 103, by Stose and Stose are right side up, and the westernmost bed in the quarry shown at the level of the road is upside down. The dip of these beds steepens to vertical within about 200 feet elevation. To the west of the Weverton quartzite their section shows Loudon from the Weverton contact to the road intersection. Normal and easily recognized Harpers shale is exposed almost uninterruptedly for 1090 feet.

Lambs Knoll section

The crest of the ridge between Weverton and Lambs Knoll is for most of the way overturned Weverton sandstone with Harpers phyllite to the west and volcanics to the east. Overturned beds have been described by Stose and Stose (1946, p. 102) and can be seen north of Crampton Gap where the dip is as little as 20 degrees east. Cleavage is here almost horizontal or dips 5 to 10 degrees east. West of Crampton Gap the Harpers shale is exposed in loose weathered fragments. Cross bedding in the Weverton shows the overturned attitude of the beds north of Crampton Gap.

The summit of Lambs Knoll is the upper limb of the anticline in horizontal position. To the west, the dome-like top bends downward but the crest of the anticline is not entirely exposed. West of the Appalachian Trail, where it descends from the Knoll, the beds can be seen bending downward with cleavage steeper than bedding, as shown in Figure 11.

According to Stose and Stose (1946, p. 103) east-west trending folds appear. Exposures are poor here as almost everywhere, but it seems more probable that the South Mountain anticline plunges gently northward and thus combined with topography produces east-west trends and reëntrants.

From Lambs Knoll to Pine Knob

Between Lambs Knoll and Pine Knob the Weverton sandstone occurs in many loosely connected exposures, few of which are undisturbed. At most places only loose material indicates its presence.

A special description in Stose and Stose (p. 103) is devoted to the Turners Gap section (alternate U. S. 40) which has been measured by the writer. They describe a syncline one-half mile west of Turners Gap; the west limb dipping 80 degrees east, the east limb 30 degrees west. Along U. S. 40, there are exposures of quartzite beds of the Harpers, identical to those in the Waynesboro section dipping 80 degrees east with a cleavage dipping 40 degrees east, indicating an overturned anticline. The bed that dips 30 degrees west is from a fold in the Harpers which appears along the entire western front of South Mountain anticline. Between the two outcrops are many others of banded Harpers shale with intense cleavage indicating several smaller folds.

At Turners Gap, south of the restaurant, the Weverton is overturned westward and dips from 20 to 50 degrees east. Volcanics are to the east and Harpers to the west. Between the exposures south of U. S. 40 and Monument Knob, the Weverton swerves westward which may be due to faulting or a low-lying overturned limb of a recumbent fold combined with topography. At Monument Knob huge loose blocks of Weverton lie right side up, but no exposures have been found in place. The westward displacement of the contact is probably due to a cross fault along which the northern block moved westward. There has likely been vertical displacement also. A comparison of the conglomeratic sandstones along U. S. 40 with the Waynesboro section suggests that the quartzites described by Stose and Stose are not Weverton but lower Harpers beds.

From Lambs Knoll to Pine Knob the anticline has been faulted severely at a number of places. Cross faults play a considerable role in this area, but due to disconnected exposures they are difficult to locate. The anticlinal axis is obviously displaced and exposed at different elevations, displaying the lower or upper limbs of the anticline or smaller folds within it.

Between Lambs Knoll and Pine Knob detailed mapping at a large scale may reveal the structure, but since the area is wooded the task would be considerable.

Pine Knob section

At Pine Knob exposures are scattered and far apart, but reveal a similar and simple picture. Excellent outcrops occur along new U. S. 40 from the summit eastward to Wolfsville Crossing. To the north and above the highway are several large loose blocks of conglomerate which have probably not moved very far. Above the conglomerate and the orchard are several exposures of conglomerate in cliffs along the base of the mountain and on its west and south side. The summit of the mountain is loosely broken up Weverton quartzite. If these outcrops are compiled into a section, it is clear that the sequence from the road to the summit is: (1) purple volcanics with quartz grains, intensely stretched and cleaved; (2) conglomerate and dark slate; and (3) Weverton quartzite. The position of grayish-green rough conglomeratic graywacke at the summit is not clear, but it may belong in the conglomerate series.

Figure 15 is a generalized profile in which these outcrops are placed in their mutual position. A continuous section as measured by Stose and Stose has not been found.

Structurally Pine Knob is the upper limb of an overturned anticline. Cleavage dips uniformly to the east in all formations. Bedding is very well exposed in the conglomerate ledge along the western slope and a detailed view is presented in Figure 12. The cliff, only a few hundred feet north of the Appalachian Trail and the orchard and below the trail to Pine Knob leanto, shows cleavage dipping east, bedding bending from horizontal to 40 degrees west, and pebbles in the conglomerates extended in the direction of the cleavage (Fig. 14). Cleavage and bedding relation also indicate that Pine Knob is the upper limb of an anticline. Detailed observations in the Weverton quartzite at the summit of Pine Knob were not possible.

Stose and Stose (1946, p. 32, fig. 8) give a section at Pine Knob which shows their interpretation diagrammatically. As stated in the text the beds are horizontal and do not dip east at angles of near 45 degrees as shown in their figure 8. The conglomerate at the western base dips 40 degrees west and not east as shown. The published section is rather misleading due to its vertical exaggeration, and it shows a synclinal structure and sequence which do not exist.

Raven Rock Hollow section

Between Pine Knob and Raven Rock Hollow are a number of important exposures. About one mile north of Pine Knob, west of the Appalachian Trail, is Annapolis Rock and $2\frac{1}{4}$ miles north of Pine Knob is Black Rock.

Both rocks are cliffs which expose Weverton quartzite in normal position as the upper limb of the anticline. From Pine Knob to Black Rock the top of the mountain is of uniform height and seemingly flat. The lower limb of the anticline is buried under rubble from the broken off upper limb above it.

In the cliffs to the north of Black Rock the quartzite is still normal and the upper limb is exposed. At the north end of that ridge, about 2 miles southeast of Cavetown, the overturned lower limb is again prominent, the dip steepens, and cleavage is gentler than bedding.

Along the old road from Bagtown to Wolfsville the upper limb of the anticline seems to be bent upward again as indicated by overturned beds on the east side of the mountain. In this section an anticline along the western slope is paralleled by a syncline along the eastern slope.

The Gap east of Cavetown shows almost no Weverton quartzite and the lower limb may here be sheared out by faulting.

To the north two good sections are exposed at Warner Gap Hollow and Raven Rock Hollow. Only the latter has been measured because the two are very similar.

Figure 23 is a plat of the section along the road up Raven Rock Hollow. The section begins under the bridge of the Western Maryland Railroad. Excellent outcrops show the Harpers phyllite with strong cleavage dipping between 40 and 50 degrees east. A few hundred feet north of the road the Harpers rests on Tomstown limestone and the Antietam is faulted out. Eastward the section shows Harpers phyllite and in some of the outcrops excellent bedding can be seen almost vertical. Between the easternmost exposure of Harpers and the first one of Weverton is a large gap which is covered

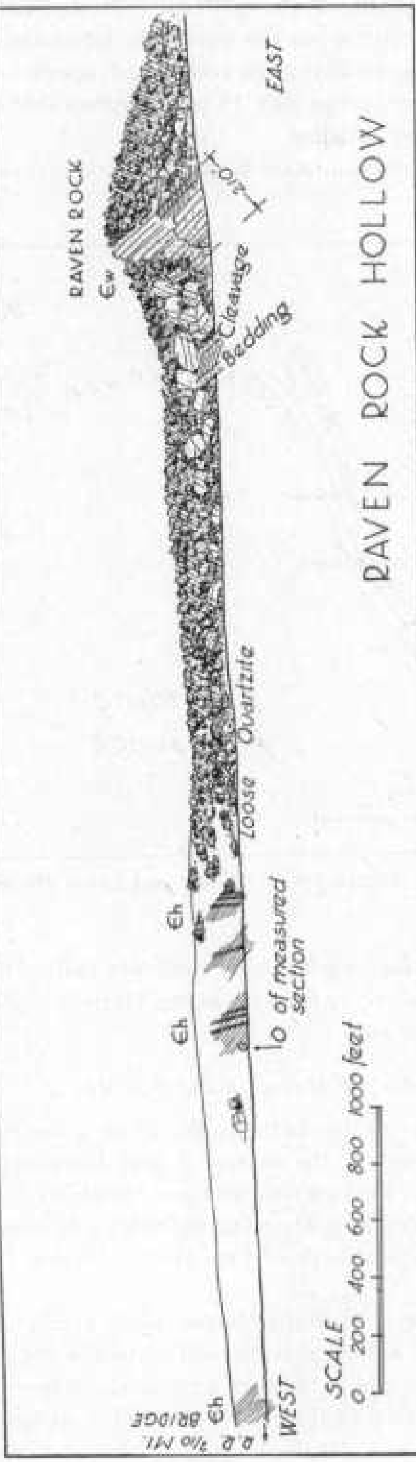

FIGURE 23. Profile at Raven Rock Hollow, East of Smithburg. Cleavage in Harpers and Weverton very intense, dipping consistently east. Bedding near vertical or overturned.

with huge blocks of loose quartzite. The quartzite itself dips east about 45 to 50 degrees and cross bedding clearly shows the top of the formation to be west. The observation is corroborated by the distinct cleavage which is seen in the lower (eastern) portion of the section where it dips only 15 to 20 degrees east, thus indicating the lower limb of an overturned anticline.

To the east of the quartzite is another large gap which is covered with rubble followed by greenstone.

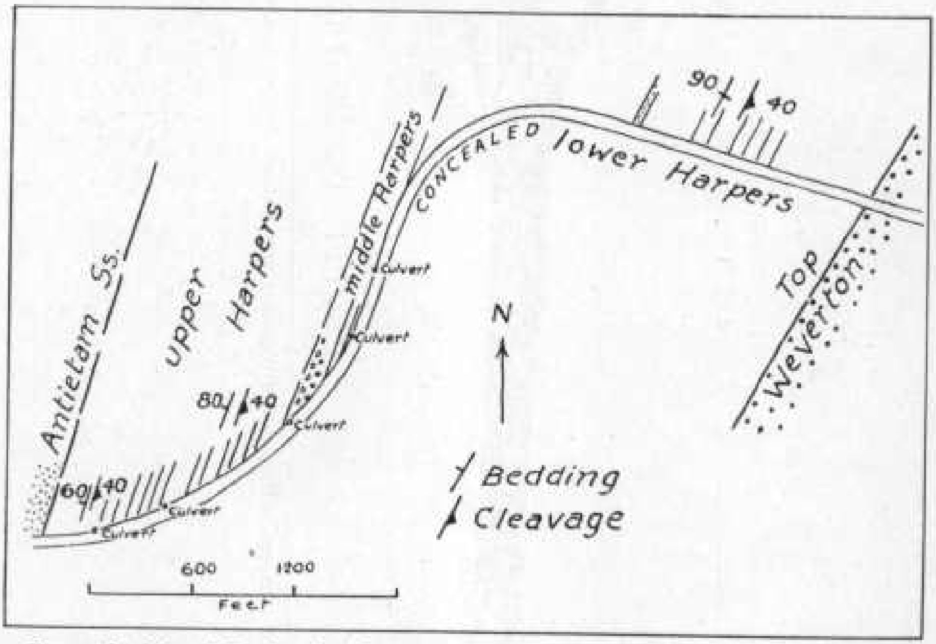

FIGURE 24. Map of Section through Upper, Middle, and Lower Harpers Formation, East of Waynesboro, Pennsylvania.

The evidence in this section indicates that the lower limb of the South Mountain anticline exposes a normal sequence from the higher Harpers phyllite through Weverton quartzite to the greenstone.

Quirauk Mountain and Pen Mar

From Raven Rock Hollow to the north the Weverton is overturned westward and dips from 15 to 75 degrees east. In the vicinity of High Rock and Quirauk Mountain are several folds; dips are to the east and west and the strata are right side up.

The width of the exposure at the State line indicates a number of folds which can partially be seen in the valley north of Pen Mar and along the highway east of Waynesboro.

In the section east of Waynesboro the Harpers shale overlies Weverton quartzite in normal position as shown in Figure 24. Several anticlines and synclines are exposed along the Appalachian Trail and in the flats west of Monterrey. The position of the Weverton is generally anticlinal or that of a much contorted upper limb of an asym-

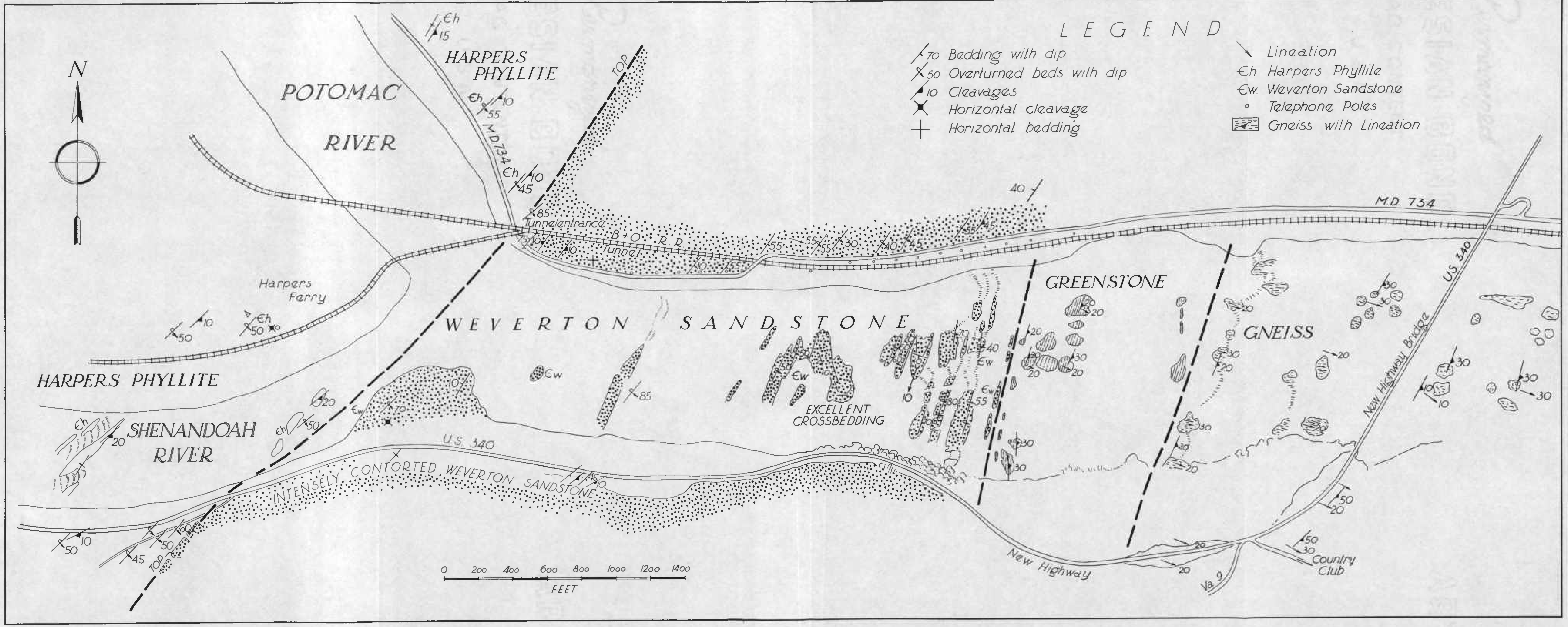

Figure 25. Map of Potomac River Gorge below Harpers Ferry.

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metrical anticline. To the east, greenstones and conglomerates underlie the Weverton; along the west side Harpers shale overlies it.

Summary on South Mountain anticline

South Mountain is an anticline as can best be seen in the exposures in the Potomac River Gorge, at Pine Knob, and Raven Rock Hollow, and by systematic observation of cleavage-bedding relations and cross bedding. The prevailing interpretation of a synclinal structure is erroneous and based on lack of detailed information. As a consequence of the reversal of the position of the Weverton at its type section, it would seem that the section as shown by Stose and Stose (1946, p. 37) is in need of revision. In addition, what they show as Loudon west of the type section is Harpers shale in normal position with respect to the Weverton section.

The type section at Weverton is worthless stratigraphically since only the top and not the bottom is exposed and since that section is greatly distorted.

To the east and west South Mountain is bounded by faults. The western one is by necessity a normal one and the eastern fault may also be normal.

BLUE RIDGE–ELK RIDGE ANTICLINE

Introduction

Two and one-half miles west of South Mountain, Blue Ridge crosses the Potomac River and continues northward to a point 2½ miles southeast of Keedysville as Elk Ridge. This Ridge is also composed of Weverton quartzite accompanied to the west by the Harpers formation. Between Elk Ridge and South Mountain is Pleasant Valley which is largely underlain by greenstone and granodiorite gneiss with some isolated occurrences of Weverton and sandy shales which may be Harpers.

At Rohrersville the greenstones are in contact with the Tomstown limestone. The Weverton prong is surrounded by some Harpers and greenstone, but on three sides is adjacent to Tomstown limestone. The interpretation of this area is subject to controversial discussion since it involves the Harpers Ferry overthrust which will be discussed more fully below. The critical area in the vicinity of Rohrersville is very poorly exposed.

Exposures to the south, in the Potomac River Gorge, however, are excellent.

Potomac River section

Figure 25 is the portion of a plane-table survey which shows the Potomac River gorge at Harpers Ferry. Harpers Ferry is built on Harpers shale. The contact between Harpers and Weverton runs just north of the tunnel entrance. It can be easily followed up the hill on the north and on the south side of the Shenandoah River. It is very nearly vertical and tends near the summit of Elk Ridge to be overturned to the east about 80 degrees.

The contact between Weverton quartzite and greenstone is 3,100 feet downstream from this contact. It is not directly exposed, but the islands of greenstone and quartzite in the river are rarely more than 50 feet apart. Stose and Stose (1946, p. 111) show a contact on the north side of the river dipping approximately 45 degrees to the east with greenstone on Weverton quartzite. Similarly on the south side of the river the Weverton quartzite is overturned and overlain by dark slate and a conglomerate which shows immensely elongated pebbles down-dip of an intense cleavage. The greenstone is intensely stretched and a strong lineation dips 30 degrees east in the cleavage planes.

One thousand feet downstream from the greenstone-Weverton contact is the contact between greenstone and granodiorite gneiss. The contact is not exposed but well-defined by a number of islands. The granodiorite gneiss is also intensely lineated. The dark minerals, quartz, and feldspar occur in spindle-shaped clusters which are about 5 mm. in diameter and 2 to 4 cm. long. The structure looks like gneissic banding if seen from above in near-horizontal surfaces.

The lineation in the gneiss, volcanics, and the Harpers is parallel and shows the uniform structure which dominates all formations equally.

The north side of the river gorge is shown in a diagrammatic section by Stose and Stose. Two overturned anticlines are outstanding and well known. They represent two quartzite layers in the Weverton formation. To the east the beds turn up and become overturned. To the west folding of the quartzite is very intense and the massive beds are unbelievably contorted and intricately folded. The large cliff above the west portal of the tunnel is essentially a fold which is overturned to the west. Bedding along the contact is vertical to overturned and the top of the beds is to the west. The river exposures reflect the intricate folding very well and seem almost unconnected with those on the north or south side of the gorge.

By far the best picture of the folding of the Weverton is presented by the large road cuts along the new U. S. 340 and the cliffs above the road. Folds are so intricate and irregular that beds separate forming synclines in one direction whilst the lower beds are pressed into an anticline. Within short distances dips change 90 degrees. The ability to fold this intricately is usually not ascribed to competent quartzites.

Folding of the Harpers shale is very much simpler and deformation is expressed largely in the formation of a strong cleavage.

The distinction between cleavage and bedding is not always easy in the individual exposure. But from the literally hundreds of large and continuous outcrops a very simple and uniform picture emerges.

Bedding consists in the same banding and change in lithology that is typical in all exposures of the Harpers formation. Laminae show rows of sand grains and weathered calcareous layers are reddish-brown and lighter than the normal shale. When fresh, the shale is bluish-gray and shiny on cleavage surfaces due to the formation in parallel orientation of mica flakes. A fine lineation and streakiness can be seen in many surfaces. Bedding is overturned and dips east from 80 to 40 degrees. Cleavage is very gentle, dipping west at some places but generally dipping east from 10 to 20 degrees. The top of the formation is to the west and parallels that of the Weverton quartzite.

Whether the contact between the Weverton and Harpers formations is normal and undisturbed or an overthrust is scarcely of great significance, since any boundary between a competent mass of quartzite and a large complex of shale must become a surface along which movements have taken place. The same is probably true for the boundary between the fine-grained highly cleaved, slaty greenstone and the massive

Weverton. The intense movement indicated by slickensided surfaces on all bedding planes and in shaly partings within the Weverton shows that all primary discontinuities served as planes of movement.

The contacts of Weverton with Harpers in the west and Weverton and greenstone in the east are tectonic surfaces and planes along which adjustments must have taken place. The mutual position of the formations has not been disturbed profoundly in that the top of the Weverton and the top of the Harpers are both to the west. A transecting discontinuity or disconformity as postulated by Keith and Stose and Stose is lacking.

The Elk Ridge prong

From the Potomac River northward Elk Ridge is a substantial Ridge capped by Weverton quartzite. The anticlinal character of the ridge follows from the exposures in the Potomac River gorge and observation of attitudes on the northern termination of the prong near Rohrersville. A cross section through the northern end along the road from Trego to Eackles Mills shows quartzite beds uniformly overturned westward. In this section greenstone is to the east and Antietam sandstone west of the Weverton. To the north the quartzite forms an anticline with beds dipping west and east. The axis of the anticline plunges gently to the north. Stose and Stose (1946, p. 106) indicate a syncline at this point.

It may be a debatable question whether Elk Ridge is an anticline or a syncline. It is essentially the much contorted crestal area of a recumbent fold which is overturned to the west and in which the sequence from east to west is: greenstone–Weverton–Harpers. This sequence is similar to that of the South Mountain anticline, in which some portions are anticlinal, others expose only one limb of the anticline, and still others show several folds. The puzzling problem is why the South Mountain sequence is repeated in Elk Ridge to the west and how this area terminates near Rohrersville. Stose and Stose followed Keith's suggestion of a far-travelled overthrust and devoted a special chapter in their report on Frederick County to the discussion.

The Harpers Ferry overthrust

Keith (1894) suggested the presence of an overthrust at Harpers Ferry, but did not outline it in any detail. Stose and Stose (1946, pp. 104–113) suggested that the Weverton at Harpers Ferry had overridden the Harpers and that Elk Ridge had moved westward over the western foreland of the South Mountain fold. The overthrust is then drawn northward along the western foothills of South Mountain to the State line and beyond. This conclusion is based on a series of assumptions and rather scattered field observations. In order to strengthen their discussion, a portion of the Washington County geologic map was re-published by Stose and Stose (1946, p. 107) but the many structure symbols which are indispensable in interpreting the geologic situation at such a critical locality were strangely omitted.

The overthrust interpretation is based essentially on the disappearance of formations like the Harpers along the South Mountain foothills, on discordant relations of axial trends with formational boundaries, and on appearance of crushed rocks, quartz veins, and cleavage in the vicinity of the hypothetical thrust plane.

The discordant relationships in the Rohrersville area call for fault contacts, and the complete absence of the Harpers and Antietam formations above the Weverton in the Elk Ridge prong northwest of Rohrersville needs explanation also. There can hardly be disagreement as to the presence of faults. The only question is whether there is sufficient evidence for a far-travelled overthrust or whether smaller faults are a more accurate explanation.

Jointed crushed quartzite and vein filling are so common in the Weverton at so many localities that they cannot be cited as indication of a thrust fault. Boudinage, quartz veins, and joints occur in the crest of almost all folds in the Weverton and in the limbs of folds as well.

Cleavage dips east regionally and is thus also much too common and not an indication of a thrust fault. At Harpers Ferry cleavage has been confused with bedding. Cleavage is there horizontal and the contact between Weverton and Harpers is vertical. The vertical relief is almost 1000 feet and the contact can be traced straight up the mountain without deflection.

The discordant contact at Rohrersville is drawn as an elegantly curved line by Stose and Stose (p. 109), but the arrangement of exposures in the field permits a straight line as well.

The Elk Ridge prong is an anticline and not a syncline as shown by Stose. The Tomstown limestone participates in the anticlinal structure and also dips outward from the Weverton anticline. This means that the Tomstown and Weverton were pushed up from beneath and arched up together. The axial pitch in both formations shows that the Tomstown limestone is above the Weverton and not below as assumed in the overthrust interpretation. The outward dip of the Tomstown prevails for two miles along the east side up to the point at which the contact swerves to the east. From here on the dip of the limestone is to the northeast and away from the greenstone.

The fault along the western foothills of South Mountain from Rohrersville is a necessity since South Mountain has been shown to be an anticline with normal sequence along its west side.

The discordant relations of formations between Rohrersville and the Pennsylvania line as outlined by Stose and Stose are questionable, because exposures are few and far between and most of the area is covered with boulders of Weverton from the mountain. There are formations which disappear like the Antietam east of Cavetown, but clearly transgressing relations have not been established in the field except at Rohrersville.

At no locality has the presence of the Harpers Ferry overthrust been established. Even at Harpers Ferry the sequence is normal and no evidence of a low angle fault can be found. If evidence for the thrust is no more detailed south of the Potomac River than north of the Potomac River, more detailed evidence is needed there also to prove the existance of an overthrust.

The normal faults on the Washington County map fit the facts quite well as they can be observed in the field. A wedge-shaped plunging anticline has been pushed up into the Tomstown dolomite which has been partly bent into an anticline due to drag. A diagnonal fault terminates the volcanics between the Weverton fault and the

Elk Ridge prong. Whether this fault is as straight as shown on the map is a matter of interpretation as long as information is scant.

Detailed mapping in the Rohrersville area by F. C. Jamín and B. W. Wilson revealed several ridges of Weverton sandstone and shale where Stose and Stose have mapped rhyolite and it may be that the situation is more complicated than shown on the Washington County geologic map and by Stose and Stose. Recognition of formations also seems difficult and open to debate. The author has found no Loudon west of South Mountain, and its presence east of the anticline also seems questionable. The Waynesboro section clearly shows dark laminated slate in the lower Harpers which may have been thought to be Loudon by Stose and Stose. The question arises whether the Loudon actually exists as a formation, since it has been established on the erroneous premise that Elk Ridge and South Mountain are synclines.

A great deal more detailed mapping has to be done before these questions can be answered satisfactorily. Cleavage-bedding relations should be established everywhere, cross bedding should be studied, and top and bottom of the Weverton established at all points. As long as this kind of information is not available, some of the most valuable evidence remains unused and conclusions are vague and unreliable.

Western Foreland of South Mountain anticline

The lowlands west of South Mountain are a part of the South Mountain anticlinorium, and the fact that they are topographically low only superficially indicates another province. The anticlinorium almost reaches Hagerstown, and in some places includes the Ordovician Beekmantown limestone. The area is a zone about 6 to 7 miles wide between South Mountain summit and the westernmost detectable pattern of the recumbent structure. In this area are many individual folds which are the wrinkles in an anticlinal crest. Within so large a structure minor folds of several orders of magnitude must be expected. Thus there are anticlines of considerable amplitude as well as smaller ones which are restricted to portions of a formation or individual beds. Depending on the competence of a bed these folds show wrinkled shaly partings and bedding surfaces. The largest are recognized only by mapping a large area, the smallest can be carried away in a specimen or seen only under a microscope.

Faults are to be expected between portions of such a structure, either tearing across beds or in the bedding planes between beds. Competence of beds is of greatest importance. Weaker beds flow forward whilst resistant ones stay behind. Resistant ones, however, may glide forward on soft shales. Thickening and thinning of formations should be the rule; some sections are pinched out and missing at some localities and are too thick at others. The irregularity of the foreland tectonics is not surprising. The astonishing factor is the presence and dominance of certain structures like cleavage, lineation, and the orientation of deformed oölites, in the whole region.

The geologic map shows many of the individual anticlines and synclines, but cannot do justice to the beauty of the pattern on that scale. The picture is much more intricate than shown and it is possible only to call attention to some of the many details.

Elk Ridge anticline near Keedysville seems to have been crowded westward onto the anticline of Antietam quartzite and Harpers shale culminating in McClellans lookout south of Keedysville. Northeast of Boonsboro the Antietam forms a smaller anticline which plunges northward under the Tomstown dolomite. East of Cavetown the formation is missing and Harpers rests on Tomstown along the road from Smithburg to Edgemont. This is one of the few actual exposures of a fault in the entire area. The Tomstown is folded most intricately, and it would be futile to name individual structures. The Waynesboro is an excellent key horizon and several structures can be seen. An anticline southwest of Keedysville and another two miles north of Keedysville plunge north. Near Beaver Creek and Wagners Crossroads the Waynesboro is intensely contorted and folded and most likely faulted. Northeast of Beaver Creek the Waynesboro is above the Elbrook. Here the tops of the hills show the red Waynesboro and the exposures in the valley are Elbrook limestone. The dips are inward so that the section may be reversed. Faulting or recumbent folding may play an important part in the distribution of formations here.

To the north at Cavetown, the Waynesboro is in a syncline which is marked along its trend to the northeast in a number of isolated remnants of Waynesboro on Tomstown, apparently in normal sequence. To the west between Cavetown and Chewsville is an anticline which plunges southward.

One of the most typical structures is the large recumbent fold at Roxbury and to the south in the Elbrook formation. Along the highway from Boonsboro to Lappans, the Elbrook appears upside down and overturned toward the west with the Conococheague below the Elbrook. At Roxbury Mills the front of a recumbent fold is exposed at the east end of the mill race. The beds bend from gently westward dipping through vertical to overturned and almost horizontal. The axis of the fold plunges gently northward. To the south the overturned limb rises to the north and the normal limb dips north. Overturned beds therefore appear from here on south and normal ones to the north.

In the Conococheague, folds are shown on the geologic map. Near the Potomac River they plunge northward; near the State line they plunge to the south. The Hagerstown area is therefore in a low area which is also expressed in the axial plunge of the Waynesboro formation.

All folds of the foreland are asymmetrically overturned to the west. A gentle upper limb frequently dominates over vertical beds or overturned ones of the lower limb. West of Hagerstown folds become generally symmetrical and upright.

Cleavage in South Mountain anticlinorium

All formations which participate in the South Mountain uplift and anticlinorium possess a typical, distinct, and regionally oriented cleavage. It differs in the formations, depending on the material. In the granodiorite gneiss cleavage is coarse, frequently a gneissic banding. At some localities it is linear streaking. Almost always, however, it is a distinct secondary structure.

In the volcanics it is mostly very intense slaty cleavage which upon weathering becomes the only visible structure (Pl. 11). In massive greenstone, cleavage may become visible as elongation of amygdules, chlorite blebs, or streakiness, and there are not many areas where even the greenstones are structureless. The greenstone cleavage is well developed along U. S. 40 (new) from the eastern greenstone contact at Catoctin Mountain to South Mountain summit. In dozens of deep large road cuts the cleavage dips about 45 degrees east along the entire ten miles.

In the metarhyolite, cleavage is most intense and the purple rock is a slate which is particularly distinct east of South Mountain summit on the new U. S. 40.

The conglomerate and slate at Pine Knob show as good a cleavage with phyllitic pebbles arranged parallel to the cleavage.

The Weverton quartzite appears massive at many places, but usually there are beds of quartz schist in which cleavage directions can be observed. Even the massive beds show cleavage upon weathering and mostly a good orientation under the microscope. Good cleavage in Weverton quartzite can be seen at the top of the old quarry at the type location at Weverton, in the new road cut of U. S. 340 between Harpers Ferry and Knoxville, in Raven Rock Hollow, and at countless other places in South Mountain, Elk Ridge, and Catoctin Mountain.

In the Harpers formation the most obvious structure is cleavage which can readily obscure bedding and has been mistaken for bedding. The most elaborate and typical exposures of well-cleaved Harpers are in the vicinity of Harpers Ferry and the Potomac River Gorge, on U. S. 40 east of Boonsboro and the new highway to the north, in Raven Rock Hollow, and in the new road cuts of the section east of Waynesboro along Sunshine Trail (Pl. 8 and 9). In addition, there are many exposures of Harpers which are readily measured and identified.

The Antietam is usually a sandy mica schist and its cleavage conforms generally with that of the Harpers.

In the limestone, cleavage is as a rule less obvious because there is little recrystallization of micaceous minerals and the cleavage surfaces are more easily healed by secondary calcite. There are mostly cracks and fine lines which connect wrinkles in the bedding planes where bedding and cleavage are at large angles. Very helpful in the observation of cleavage in limestones is the determination of deformation axes of oöids in oölites.

Cleavage in all rocks is a secondary structure and transects bedding in sedimentary rocks and primary banding in the volcanics. It is due to the orientation of micaceous minerals mostly of small dimensions. Cleavage surfaces in metarhyolite, for instance, are glistening, shiny planes covered with sericite. In the Harpers the surfaces are also bright and covered with muscovite. In the Weverton newly crystallized micas indicate a good orientation in statistical diagrams. In limestone, the orientation of calcite and dirt particles, oöids, or impurities makes cleavage a distinct structure.

Cleavage dips to the east in about all outcrops in all formations at angles of 40 to 60 degrees in the center of the uplift and at lesser angles in South Mountain and Elk Ridge where it is horizontal or even dips gently west locally as at Harpers Ferry.

The cleavage plane is the axial plane of the folds, but since it fans out in the folds its dip varies from Catoctin Mountain where it is steep to the westernmost portions of South Mountain where it becomes horizontal locally. In such a varied and inhomogeneous mass of rocks cleavage dip must be expected to change with the position in the fold, the stratigraphic column, and the resistance of the rock against deformation. Unexpected and rather astounding is the uniformity of cleavage orientation in the large area. There is little deviation of the strike which parallels that of the fold axes and general trend of South Mountain. It is so regular that it can be predicted for almost any portion of the area.

This general orientation is deflected for about 2 miles along the highway east of

Turners Gap and especially in the valley south of the highway. Here a flexure or fault seems to drag the cleavage into an east-west strike and north dip. Such flexure would explain the apparent offset of the Weverton at Turners Gap.

Cleavage orientation in the South Mountain uplift has been described by Cloos (1947) and Fellows (1943). Stose and Stose (1946) mention it repeatedly but have not made a systematic study of it, and their geologic map of Frederick County (1938) shows no symbols for cleavage.

Lineation

Almost all exposures in South Mountain uplift show upon close inspection one or more distinct linear structures which are valuable indications of directions and planes of movement (Cloos, 1946).

The intersection of bedding and regional axial cleavage parallels the fold axes and permits determination of the axial trend where direct observation of folds is not possible.

Another pronounced orientation is perpendicular to the fold axes and in the steepest dip of the cleavage. This linear structure occurs in all formations in the same orientation. Its strike (horizontal projection) is between N50W and N60W, and it dips as the cleavage.

In the granodiorite lineation can be seen especially well in the river exposures above the new highway bridge at Sandy Hook. Here subparallel mineral clusters occur as spindle-shaped bodies. There is no obvious foliation at that locality and the spindles are visible only in surfaces which include the lineation.

In the volcanics, the structure is visible in innumerable chlorite or sericite blebs whose longest axis indicates the lineation. The mean axis parallels the fold axis and the shortest axis is normal to the cleavage. The axial ratio varies greatly, but is about 100:30:1. The blebs are paper-thin but well visible on cleavage planes. In the metarhyolite the sericite blebs are smaller than the chlorite blebs in the greenstones, but the lineation is accentuated by elongate clusters of kaolinized feldspar.

Excellent lineation can be seen in a conglomerate layer just above the overturned Weverton quartzite along the Appalachian Trail where it leads up to the summit from the new highway on the south side of the Potomac River gorge below Harpers Ferry. Pebbles are spindle-shaped and are up to 10 inches long, 1 inch wide, and $\frac{1}{3}$ inch thick. The conglomerate is between Weverton and greenstone.

In the Weverton, lineation becomes visible in the arrangement of elongated quartz grains as described by Fellows (1943, p. 1414), and Gair (1950, Pl. 2, fig. 3). Less competent layers in the Weverton frequently show streaks, grooves, or parallel arrangements of impurities.

In the Harpers shale cleavage planes are mostly streaked. Some of the lineations show well on cleavage planes, but others reveal only an orientation of particles which may have to be determined microscopically.

In the limestones, the direction of lineation is best determined in the observation of oölite deformation.

Regularity in the orientation of lineation is possible only in a uniform deformation plan that dominates the entire anticlinorium. It has been shown that the lineation continues in similar orientation to the northern termination of the anticlinorium southeast of Harrisburg (Cloos, 1946, Pl. 10). It can be assumed that similar structures continue far into the southern Blue Ridge anticlinorium, though no observations south of the Potomac River gorge are available.

Oölite deformation

The results of a systematic investigation of the deformation of oöids in oölitic limestones have been published by the writer (1947). Oriented samples of oölites were taken at hundreds of localities and appropriately sawed and sectioned. The dimensions of the ellipsoidal oöids were measured and the ratios plotted into maps and sections.

The study is an attempt to ascertain deformation quantitatively. The area covered includes the western foothills of South Mountain from the Potomac River to its termination south of Carlisle, Pennsylvania. Along the entire South Mountain fold

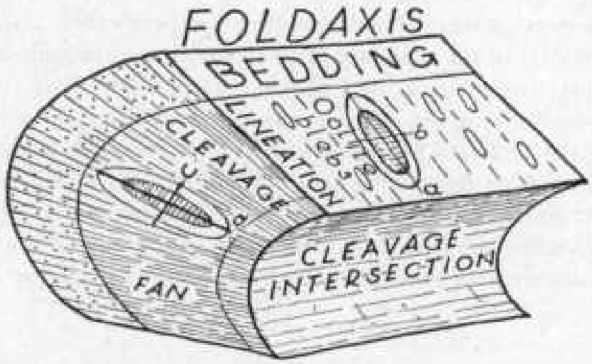

Figure 26. Deformation Plan in South Mountain Anticlinorium. Fold axes and cleavage-bedding intersection, *b*; lineation, direction of transport, maximum extension of oöids, *a*; cleavage plane, *ab*; *c* normal to *ab* cleavage plane.

limestone deformation decreases gradually from over 100 per cent distortion to 10 per cent or less within a zone several miles wide.

East of this zone all rocks are deformed in such a manner that their internal texture has changed either by recrystallization or reorientation of minerals. West of this zone the texture has not always changed, but the rocks are folded. To the east a uniform regional deformation plan dominates: a cleavage which dips east and southeast and a lineation in its steepest dip. Folds are asymmetrical and overturned to the west and as intensity increases may become recumbent as in South Mountain. To the west folds are mostly upright and axial planes generally vertical. Cleavage is intense only in less competent rocks as the Martinsburg shale of Massanutten syncline.

The boundary is considered the western limit of the South Mountain fold or Catoctin Mountain-Blue Ridge anticlinorium.

Deformed oölites show that cleavage includes the maximum and mean deformation axes as illustrated in Figure 26. Cleavage is also the axial plane cleavage of the folds. The cleavage is interpreted as due to shearing and the folding essentially as shearing. Lineation indicates the direction of maximum movement or flowage of material. This follows from the fact that oöids, blebs, and all other bodies are elongated, indicating movement in the lineation direction. As elongation took place, movement became necessary and the South Mountain folds moved forward and upward in that direction. The outermost parts moved farther than the innermost ones, but their distortion is less. South Mountain fold is thought of as a large shear fold in which folding is for the most part due to movement on shear planes, and not principally to bending of strata and slippage on bedding planes.

In so large a complex, deformation is not the same in all parts, but is different due to differences of resistance of certain formations, like the Weverton, against deformation. Folds in Weverton and Antietam are in part flexure folds. In the shales and limestones, bedding has become obsolete and is only a design without mechanical effect. Movement is, in its latest stages at least, on cleavage planes. This can be seen in the dislocation of bedding in the Harpers Ferry area where portions of a bed are displaced slightly with respect to the adjacent portions.

A rock which owes its texture to deformation has been called a tectonite (Knopf and Ingerson, 1938), and the boundary of an area of tectonites against non-tectonites has been named tectonite frontier by Fellows (1943, p. 1430). Since all rocks of South Mountain show the effect of deformation, they are tectonites. The western boundary of this effect is the tectonite front and at the same time the western limit of the Catoctin Mountain-Blue Ridge anticlinorium. Within this region movements were to the northwest and upward in the direction of the extension of oölites, blebs, and pebbles which parallels the lineation. In the area to the west of the tectonite front movement and deformation generally is entirely different as will be shown below.

MASSANUTTEN SYNCLINORIUM

Introduction

Earlier workers have called the structure Massanutten syncline, but since it includes about ten smaller anticlines and synclines, the term synclinorium is more appropriate.

The area reaches from the western limit of South Mountain anticlinorium to the foot of the Bear Pond Mountains which almost coincides with two major faults separating the synclinorium from the Bear Pond Mountains area (Foltz anticlinorium) to the west.

Conococheague syncline

In the deepest portion and the center of the synclinorium is Martinsburg shale in a steep-walled and probably faulted syncline. The exposure of shale has an average width of $2\frac{1}{4}$ miles in Maryland and is flanked along its walls by steeply-dipping limestones. The east wall is in part a fault near Williamsport because Chambersburg and Stones River limestones are lacking. Neuman describes a thrust near Cearfoss so that the eastern boundary may be a much more important tectonic line than appears on the geologic map. The west wall is also faulted near Pinsburg station where the Chambersburg limestone is partly missing and the Stones River is abruptly flexed from nearly horizontal to a vertical attitude at the contact. In the west face of a quarry south of Pinesburg station from which shale has been taken up to the

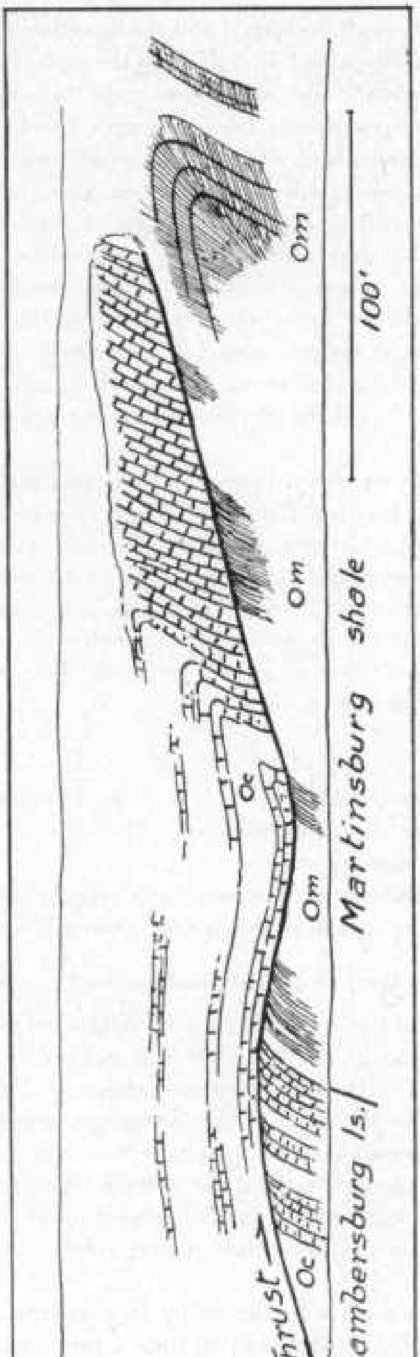

FIGURE 27. Chambersburg Limestone Thrust on Martinsburg Shale on Low-dipping Surface South bank of Conococheague Creek three-fourths mile southeast of Fairview.

limestone contact, a reverse fault is exposed and the limestone has been pushed eastward over shale. The fault dips about 45 degrees to the west. Part of the Chambersburg limestone is missing and the fault seems to cut into the formation.

One mile southeast of Fairview along Conococheague Creek, Chambersburg limestone is thrust onto Martinsburg shale along a fault which dips about 10 degrees east, but is horizontal in places. The profile along the creek is unusual and offers the rare opportunity to see a thrust surface exposed for several hundred feet and study it in detail (Fig. 27). Drag in the shale and limestone indicates movement from east to west. The displacement may be several hundred feet and a small anticline in the shale seems to have been moved over a syncline next to the western contact. The thrust cannot be traced to the south because of lack of exposures.

Northwest of Fairview a fault cuts across the contact diagonally. At the State line an anticline and syncline plunge to the north and from here on to the north the contact is modified by folding.

Within the syncline many smaller anticlines and synclines can be seen in the Western Maryland railroad cut between Williamsport and Pinesburg Station. The folds are open and bedding is transected by a steep slaty cleavage which obliterates bedding at many places or produces pencil slate where the angle of intersection is large. Bedding is visible as a parting in the direction of lithologic changes in the shale.

The width of the shale belt, the presence of many open folds, and the fact that the shale is only about 2500 feet thick, suggests a rather flat-bottomed syncline limited by nearly vertical or overhanging walls.

St. Pauls syncline

St. Pauls Church is located on a hill north of U. S. 40, $1\frac{1}{2}$ miles west of Wilson and the highway bridge across Conococheague Creek. The hill is at the southern end of a smaller syncline of Martinsburg shale.

The western contact of the syncline is normal with vertical limbs. The eastern contact is a fault which seems to continue to the south. The shale forms a ridge.

Western limit of synclinorium

Along the western limb of the synclinorium the Conococheague and Elbrook limestones come to the surface again, but the latter is in contact with Martinsburg shale which normally underlies Juniata and Tuscarora sandstone. This western boundary is a fault roughly parallel to the strike of the formations on either side. The rather even width of both formations along the mountain front indicates that the strike of the fault is approximately parallel to the strike of the formations on each side. Along this fault the east side has clearly moved up with respect to the west side, but nothing is known about its dip. Whether it is a thrust, a steep reverse fault, or a normal fault is indeterminate.

At its southwest end, the fault is transected by another strike fault considered by Butts, Stose, and Jonas (1932, p. 33 and Pl. 6) to be a thrust along which the valley limestones are thrust over the Silurian and Devonian to the west. This fault dies out toward the north of Gillians Knob and gains displacement toward the south. At

McCoys Ferry the displacement is from Conococheague limestone to Devonian Romney shale. At McCoys Ferry in a cut of the Western Maryland railroad the fault is almost exposed and seems to dip steeply. Its straight trend and increase in displacement suggest a steep fault along which the west side dropped down relatively to the Valley limestones. The rapid southward increase of displacement is accompanied by a noteworthy change in axial plunge which makes the increase necessary. East of the Massanutten fault the axes plunge gently to the north and northeast; west of the fault the axes plunge to the south. The plunge is about 10 degrees in both directions which adds up to a divergence of 20 degrees. A 20 degree difference can within a few miles provide a large increase in displacement along the strike of the fault. To the north, the axial plunge decreases on both sides of the fault where it dies out. In the Mercersburg Valley the axes are horizontal which explains the large widening in the area of Martinsburg shale and the northern termination of the Bear Pond Mountains.

FOLTZ ANTICLINORIUM

The Bear Pond Mountains area or Foltz anticlinorium is the northern end of the North Mountain uplift of Stose and Swartz (1912, p. 125). Its structure is dominated by three northward emerging anticlines and two synclines in which the ridge-making Silurian Tuscarora and underlying Juniata sandstones determine the shape of ridges and mountains. Synclinal or anticlinal crests make the highest mountains, as Cross Mountain, Hearthstone Mountain and Fairview Mountain. They are connected by lower ridges in which the dip is vertical or nearly so. To the south the Devonian overlies the Silurian and the Potomac River avoids the Silurian rocks. To the north the Martinsburg shale provides the valley floor of Mercersburg Valley.

The Bear Pond Mountains offer one of the best examples of plunging folds in Maryland. To the west the anticlinorium is flexed steeply and the vertical sandstones make the long sharp ridge of Cove Mountain which emerges from Cross Mountain in a sharp flexure. The summit of Cross Mountain is a plate of Tuscarora and Juniata sandstones which dip southward at 2 to 5 degrees, making a dip slope with a most prolific growth of huckleberries and pines. West of the fire tower the sandstones bend into a vertical position within a little more than a hundred feet. Further west a fault accentuates the steep flexure.

Stose and Swartz (1912, p. 126) have described the two faults west of the Foltz anticlinorium as thrusts which include between themselves a wedge of Helderberg and Oriskany.

MEADOW BRANCH SYNCLINORIUM

West of the Bear Pond Mountains arêa is a synclinorium in which the Devonian formations occupy the entire width of the State between Potomac River and the Pennsylvania line. Stose and Swartz named this structure after Meadow Branch in West Virginia. In Maryland, it is transgressed by Licking Creek from the Pennsylvania line to Potomac River. The fold axes plunge gently toward the river paralleling the axes of the Bear Pond Mountains area to the east.

DICKEYS MOUNTAIN ANTICLINE

Silurian strata rise west of Meadow Branch syncline in Keefer and Dickeys Mountains, but enter Maryland only just north of Elbow Ridge in a small semicircular area. North of the State line and included on the County map is the core of the anticline exposing the Tuscarora sandstone forming Dickeys Mountain. The anticline plunges gently southward toward Potomac River.

According to Stose and Swartz (1912, p. 129) the west limb of the anticline is faulted along a great thrust fault which brings the Beekmantown limestone into contact with the Jennings formation, a displacement of 9000 feet. This fault is shown on the County geologic map. Licking Creek follows its course north of the State line. The displacement has decreased southward and the fault seems to die out.

TIMBER RIDGE SYNCLINE

West of Dickeys Mountain anticline is a syncline of Devonian formations which crosses the County as a band of parallel-striking formations with nearly horizontal fold axes. Stose and Swartz named it after Timber Ridge just east of Hancock. The depth of the syncline increases northward in Pennsylvania and includes coal-bearing Carboniferous rocks.

CACAPON MOUNTAIN ANTICLINORIUM

Silurian rocks appear again west of Hancock in Cacapon Mountain anticline, so named by Stose and Swartz (1912, p. 129–131) after Cacapon Mountain in West Virginia. The two prominent limbs of the anticlinorium in Maryland are Cove Ridge just west and north of Hancock and Tonoloway Ridge 2½ miles west of Hancock. Both ridges are Oriskany sandstone which is here the backbone of all major elevations.

The Silurian outcrops are 2½ miles wide and include the best and most interesting sections of folded rocks in Maryland and probably some of the best in the entire Appalachian region. The stratigraphic section includes the Silurian above the Bloomsburg red shale and the overlying Devonian. To the west the sequence is continuous up to the lowest Carboniferous in Sideling Hill syncline.

Two sections along the Western Maryland Railroad are outstanding for their magnificent exposures, easy accessibility, and beauty of detail: one at Round Top, 2½ miles southwest of Hancock, and the other north of Great Cacapon. Both sections are in the Bloomsburg, Wills Creek and Tonoloway formations. An enormous amount of detail is shown and much can be learned about the mechanics of folding, formation of cleavage, thrusting, faulting, and deformation of bedded rocks. Deformation has progressed only far enough to show the structures at their early stages, but not so far to obliterate much of the evidence. Similar sections are partly exposed along U. S. 40 and along the B. and O. Railroad.

South Mountain is an example of regional deformation and deformation has reached the stage of a common plan in a large area. The Cacapon Mountain anticline deformation is governed by local conditions as relative competence and incompetence of beds, the crowding of strata into a small space between the limbs of an anticline or syncline, thrusting along bedding planes or at very low angles, and the formation of cleavage in response to local stresses. The overall deformation plan is simple and very nearly symmetrical. There is no regional cleavage, but all rocks show cleavage. Beds are not asymmetrically overturned but upright and normal and many lean eastward. Thrusts may move west or east. Movements are directly upward or outward from the center of a syncline or anticline.

Both sections have been mentioned in the literature (Stose and Swartz, 1912, p. 130–131). Swartz measured the Round Top section and noted that the section is rather complex and much contorted by minor folds. Cacapon anticline is essentially an uparched area of Silurian rocks flanked by the Devonian. Its crest has collapsed into a large syncline and the variety of structures exposed is due to the crowding of the beds in this synclinal crest.

STRUCTURES RESULTING FROM APPALACHIAN FOLDING

Introduction

The intense folding of all formations produced an uncountable number of structures of various orders of magnitude. Some folds comprise entire mountains like the Sideling Hill syncline; others can be seen only with a magnifying glass. Thrust surfaces may be due to displacement of rock masses for miles, others are restricted to only one bed or part of a formation. Since all these structures are the result of deformation they are all significant and need to be considered in an analysis of the folding process and in an attempt to reconstruct the original condition prior to the deformation. Measurements of stratigraphic thicknesses have to take folds, faults, boudinage, and cleavage into consideration.

The major large scale structural units have been outlined and attention is directed here to some of the smaller traces of deformation. The best exposures for the study of detail are the two sections in the Cacapon anticlinorium at Round Top and opposite Great Cacapon.

The Round Top section is 2½ miles southwest of Hancock, Maryland, and can be reached by car to within a few hundred feet from the east end of the section. The Cacapon section can be reached by car following U. S. 40 and turning south to Woodmont. A road turns east at Woodmont and can be followed to within a mile of the section. The best approach is on foot along the railroad track from the end of the road.

Folds

In the Round Top section there are at least ten well-exposed anticlines and synclines and in the Cacapon section about fifteen.

The folds of massive beds are large and parallel. Laminated and thin-bedded shale and limestone sequences show a great deal of thickening and intrusion of shale between sandstone or limestone fragments at the crests. The shale has been mobilized and thin competent beds in such mobilized shale are torn apart and float in the shale like boulders.

In general the folds are open and non-isoclinal. In competent beds they are flexure folds with constant thicknesses, slippage on bedding planes, and tension fractures near and at the crest. In incompetent beds, they are shear folds with extraordinary thickening of beds in the crest and with axial plane cleavage. The two kinds of folds

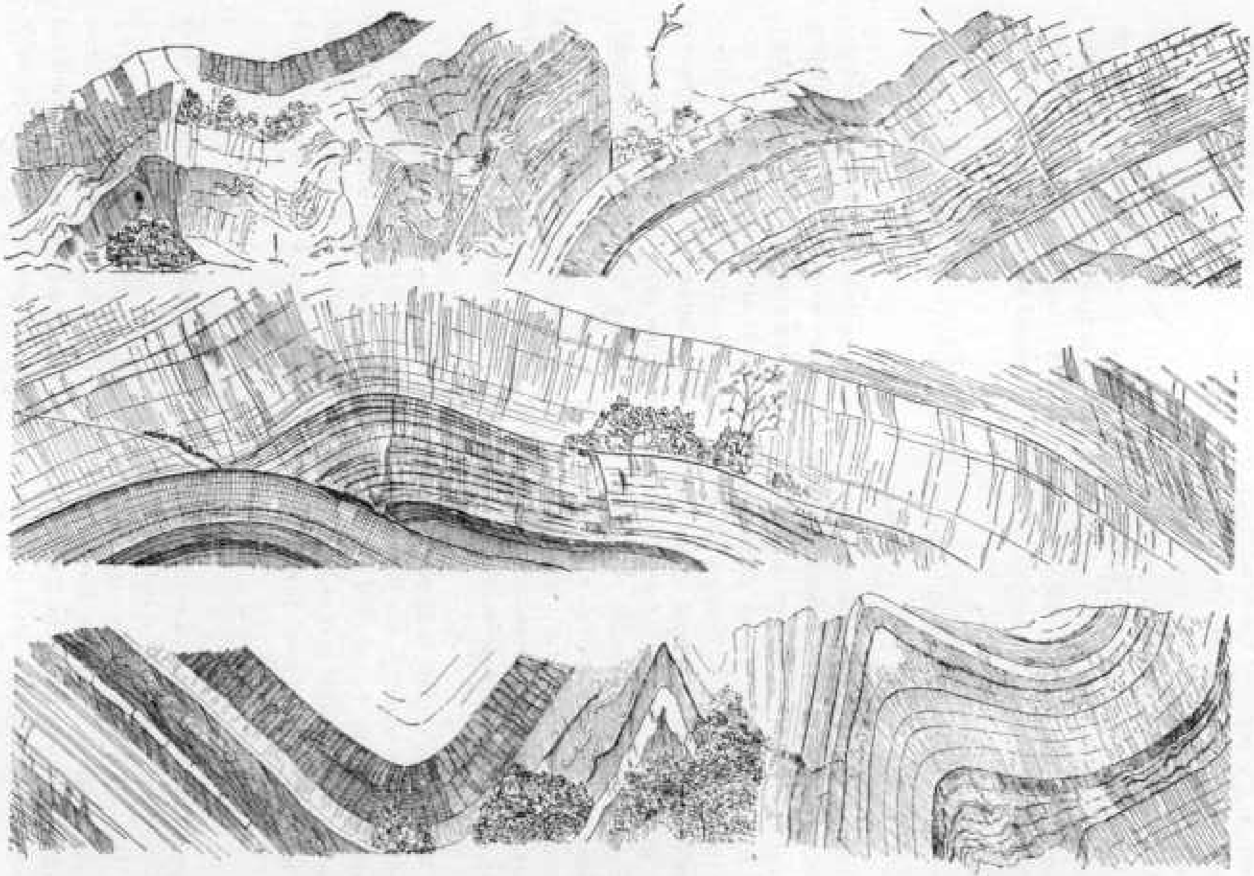

FIGURE 28. Drawing of Central Portion of Cacapon Section. Wills Creek shale. Competent beds in flexure folds, incompetent beds in shear folds with axial plane cleavage. Thrusts follow bedding planes and eliminate some portions of the section. Thrusts seem to be early because some of them are intensely folded.

occur side by side in the Cacapon section and are shown in Figure 28 to 31 and in Plates 12 to 14.

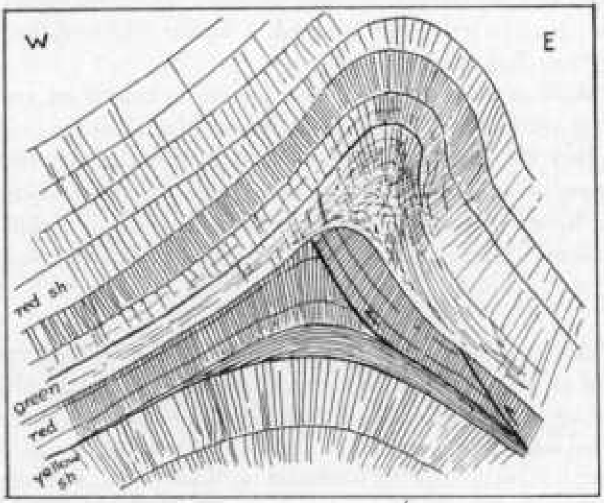

FIGURE 29. Flexure Fold at Round Top, Western Maryland Railroad Cut. Thicknesses of beds are constant in competent layers. Cleavage is radial. Bedding planes are striated intensely. Height of exposure about 50 feet.

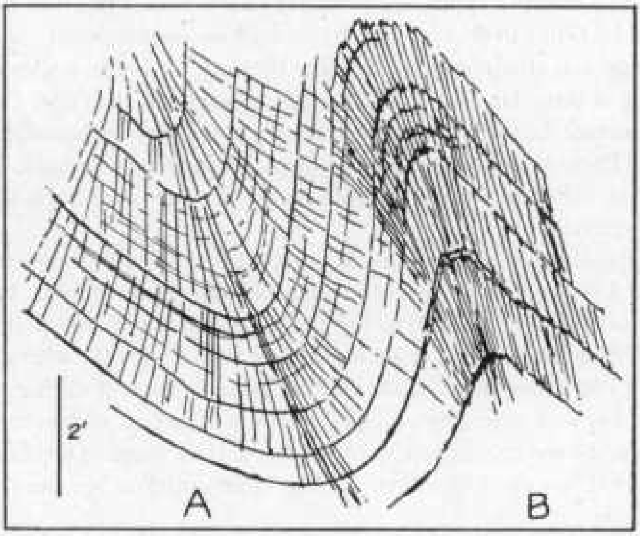

FIGURE 30. Flexure and Shear Fold Side by Side, Cacapon Section. In flexure fold A: bedding thickness constant, cleavage fans strongly. In shear fold B: bedding thickness constant, parallel cleavage, but not normal to bedding planes; crest intensely crenulated, cleavage fans little.

Figure 29 is the often illustrated anticline at Round Top (Clark and Mathews, 1906, Pl. IX, fig. 1). Beds are bent about an almost horizontal axis and their thickness remains constant when measured perpendicular to the bedding planes. The latter are covered with striae and thick coatings of secondary calcite. Striae are perpendicular to the fold axis. An intense cleavage remains very nearly normal to the bedding and thus forms a fan which diverges upward. A similar fold is in the center of Figure 28 but showing thrusting in addition.

Figure 30 B shows a fold in the Cacapon section in laminated gray shale. In the crest the beds are thickened, laminae are wrinkled, and cleavage planes remain subparallel throughout the fold. The shale flowed and flow cleavage formed. In Figure 30 A the beds were bent and the cleavage remained a fracture cleavage. The sections at Cacapon and Round Top offer many examples of both kinds of folds and of transitions between the two. Many examples were recently described by Gair (1950, p. 864).

Cleavage

Almost all rocks of the area show a cleavage depending on their resistance against deformation and on the intensity and direction of the deforming stresses. Cleavage planes are definite planes other than bedding planes along which rock is readily cleavable or along which the rock breaks when weathering. A conspicuous cleavage is visible in almost all shale beds as the Bloomsburg, Wills Creek, Romney, and Martinsburg. The cleavage planes are closely spaced, and the rock breaks into pencil shaped fragments, flakes, or cobbles. The most impressive outcrops showing such cleavage are in the Wills Creek and Bloomsburg shales in the Round Top and Cacapon sections. Fold after fold shows cleavage normal to bedding and fanning through a large angle in the massive appearing gray and yellow weathering red shales (Figures 28–31, Plate 13). Gair (1949, Pl. 5, fig. 6) shows how displacements occur along fan cleavage planes and discusses the relation between cleavage angles and thinning and thickening of beds. He calls the diverging cleavage fan cleavage.

In more resistant beds, a coarse fracture cleavage divides laminated shale into long columns. These have been tilted and displacements are common. This cleavage may properly be called fracture cleavage because mineral orientation is not its main cause or consequence.

A second type of cleavage seems clearly related to differential movement between beds, as in the flowage of shale, from the limbs into the crests of folds. In thin section mineral orientation is seen parallel to the cleavage, and it is therefore thought of as a flow cleavage. A good example of such cleavage is in Figure 31 where a shale layer has served as a lubricating horizon for a rather large movement during which a sandstone bed has been considerably shingled. Such localization of movement is rather common and can be recognized by the angle between cleavage and bedding and verified by other observations on displacements. The same anticline has been described by Gair (1950, Pl. 3).

Interpretation of cleavage

Fracture cleavage has been interpreted as due to shearing and flow cleavage as due the plastic deformation (Billings, 1942, p. 216) or flowage in its broadest sense. Shearing is thought to be due to relative movements of beds which are folded. Diverging cleavage normal to bedding or nearly so is not generally shown in texts or discussed in the literature. If fracture cleavage is shearing due to relative movement of beds in the limbs of folds the question arises how it can be as intense in the crest of an anticline.

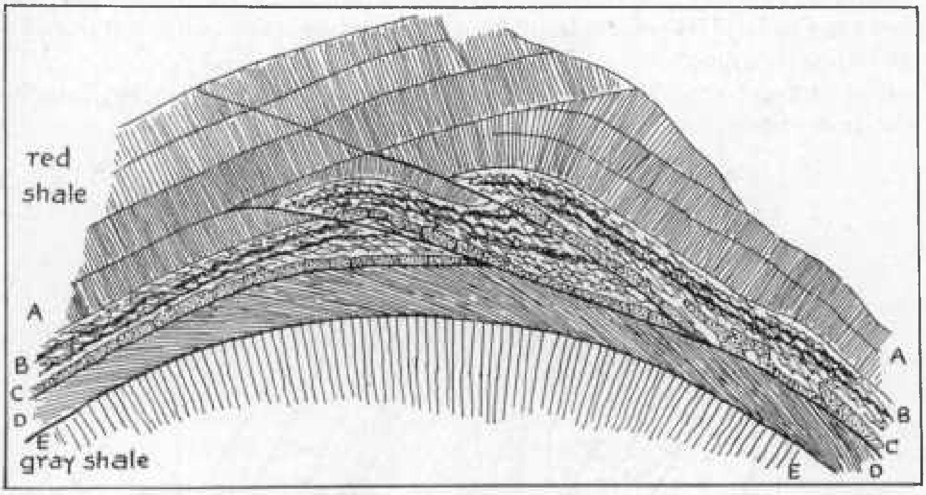

FIGURE 31. Anticline in Bloomsburg Shale Showing Fan Cleavage (layers A and E), and Flow Cleavage (layers B and D). Cleavage in D is due to thrusting from right to left (west) during which sandstone C has been shingled into several layers. (See also Gair 1950, Pl. 3). Thrusting may be of fairly large order of magnitude and prior to the up-arching of the fold.

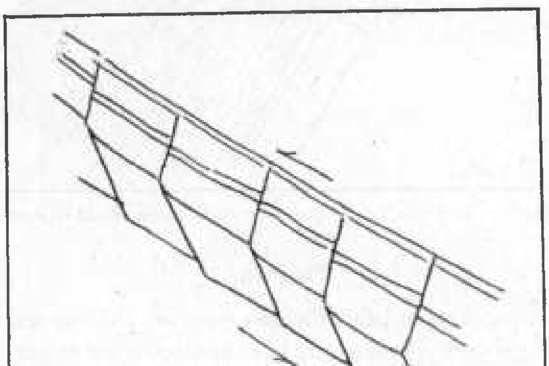

FIGURE 32. Bedding Fractured and the Blocks Tilted Due to Relative Movement of Beds during Flexure Folding.

Fan cleavage presents an interesting problem which has not been discussed or systematically investigated. It may be a cleavage or closely spaced jointing which formed at a very early stage and possibly prior to folding. The cleavage has then been tilted with the bedding and due to relative movements and drag it became tilted in the limbs. Drag along bedding planes seems to indicate that the cleavage existed prior to the relative movement of beds over each other.

Some of the blocks were also tilted and bedding displaced along cleavage planes as shown in Figure 32, likewise indicating that the cleavage was an early and probably pre-folding structure.

Flow cleavage very clearly results from extension (flowage) of material due to relative movement.

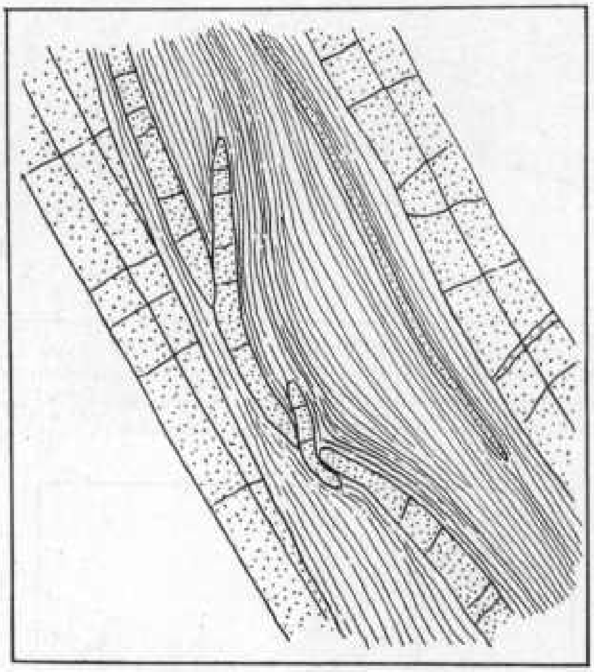

FIGURE 33. Sandstone Bed in Shale Telescoped Due to Differential Movement of Adjacent Beds

Thrusting

Thrusting on a large scale is probably less common than generally assumed, but small scale thrusting is very common and has been described recently by Gair (1950).

Thrusting in relation to cleavage is shown in Figure 31. Similar telescoped sandstone beds are shown in Figure 33. A fold which is broken and thrust forward on a curved, highly polished and slickensided surface is shown in Figure 34 and Plate 13, figure 1. It represents a commonly described form of thrusting.

Bedding planes frequently are thrust planes and the movement surface may cross over to the top of the bed along gently curved surfaces as shown in Figure 37 and Plate 14, figure 2. This figure shows a sandstone bed in red Bloomsburg shale at the west end of the Cacapon cut. The bed thickens because parts of it have been wedged together. The movement is of small order, but since these short thrusts are extremely numerous the total thickening is not negligible.

A different kind of reverse faulting is shown in Figures 36 and 37. Figure 36 shows a low angle reverse fault where the fault plane transects all beds and the top has been moved toward the left and upward. Figure 37 simulates an unconformity which seems to be upside down. The beds now above the bottom part have been moved about 40 to 50 feet to the left along the thrust plane.

Figure 38 shows still another kind of thrusting in a sharply folded syncline. Blocks of a laminated dolomite bed have been sheared loose and moved upward between

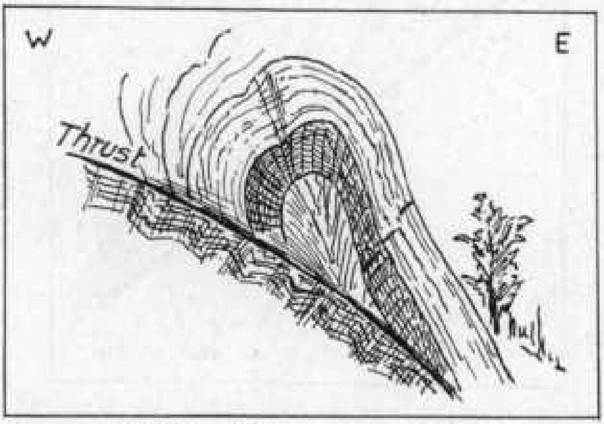

FIGURE 34. An Overturned Fold Sheared Off in the Lower Limb and Moved Forward on a Highly Slickensided Thrust Plane, Round Top Section.

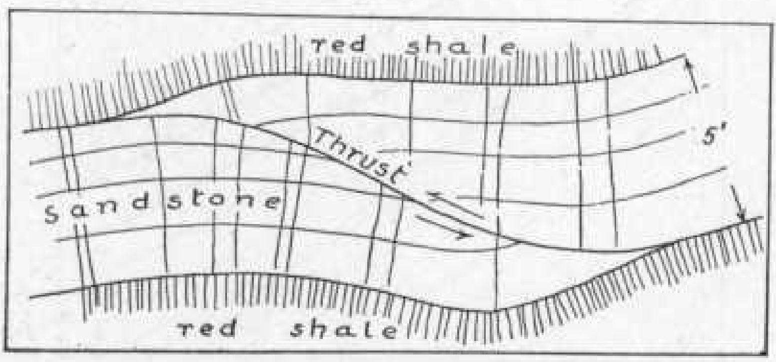

FIGURE 35. Movements in Bedding Plane Transect a Competent Bed in a Thrust Plane. The bed is thickened due to wedging of the bed. Bloomsburg shale, Cacapon section.

the two limbs of the syncline and have been thrust into the dark shale above. The syncline of Figure 38 suggests an explanation of the many thrusts in all sections. The same fold has been shown by Gair (1950, figure 7).

The Cacapon section (Figure 28) shows a number of thrusts of various orders of magnitude. The most obvious is the thrusted anticline approximately in the center of the section. On each side of the crest of the anticline is an apparently undisturbed normal sequence of shale. However, due to thrusting about 20 feet of shale are missing in the left (west) limb of the anticline. The thrust plane follows the bedding surface of the footwall but cuts across some members of the hanging wall. The displacement is about 100 feet but cannot be accurately measured due to lack of reference planes.

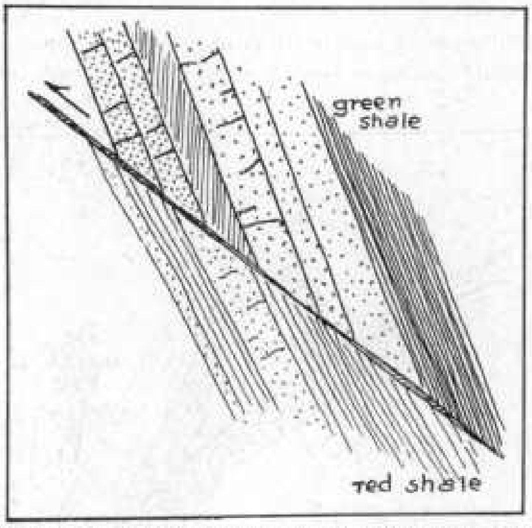

FIGURE 36. Thrust in Shale and Sandstone Away from Center of Syncline (right). Potomac River Gap, Sideling Hill.

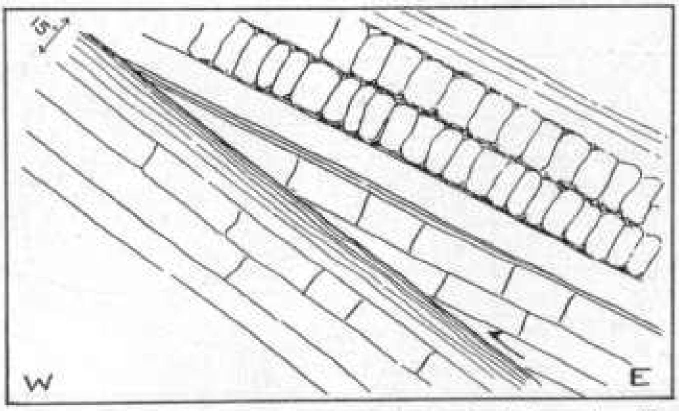

FIGURE 37. Low-angle Thrust in Lower Mississippian Rockwell Formation. The syncline is to the right and its center is thrust outward. Road on north side of Potomac River gap at Sideling Hill.

Most of the thrusts seem to be closely related to the folding of the individual folds and the crowding of material outward and upward from between the closing vice of the limbs of the syncline.

In the Cacapon section an anticline of Tonoloway and Wills Creek has collapsed in the center and been crowded between two limbs of Bloomsburg shale. To accommodate the Wills Creek, many small thrusts served as movement planes for the crowded synclinal center. Bedding plane slips are generally assumed to serve in the accommodation of stresses, but they may not have been sufficient and the low angle thrusts formed. Movement on these thrusts is always away from the center of the syncline. An excellent example of thrusting outward from the syncline is along the road north of the river through Sideling Hill. One of the thrusts is shown in Figure 37. The sense of movement is in opposite directions on both sides of the synclinal axes.

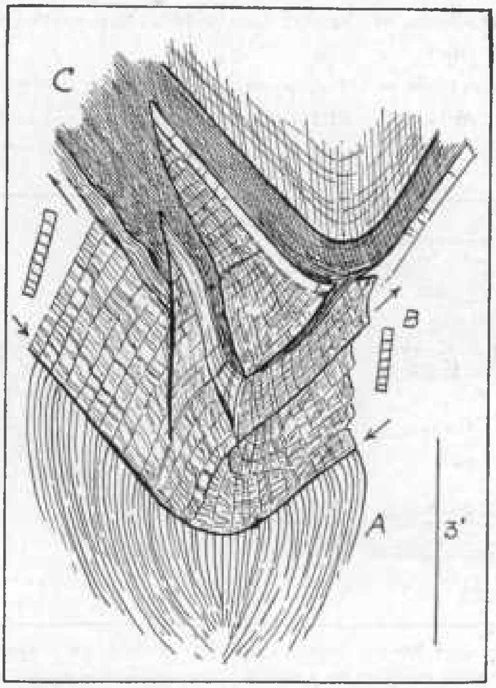

FIGURE 38. In a Sharply Folded Syncline Portions of a Relatively Competent Laminated Dolomite Bed (B) are Crowded Out and Thrust into the Soft Shale (C) Above. Relative movement of beds has produced small faults in the dolomite (B) beds by tilting of blocks. Round Top section opposite watchman's shelter. A: brown shale; B: laminated dolomite; C: shale.

Boudinage

Boudinage is a term coined by Lohest (1909) for sausage-shaped structures which are due to folding of a series of competent and incompetent beds. The information on these structures has been summarized because they are very common and useful indications of the mechanism of folding (Cloos, 1947). A competent bed of sandstone or limestone between shale beds may be broken into fragments along fractures normal to the bedding by relative movements of higher beds over lower ones as indicated in Figure 39. The fragments of the bed are then pulled apart and the shale flows into the gaps. Due to the intensity of pressure, corners are rounded or broken off so that a chain of loose boulders may appear.

The structure is very common, particularly in the Tonoloway because it consists of a series of interbedded shale and limestone beds. Figure 39 shows examples of boudinage in several stages. The sausage-shaped structures are well shown on Plate 15.

Boudinage serves to accommodate elongation of beds over the arch of an anticline and is not common in synclines where the compression of the center favors thrusting.

Striation

Striation is common on many surfaces and as a rule accompanied by infiltration of secondary calcite. Some of the striated surfaces are coated with layers of calcite more than one inch thick.

Two principal directions of striation can be observed: normal to fold axes on bedding planes and on faults not in direct relation to fold axes. The former are the visible directions of slippage normal to the axes in flexure folds and are paralleled by thrust

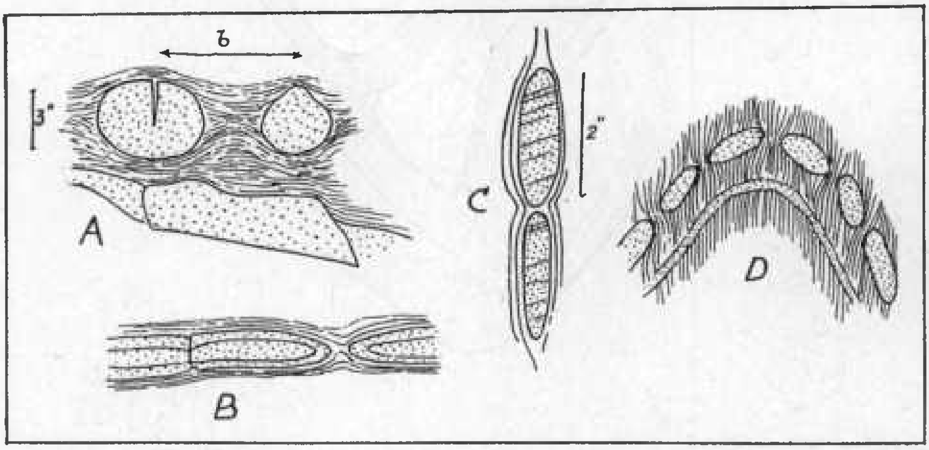

FIGURE 39. Boudinage, Round Top Section. A: a bed has been completely torn apart and boulder-like fragments remain. B: a bed is disrupted and rounded, the soft shale flows into the gap. C: elongate bodies are disconnected similar to B. D: one competent bed has been torn into fragments of approximately equal size which now form rolls or boudins elongated parallel to the fold axes.

directions in the small thrusts as in Figure 28. The latter may be in any direction along which two rock masses have moved past each other.

Drag folds

Drag folds are very common and can be used to determine the position of the observer in a fold. Very small drag folds are shown in Plate 16, figure 1, from a bedding plane surface at Cacapon. These folds are traversed also by rather deeply engraved striae normal to the drag fold and general fold axes.

Lineation

Linear directions are generally indicated everywhere as fold axes, intersection of cleavage and bedding, drag fold axes, striae, and in the longest dimensions of polygonal mud crack figures. The latter are shown in Plate 16, figure 2, from Round Top and are frequently met with. Cleavage and bedding intersect in lines which parallel fold and drag fold axes.

Jointing

Joints are very numerous. Cross joints perpendicular to fold axes are thought of as tension joints and are frequently filled with carbonates as veins. They are evenly distributed and almost no sizeable outcrop is free of them. The largest and most spectacular display of cross joints on a regional basis is outside of the County in the glass sand quarries at Berkeley Springs, West Virginia, where the large bedding planes of the Oriskany sandstone are divided by fractures that reach from the foot of the quarry wall to the top of the mountain. These joints are also planes of small displacements which produce steps in the bedding planes and the individual blocks stand out in bold relief. All railroad and larger road cuts exhibit joints in the same relation to the deformation axes.

Strike joints parallel to the fold axes are also common and frequently follow the cleavage.

Diagonal joints at various angles to bedding and the deformation axes are also common.

MINERAL RESOURCES OF WASHINGTON COUNTY

BY

ERNST CLOOS

INTRODUCTION

The most important industrial minerals of the county are the limestones and shales. Only few quarries are now operated in spite of excellent railroad and road conditions. Metal mining played a role in the early history, but can now not compete with the large scale mechanized operations of large deposits in other areas. The county does not even provide all its own agricultural lime, road metal, and railroad ballast.

LIMESTONE, LIME, AND CEMENT

In Washington County limestone is used as burned lime, granulated limestone, building stone, and in the manufacture of cement.

Almost half of the county is underlain by limestone. Hagerstown Valley is the largest area. It is about 20 miles wide and extends from the Potamac River to the State line. There are two belts of limestone of Cambro-Ordovician age with an intervening shale zone about 2 to 2½ miles wide.

In the western part of the county west of Bear Pond Mountains are a few narrow bands of limestones which extend across the State. They are of Silurian and Devonian age.

HAGERSTOWN VALLEY

The following formations comprise the limestones of the valley floor:

Ordovician	Chambersburg limestone Stones River limestone Beekmantown limestone
Cambrian	Conococheague limestone Elbrook formation Waynesboro formation Tomstown formation

The distribution of these formations is shown on the geologic map of the county (1941) and they are described in the chapter on stratigraphy of the sedimentary rocks. The sequence is about 10,000 feet thick which is economically unimportant because all these rocks are intensely folded and the beds are rarely horizontal. The situation is different at each locality and needs careful study and analysis.

Tomstown limestone

The Tomstown limestone is the lowest of the limestone formations in the geological sequence. It is confined to the foothills west of South Mountain and is intensely folded, faulted, and infiltrated by impurities.

There are no active quarries in the Tomstown. Two old workings are at Cavetown and Eakles Mills. The Cavetown deposit has been exhausted but the old quarry shows the structures and thick limestone beds well. The stone was used for crushed stone and for burning lime. The quarry at Eakles Mills had been a source of building stone and marble. Many, small old quarries were worked locally for road building.

The following analyses of Tomstown limestone show its general composition (Mathews and Grasty 1909, pp. 410–412).

ANALYSES OF TOMSTOWN LIMESTONE

	CAVETOWN		¼ mi. w. of CAVETOWN
SiO_2	.79	1.21	1.77
Al_2O_3 Fe_2O_3	.94	.54	.73 .45
CaO	48.49	50.07	31.80
MgO	5.19	4.85	19.51
Ignition loss	43.95	43.65	45.69
$CaCO_3$	86.40	89.10	57.00

Waynesboro formation

The Waynesboro formation consists mainly of red shale, some sandstone, and also hard limestone. At Cavetown it limits operations in the underlying Tomstown formation. There are no openings of any size in this formation.

Elbrook formation

The Elbrook consists of bluish-gray limestones which are usually thin-bedded and shaly when weathered, but appear rather massive in fresh openings. The formation occurs in two zones, one in the eastern and one in the western part of the valley.

Near Chewsville there were some old openings from which samples have been taken and analyzed (Mathews and Grasty 1909, p. 412).

ANALYSES OF ELBROOK LIMESTONE

SiO_2	1.20	1.10	1.40
Al_2O_3 Fe_2O_3	1.50	.70	.94
CaO	52.30	54.60	54.00
MgO	2.35	.86	1.15
Ignition loss	43.56	43.68	43.51
$CaCO_3$	93.00	97.00	96.00

The Elbrook limestone has generally been considered suitable for the manufacture of cement. Mathews and Grasty (1909, pp. 418–419) recommend two localities, one 2 miles south of Breathedsville at Burtner and another near Keedysville. Their analyses at these localities are at the top of page 166.

The only significant recent use of the Elbrook is in construction of the buildings of the Maryland Penal Farm at Breathedsville. The flat and rather thin-bedded limestone has furnished excellently-shaped building stone (Plate 19). Some of these

ANALYSES OF ELBROOK LIMESTONE

	Burtner		Keedysville	
SiO_2	8.71	8.36	15.23	21.98
Al_2O_3	1.89	2.76	9.21	17.34
Fe_2O_3	.32	.90	1.65	2.67
CaO	45.67	46.42	26.53	20.20
MgO	4.67	2.74	11.55	4.61
Ignition loss	39.46	39.39	35.67	30.89
$CaCO_3$	80.90	82.70	41.20	36.00

beds would be suitable for the making of lime or cement, although most beds are highly dolomitic.

During the early days of natural cement manufacture the Elbrook was used more extensively than any other, as is indicated by the abandoned quarries and mill of the Potomac Natural Cement Company near the Potomac River southwest of Sharpsburg.

Conococheague formation

The Conococheague consists of siliceous and argillaceous limestones with a number of horizons suitable for the manufacture of cement or crushed limestone. Dolomite and sandstone beds occur at several horizons in the section. The formation occurs to the east and west of the shale belt at Conococheague Creek.

The only large scale quarrying operation in the County is that of the North American Cement Corporation located in the Conococheague limestone at Security two miles west of Hagerstown.

Analyses from this quarry published by Mathews and Grasty (1909, p. 423) are:

ANALYSIS OF LIMESTONE AT SECURITY

SiO_2	7.06	6.04	5.62
Al_2O_3	1.08	1.94	1.21
Fe_2O_3	1.01	.62	.81
CaO	49.14	48.88	49.78
MgO	1.70	1.74	1.58
Ignition loss	40.02	39.30	40.96

A mill for the manufacture of natural cement was situated at the Chesapeake and Ohio Canal about one mile downstream from the old river bridge at Shepherdstown, West Virginia. The plant was started in 1888, but according to reports was never a financial success. Analyses of the limestone are (Mathews and Grasty, 1909, p. 428):

ANALYSES OF NATURAL CEMENT ROCK, SHEPHERDSTOWN

SiO_2	15.89	17.84
Al_2O_3	5.58	4.60
Iron Oxides	1.74	1.70
$CaCo_3$	52.74	58.25
$MgCO_3$	19.06	11.16
$Na_2O + K_2O$	4.92	3.26

A large quarry used to be operated by S. P. Angle at the intersection of the Western Maryland Railroad and the Cumberland Valley Railroad at Hagerstown before the area was engulfed by the city. The stone was used largely for ballast and road metal. The range in analyses of this stone is (Mathews and Grasty, 1909, p. 413):

RANGE IN ANALYSES OF LIMESTONE AT HAGERSTOWN

SiO_2	4.28–16.04
Al_2O_3	0.90– 5.27
Fe_2O_3	0.33– 1.65
CaO	41.30–52.29
MgO	0.32– 2.01
Ignition loss	33.82–41.10
$CaCO_3$	73.70–92.40

The variability shown in the analyses is due to interbedding of siliceous limestone beds, shaly partings, and dolomite layers.

The Conococheague has been used as building stone in many of the old farm houses and bridges, but is now largely used locally for road metal and ballast.

Beekmantown limestone

The Beekmantown consists of more massive and finely laminated beds usually high in magnesia and silica. The largest part of the Valley is underlain by Beekmantown limestone on both sides of the shale belt. Several localities have been prospected for high quality stone but no large scale operations have been undertaken.

Near Williamsport analyses were made from samples taken east of the railroad station because the close proximity of shale and limestone suggested the possibility of cement making (Mathews and Grasty, 1909, p. 413).

ANALYSES OF BEEKMANTOWN LIMESTONE EAST OF WILLIAMSPORT STATION

SiO_2	6.04	4.46
Al_2O_3	1.29	2.13
Fe_2O_3	.58	.97
CaO	49.68	47.55
MgO	2.60	2.73
Ignition loss	40.65	41.44
$CaCO_3$	88.40	84.60

Samples were taken also about 1 mile west of Pinesburg Station as a prospect for cement making (Mathews and Grasty, 1909, p. 416).

ANALYSES OF BEEKMANTOWN LIMESTONE WEST OF PINESBURG STATION

	MIN.	MAX.	AVERAGE OF 21
SiO_2	2.23	16.20	6.86
Al_2O_3	.12	4.27	1.57
Fe_2O_3	.16	1.28	.62
MnO	.04	.23	.12
CaO	34.53	52.25	46.62
MgO	.65	15.99	3.33
$K_2O + Na_2O$	.09	2.85	.92
Ignition loss	33.89	44.07	39.33

Another prospect for cement making is near the railroad bridge across the Potomac River south of Williamsport from which five analyses are available (Mathews and Grasty, 1909, p. 416).

ANALYSES OF BEEKMANTOWN LIMESTONE NEAR WILLIAMSPORT

	MIN.	MAX.	AVERAGE
SiO_2	4.00	10.80	6.66
Al_2O_3 / Fe_2O_3	1.40	3.80	2.82
CaO	43.60	50.20	48.52
MgO	1.19	4.13	2.04
Ignition loss	38.68	40.77	40.24

These analyses are similar to those west of Pinesburg Station.

The only active quarry in the Beekmantown limestone is south of Williamsport and owned by Joseph H. Forsyth. The entrance to the quarry is in the Stones River formation. The beds are vertical. The location is ideal for a study of the Stones River and Beekmantown beds.

The Beekmantown formation occupies such a large part of the Hagerstown Valley floor that it would not be difficult to locate commercial limestone quarries at many localities.

Stones River formation (*St. Paul*)

This formation has been distinguished by some beds of especially high grade limestone which are suitable for metallurgical stone. To the southwest in West Virginia the upper portion of the formation attains considerable thicknesses and is mined because of its purity.

There are several belts of Stones River limestone adjacent to the Chambersburg limestone and Martinsburg shale. At some localties it is faulted out, however, and the Beekmantown is in direct contact with the shale.

The high grade stone is mostly a gray to dove-colored smooth velvet-like stone without laminations or yellow layers, but in part it is crystalline. It makes up the upper portion of the Stones River formation.

The only sizable operation used to be at Pinesburg Station where high grade stone was quarried between the river and the Western Maryland Railroad. At this locality the calcium carbonate content runs as high as 97.9 percent. Typical analyses are:

ANALYSES OF STONES RIVER LIMESTONE

SiO_2	.60	.80	.80
Al_2O_3 / Fe_2O_3	.96	1.00	1.20
CaO	55.00	54.50	53.00
MgO	—	—	2.06
Ignition loss	42.90	42.88	43.40
$CaCO_3$	97.90	97.40	94.30

The above analyses are only from the top of the formation. The average of 20 analyses of the whole formation are less favorable and as follows:

ANALYSES OF STONES RIVER FORMATION

	MIN.	MAX.	AVERAGE OF 20
SiO_2	.60	12.70	4.96
Al_2O_3 / Fe_2O_3	.96	4.40	1.61
CaO	55.00	30.59	44.47
MgO	.69	16.67	3.97
Ignition loss	25.69	43.40	36.36
$CaCO_3$	54.50	97.90	79.20

These analyses show that quarrying and prospecting for high grade stone has to be very selective and certain beds only can be worked. That this can be done profitably is clearly shown by the operations at Martinsburg where only the best layers are extracted.

Chambersburg formation

The formation consists of more or less pure argillaceous limestones and calcareous shales. It is of little economic significance except for local road building and repair. It has never been used industrially. Its composition may, however, be suitable for cement manufacturing.

WESTERN WASHINGTON COUNTY

Two formations are calcareous and have been used in the past, the Helderberg and Tonoloway limestones.

Aside from a number of local stone quarries, a natural cement plant was formerly operated west of Hancock at Roundtop on the Chesapeake and Ohio Canal.

Today only the lonely smokestack reaches above the railroad tracks at Roundtop to bear witness to the skill of the craftsmen who built it. The brickwork is as good as in any newly built piece of masonry and it may be a long time before this last witness of a thriving industry disappears. The canal is overgrown with sizable trees and many of the mine openings have collapsed though some tunnels are still visible above the railroad tracks. A picture of the mill was published by Mathews and Grasty (1909, Plate 23, figure 2).

Analyses of the "cement beds" in the Tonoloway limestone are:

ANALYSES OF CAYUGA LIMESTONE
Round Top Natural Cement Company

SiO_2	20.16	19.81	27.10	26.07
Al_2O_3	6.34	7.35	1.50	11.40
Fe_2O_3	1.36	2.41		3.17
CaO	28.56	35.76	36.40	23.05
MgO	2.07	3.18	2.52	3.44
Ignition loss	31.74	30.29	31.16	25.94
$CaCO_3$	50.90	63.80	64.70	50.00

The Round Top plant burned down in 1903, but was rebuilt with a daily capacity of 300 barrells. The first cement was made here in 1837.

The excellent Helderberg section opposite Great Cacapon at Dam No. 6 or Tonoloway Station was considered a favorable site for a cement plant by Mathews and Grasty who gave the following analysis of the "cement rock" beds (1909, p. 437):

ANALYSIS OF HELDERBERG LIMESTONE, DAM NO. 6
East of Woodmont Station

SiO_2	21.72
Al_2O_3	5.88
Fe_2O_3	1.85
CaO	36.91
MgO	2.10
Ignition loss	30.91
$CaCO_3$	65.00

The report on the limestones of Maryland includes a table with 141 analyses of Washington County limestones (Mathews and Grasty, 1909, pp. 438–443).

Limestone-using industry

Mathews and Grasty list 28 active quarries in Washington County in 1909. Today there are only 3: Security, Williamsport, and a small lime-burning plant on Conococheague Creek. Some limestone is produced by the Maryland Penal Farm for its own use.

North American Cement Corporation

The Security plant was completed and put in operation by the former Security Cement and Lime Company in the summer of 1908. The plant was constructed by the Maryland Portland Cement Company which combined in the fall of 1909 with the Berkeley Lime Company of West Virginia. The plant capacity was then 2400 barrels a day.

The plant is located 2 miles east of Hagerstown on the south side of the Western Maryland Railroad. The quarry is located on the north side and connected with the plant by conveyors.

The stone at the open-pit quarry is drilled with blast hole drills, blasted with dynamite, and loaded on trucks with electric shovels. The daily output is about 2500 tons.

The stone produced for commercial stone is crushed and screened for size.

The stone used to produce portland cement is crushed in a jaw crusher and a hammer mill, dried, crushed in a second hammer mill, blended with a shale (purchased), and pulverized in grinding mills. After storage in tanks and testing by the laboratory, the dry raw mix is burned in rotary kilns at 2700 degrees F. Pulverized coal is used for burning.

During the burning in the rotary kilns, the potash in the raw mix is volatilized, and is collected in cyclones and electric precipitators. This material is a by-product and is sold as potash liming material.

The burned material as it leaves the kilns, in the form of cement clinker, passes through a cooler and then is ground into cement. During the grinding a small amount of gypsum rock (purchased) is added. The final grinding mills are in closed circuit with air separators, which maintain the high degree of fineness required. The finished cement is stored in silos. The entire process is under the quality control of the laboratory.

An important product of this plant, next to portland cement, is mortar cement. The materials for mortar cement, one of which is portland cement, are weighed, blended and ground in a grinding mill.

The daily capacity of the plant is approximately:

1000 tons commerical crushed stone
5000 barrels portland cement (including portland cement used in making mortar cement)
2400 barrels mortar cement
20 tons potash liming material

Joseph H. Forsyth

The Forsyth property at Williamsport, a stone quarry south of Williamsport at the river's edge, produced approximately 18,000 tons of crushed stone in 1949. The quarry is entirely in Beekmantown limestone which it enters at river level. The quarry face is 60 feet high and the overburden is up to 25 feet in places. The stone is crushed in the quarry and sold locally and delivered by truck.

Schetromph Lime Company

On Conococheague Creek, the Schetromph Lime Company burns lime in small quantities in draw kilns. The company produces approximately 1500 tons of burned lime annually.

Potentially, Hagerstown Valley could well be an area of intensive limestone production. The decline of small enterprises indicates a trend which is observed everywhere. Profitable quarrying is only possible if large quantities of stone are handled which calls for efficient machinery with considerable capital investment.

MARL

BY JOSEPH T. SINGEWALD, JR.

The marl occurring in Washington County is calcium carbonate marl. It is a loose, soft, earthy material, fine-grained to more or less granular in texture, containing variable amounts of coarser concretionary masses ranging in size from small pebble-like fragments to large irregular masses. Its chemical composition and physical character make it useful in agriculture as a substitute for ground or pulverized limestone.

Origin of Marl

Surface and underground waters flowing over and through limestone dissolve the limestone and carry the lime in solution as calcium bicarbonate. Carbon dioxide in solution in the water combines with the calcium carbonate of the limestone to form the soluble calcium bicarbonate. When the waters containing the soluble calcium bicarbonate are subjected to physical and chemical conditions that cause them to lose carbon dioxide, the insoluble calcium carbonate is again precipitated.

Many of the smaller streams in the Hagerstown Valley have their source and their course entirely within the broad limestone areas of the valley, and are fed largely by spring waters that have flowed underground through those limestones. These surface waters are charged with calcium bicarbonate. Under favorable conditions the calcium bicarbonate breaks down to the insoluble calcium carbonate which accumulates to form the marl deposits.

The processes that formed the marl deposits are essentially the same as those that formed the limestones from which their calcium carbonate was derived. Physical conditions played a role through evaporation and rise in temperature when the waters were ponded along stream bottoms or in broad shallow sink hole depressions. That biochemical processes played an important part in the extraction of the calcium carbonate from the waters is evident from the algal texture in the marl nodules and the intricate network of hollow tube-like concretions throughout the marl, representing incrustations around former blades of grass and stems of plants. Much less abundant than the products of lime secreting and extracting plant life are those of lime extracting animal life. However, abundantly distributed through the marl are the shells of fresh-water snails and clams that lived in the waters. Species collected from Washington County marl pits identified by Dr. H. E. Vokes are the snails *Physa* species and *Planorbis* sp. and the clam *Sphaerium* cf. *simile* Lamarck. Land snails that were doubtless washed into the marl as it was forming are likewise abundant. Dr. Vokes identified shells of the land snails *Polygyra albolabris* Say, "*Pyramidula* (*Patula*)" *alternata* Say, and ? *Stenotrema* sp.

Most of the marl deposits are found in flat flood plain areas along present streams, suggesting they are deposits formed during the present physiographic stage of those streams. That they in part at least are much older is indicated by the topographic position of the deposit of the Maryland Lime and Fertilizer Corporation on the Western Maryland Railroad, 4 miles southwest of Hagerstown.

Chemical Composition of Marl

Marl consists of the precipitated calcium carbonate, silt and mud deposited with the calcium carbonate, and residual organic matter. Due to its loose and porous texture it carries a large proportion of water. The chemical analysis of marl varies according to the proportions of these constituents present in a deposit.

The range in chemical analyses of raw marl produced in Washington County is relatively small according to the analyses published in the August 1950 report of the Maryland Inspection and Regulatory Service, College Park, and much less than the range in analyses of pulverized limestone published in that report. The range and average of the raw marl analyses are:

	MINIMUM	MAXIMUM	AVERAGE
	per cent	*per cent*	*per cent*
CaO	39.40	42.50	40.25
MgO	0.18	0.25	0.22
Insol.	1.40	5.52	3.07
Water	19.67	24.21	22.01

The organic content of 10 marl samples ranged from 1.35 per cent to 3.00 per cent, and averaged 2.32 per cent. The average composition of the raw marl produced in Washington County, calculating its lime and magnesia in calcium carbonate and magnesium carbonate equivalents and adding the average organic matter content, is:

$CaCO_3$	71.88 per cent
$MgCO_3$	.46
Insoluble	3.07
Organic matter	2.32
Water	22.01
	99.74

Converting this average raw marl analysis into a water and organic matter free basis, the average composition of the actual marl substance is:

$CaCO_3$	95.32 per cent
$MgCO_3$	.61
Insoluble	4.07
	100.00

The average percentage of insoluble matter is essentially the same as the average insoluble content of ground limestone and in both cases it is the silt and clay deposited with the precipitated calcium carbonate.

Use of marl

The function of marl in agriculture is identical with that of pulverized limestone. The choice of one or the other need be determined only on the basis of cost on the fields of an equivalent amount of calcium carbonate. In general, one has to spread 4 tons of raw marl for the same effect as the spreading of 3 tons of pulverized limestone.

The current price of raw marl is $3.00 to $3.10 per ton. Two Washington County operators dry the marl in rotary dryers to drive off water. The kiln-dried marl has a higher calcium carbonate content and sells for $3.50 per ton.

Prospecting for marl deposits

The formation of a marl deposit of commercial grade depends on three essential conditions: (1) surface waters rich in calcium bicarbonate, (2) topographic environment favorable to the physical and biochemical processes that precipitate the calcium carbonate, and (3) topographic environment unfavorable to the simultaneous deposition of silt.

These conditions are occasionally met at or in the vicinity of the orifice of a large spring. More commonly, they are met along the flood plains of streams whose entire course is in limestone and which accumulate relatively little silt. These streams are often fed by a large spring not far upstream from the marl deposit. A low flat area along the smaller streams in the Hagerstown Valley is the most likely location for a marl deposit. The marl deposits are usually covered by only a few inches of soil and their presence is often revealed when such flat areas are ploughed by the ash-gray color and granular texture of the sub-soil. The area underlain by marl and the character and quality of the marl is easily determined by prospecting with a clay auger or post-hole digger.

The area of marl deposits ranges from a few acres to tens of acres. Very little information is available concerning the thickness or depth of the marl deposits. Because of the porosity of marl, the chief diluent is water. Operations in marl pits have been confined to above water level and hence have been limited to maximum depths of 10 to 12 feet. This limitation is essential in an operation producing only sun-dried raw marl. Some of the operators report a depth of as much as 30 feet, but such thicknesses are probably very local and exceptional in view of the small size of the streams along which the marl deposits are found.

Operation of marl deposits

The Washington County marl pits are operated with mechanical equipment. The overlying soil is removed to expose the desired area of marl. A layer of marl is then loosened with a mechanical scraper and allowed to sun dry. The sun-dried marl is collected with mechanical dirt-moving equipment and conveyed to a loading dock where it is usually screened to remove the larger lumps and concretions and dumped into trucks for transportation. The smaller pits are operated only intermittently to fill current orders.

The plants using dryers run the product through a hammer mill and thence to a storage bin from which orders are filled.

Marl producers in Washington County

Three of the six marl operations in Washington County are on marl deposits that extend along Marsh Creek for a distance of more than two miles from below Grimes to a half mile northeast of Spielman on the branch of Marsh Creek that heads near Lappans. Another operation is on Downey Creek, 1 mile southwest of Downsville. One of the two largest operations is at the crossing of the Hopewell Road and the Western Maryland Railroad, 4 miles southwest of Hagerstown. The newest operation is on Landis Spring Branch, one half mile east of old U. S. 40 and 1 mile southwest of Pleasant Hill on new U. S. 40.

Eastern Lime Marl and Fertilizer Company.—The plant is located at Grimes Station on the Norfolk and Western Railway, and the marl pit on the west side of Marsh Run north of the plant. The pit covers an area of about 3 acres. The operation was acquired by the present owners in 1949 from Peter Ruffner.

The plant is equipped with an oil-fired rotary dryer and hammer mill with a capacity of 15 to 20 tons per hour and a storage bin with a capacity of about 1200 tons. The kiln-dried marl is sold under the trade name P. A. L. M. (Process Activated Lime Marl).

W. J. Hilliard.—The Hilliard marl pit in on the west side of Marsh Run about midway between Grimes and Spielman. It is served by a lane from Spielman. The pit covers an area of about 3 acres and has reached a maximum depth of about 12 feet. It has been in operation about 4 years.

Paul R. Metz.—The marl pit is at Grimes on the east side of the branch of Marsh

Run that heads near Lappans and on the south side of the road between Spielman and Fairplay. The pit has an area of less than two acres, but marl is exposed for some distance along this branch of Marsh Run on the north side of the road. It has been in operation about 2 years.

Henry Dellinger.—The Dellinger marl pit is on the east side of the road to Cedar Grove Mill at the road fork one mile southwest of Downsville on the east side of Downey Branch. It occupies a triangular area of about 1½ acres and has been in operation about 2 years.

Maryland Lime and Fertilizer Corporation.—This plant is on the south side of the Western Maryland Railroad and on the west side of the Hopewell Road, one mile northwest of Halfway and 4 miles southwest of Hagerstown. It appears to be the oldest marl operation in Washington County and was acquired by the present operators in 1948 after the older plant was destroyed by fire. It is equipped with a rotary dryer, hammer mill, and storage bins. The burnt pulverized marl is screened to 87 per cent under 20 mesh and 60 per cent under 100 mesh and the moisture is reduced to raise the lime content (CaO) to 52 per cent. It is marketed under the trade name Green Thumb marl.

The marl pit covers an area of about 4 acres. The topographic position of this deposit differs from that of the other marl pits. It lies on a terrace above the level of the nearby stream and without relation to the present course of the stream The marl has also larger and more abundant masses of hard travertine and includes residual masses of limestone. It is probably not the product of a recent stream. The greater abundance of travertine and indurated masses may in part be the result of long-continued solution and redeposition of earthy marl, but the abundance of residual masses of limestone make it more likely that the deposit was formed in the immediate vicinity of the outlets of now extinct springs rather than along the flood plain of a stream.

Samuel S. Adams.—The Adams marl pit is on the west side of Landis Spring Branch and on the south side of the lane between U. S. 40 at Pleasant Hill and old U. S. 40. It has been operated only one year and the stripped area is less than one acre.

SHALE

Shales are abundant in the county and are used at many localities mostly from small openings for repair of county roads.

Only the brick plant of Victor Cushwa and Sons at Williamsport produces on a large scale.

This plant is equipped with 12 round beehive kilns, 30 and 33 feet in diameter, and has a capacity of 90,000 to 115,000 bricks. The burning time is 4½ to 5 days.

The plant is equipped to make extruded ware, brick of any kind of hollow ware, building tile, radial chimney blocks, and hollow facing tile. In addition, sand-molded ware is made in which bricks are produced by forcing soft plastic shale into sand-coated wooden molds. The bricks resemble the old hand-molded sand-mold bricks.

The quarry is located north of the Western Maryland Railroad tracks and connected with the plant on the south side by a conveyor system.

The plant produces about 100,000 bricks a day and uses about 3 tons of shale for 1,000 bricks or about 300 tons a day or 90,000 tons of shale a year. The shale is weathered Martinsburg shale. About 30,000 tons of shale are sold for other purposes like cement making. The Williamsport bricks are sold in large quantities in Baltimore and Washington where they are shipped by truck. Shipments to New England are not rare and some have been shipped as far as Venezuela.

BUILDING AND ORNAMENTAL STONE

In their report on Maryland mineral industries (1909, p. 128) Clark and Mathews state: "The blue and gray limestones of Paleozoic age have with one single exception never been quarried in Maryland as building stone except for local use." The same could be said today and cinder block-concrete construction and brick masonry have pretty well eliminated the use of limestone as building stone. Where the stone can be found nearby or on the building site it is used, and in ornamental buildings such as St. Pauls Church on U. S. 40 (Pl. 18, fig. 2), and similar buildings. The construction of the Penal Farm is a good example of use of local stone in combination with cheap labor (Pl. 19). Most of the canal aqueducts of the Chesapeake and Ohio Canal are limestone masonry built for the ages.

The use of limestone for fence and retaining-wall construction can be observed all over the county, but is usually a function of availability of stone in outcrops nearby or the blasting of limestone ledges for road building and re-location.

There are no quarries that specialize in building stone today and all uses are merely local and almost accidental. Many old bridges like the highway bridge across Antietam Creek or the old bridge at Wilson (Pl. 18, fig. 1) are of local limestone and are picturesque even if somewhat too narrow for present traffic. It is doubtful whether there will ever be an increased usage of hand-hewn stone except for special purposes or under specially favorable circumstances. The trend is to build houses with artificial stone like brick or cinder blocks with foundations only of natural stone ledges.

IRON ORE

INTRODUCTION

During the Colonial period Maryland's iron industry had gained considerable importance, but it declined due to the discovery of the huge ore bodies with which the Maryland deposits could not compete. The last furnace was given up in the beginning of this century.

Washington County participated in the iron production to a small extent. A full discussion of Maryland iron ores has been published in Volume IX of the Maryland Geological Survey (Singewald 1911, pp. 123–327) and only the part which deals with Washington County is briefly summarized here.

The iron ores occur in the form of magnetite (Fe_3O_4), hematite (Fe_2O_3), limonite ($Fe_2O_3 \cdot n\ H_2O$), and siderite ($FeCO_3$).

The ores of Washington County are limonites which were found associated with limestones and along zones where movements of rock masses have taken place. They occur above the Romney and Oriskany contact and at the Helderberg and Oriskany contact. Another group of ore bodies is in the Cambrian and Ordovician limestones.

ORISKANY-HELDERBERG LIMONITES

Two deposits are known from Washington County: one, 3 miles west of Hancock and another 2 miles northeast of Indian Springs at the foot of the west slope of Fairview Mountain. The former has never been worked.

Ore from the latter locality was shipped to the Green Spring furnace about 3 miles to the south. An analysis of this ore is:

Fe	36.20
SiO_2	37.06
Al_2O_3	7.96
Mn	trace
P	.63
S	.10
Ignition loss	9.58

The ore is a highly ferruginous ledge of conglomerate which consists in part of over 50 per cent limonite.

ROMNEY-ORISKANY LIMONITE

These ores were formed by replacement of limestone beds near the base of the Romney shale. The limestone beds are thin, not exceeding 6 inches, and the ores have been of little economic value. These ores attained their chief development in the North Mountain area southwest of Clear Spring where several ore bodies have been worked in the past. Here the ore occurs mainly along the contact between the Oriskany formation and the Romney shales. Singewald shows the locations of the old mines on a map (1911, p. 185).

An analysis of the ore shows good grade non-Bessemer ore:

Fe	45.79
SiO_2	18.37
Al_2O_3	3.98
Mn	little
P	.51
S	.10
Ignition loss	10.72

CAMBRO-ORDOVICIAN LIMONITE

Cambro-Ordovician rocks occur in eastern Washington County and the one of the most extensively worked iron-ore bodies in Maryland, the Maryland bank on the Potomac River northwest of Harpers Ferry, belongs to this group.

LIMESTONE-CONTACT DEPOSITS

Most numerous and largest are the limestone contact deposits, especially at fault contacts. Faulting produces shatter zones and fractures and gives more ready access for ore-bearing solutions and space for ore deposition. In Washington County there are several contact deposits of this kind.

Three miles north of Clear Spring a deposit has been worked for a short time on the Wilson Farm. An analysis of this ore was published by Singewald (1911, p. 191):

ANALYSIS FROM WILSON FARM

Fe	51.63
SiO_2	8.52
Al_2O_3	3.37
Mn	little
P	.99
S	.10
Ignition loss	11.77

Other ore bodies were opened on the east side of Hagerstown Valley: one mile south of Pondsville, two miles south of Pondsville on the road to Smoketown, and at the north end of Appletown about one mile south of Boonsboro.

A more important occurrence is the Maryland Bank on the north bank of the Potomac River one mile northwest of Harpers Ferry. This deposit ranked second only to the Catoctin deposit in Frederick County and it was one of the chief sources of ore for the Antietam furnaces and forge at the mouth of Antietam Creek. The ore occurs in the Tomstown limestone (formerly a part of the Shenandoah limestone) at a fault between Harpers shale and the limestone.

RESIDUAL DEPOSITS IN LIMESTONE

Only a few small deposits of this kind were worked in Hagerstown Valley: three miles northeast of Clear Spring, a mile and a half northwest of Boonsboro, at Boonsboro, one half mile west of Keedysville, and one mile southwest of Keedysville. None of these occurrences had great economic significance and the only present evidence of the existence are occasional scattered lumps of ore in the field and in the annals of history (Singewald, 1911, pp. 202–203).

MANGANESE

About three miles north of Harpers Ferry on the north bank of the Potomac River at the river bend is the old manganese mine of the Potomac Refining Company. A fault brings Harpers shale in contact with limestone, and the ore occurs along the fault and its accessory fractures.

The deposit was opened in 1876 and the ore was shipped on the Chesapeake and Ohio Canal. The openings went below the canal level and flooding of the workings caused suspension of operations. As late as 1908 attempts were again made to reach the ore (Singewald, 1928, pp. 192–194).

Analysis of the ore showed the following composition:

Mn	22.59
SiO_2	26.58
Fe	2.73
P	.37
S	.004

WATER RESOURCES OF WASHINGTON COUNTY

GROUND-WATER RESOURCES

BY

ERNST CLOOS

INTRODUCTION

A detailed ground-water investigation of Washington County has not been made as yet, but available records of wells and springs and the published geologic maps afford a basis for a general analysis of the occurrence of ground-water. Well records were compiled in the past by the Maryland Geological Survey and a general discussion of underground water resources of Maryland was published in 1918 (Clark, Mathews, and Berry, 1918). A list of wells is appended to this report.

The available records are somewhat incomplete. Though the reported depth of a well is usually correct, the reported yield is usually merely the capacity of the pump installed and not the capacity of the well. The actual capacity of a well may be much more than the reported yield.

Springs are the most important source of water in Washington County, especially in Hagerstown Valley, but little is known of their yield. Such localities as Big Springs, Indian Springs, and Clear Spring, indicate the importance of these springs during the early days of settling in the county.

Figure 40 shows the approximate configuration of the ground-water table in Hagerstown Valley. The relief is too rugged and the incision of the Potomac River Valley too deep for construction of a useful map of this kind for the western part of the County. In addition, the complex geologic conditions probably result in a number of separate ground-water reservoirs in that area. Also, as most of the local water demand is satisfied by springs, well data are rather scant.

VALUE OF GROUND-WATER

Water is by far the most valuable natural resource. To assume that water is available in unlimited quantities in all places is short-sighted. Accumulations of people in cities or of industries in given localities may increase the demand for water beyond the amount stored below the ground, making it necessary to seek additional sources of water. Thus the Washington, D. C., area drinks purified Potomac River water with additions from the Patuxent River. The City of Hagerstown also uses Potomac River water. Baltimore uses the Gunpowder River and is now adding the Patapsco to its reserves. Philadelphia uses the Schuylkill River and New York had to build long highly expensive aqueducts for its water supplies. The City of Los Angeles finally had to construct an aqueduct 260 miles long to tap the Colorado River.

If more water is taken out of a ground-water reservoir than can be replenished by precipitation, the water table will be lowered and contamination may occur, as, for instance, by infiltration of salt water near the ocean or of polluted surface waters.

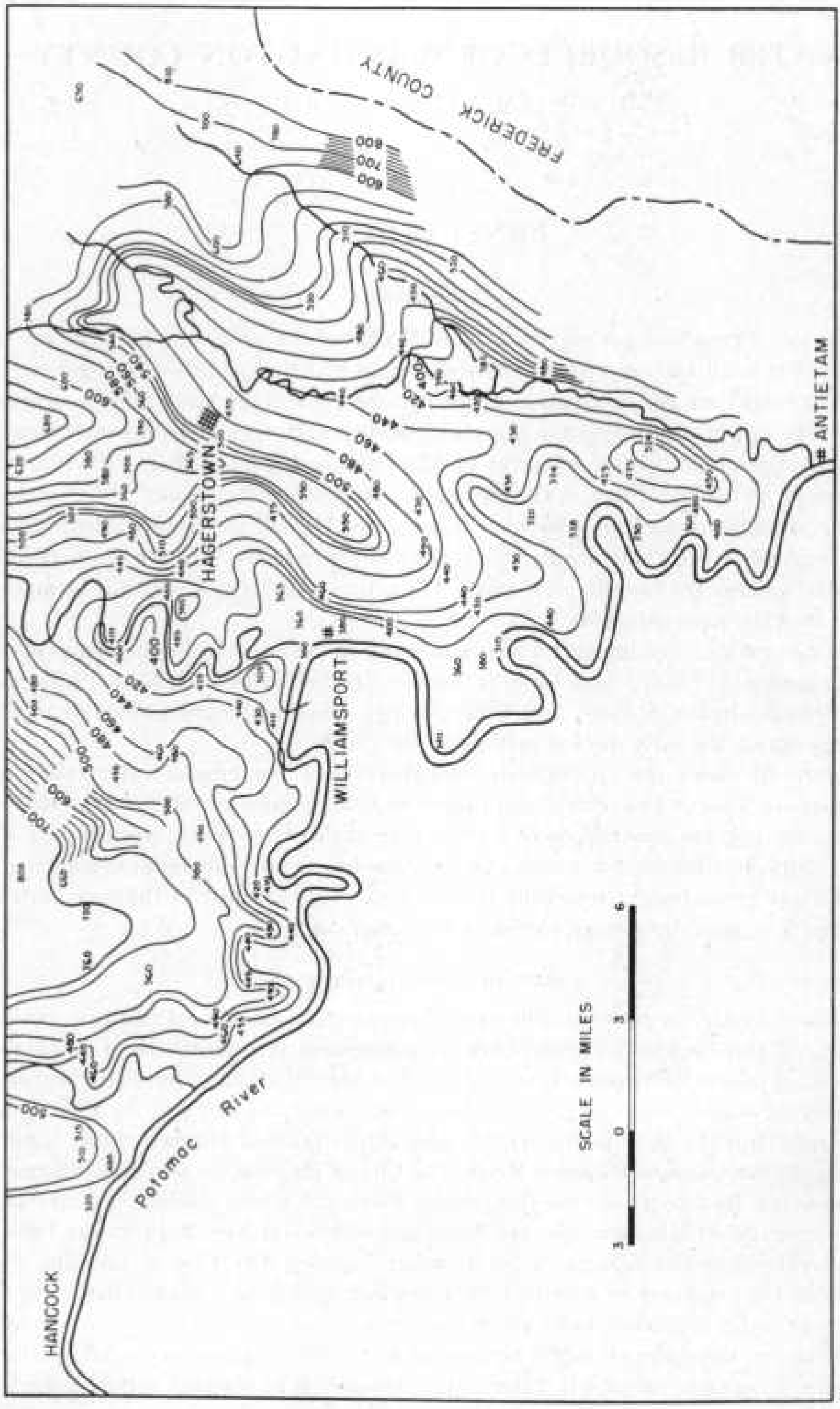

FIGURE 40. Map of Ground-water Table of Hagerstown Valley. Contours represent approximate elevation of water surface above sea level.

Such damage to ground-water supplies is not easily reparable. A ground-water reservoir is an invisible pool from which all users draw their supply. If it becomes contaminated by one it may be spoiled for all, and if it is overdrawn by one it may affect the supply for all. In order to use the limited supply intelligently, it is necessary to obtain all possible data on the depth and yield of the wells, the chemical quality of the water, the rate of recharge to the reservoir, and other hydrologic and geologic factors.

As the population of an area grows, the reserves of available ground-water are reduced proportionately.

RELATION OF GEOLOGY TO GROUND-WATER

Ground-water is retained in spaces underground and thus is directly related to the geology of an area. Spaces that contain ground water are pore spaces between sand grains or clay particles. In the first case the water can move readily due to the large size of the pores and permeability is high. In the second case, porosity may be just as high, but permeability so low that the friction of the water in the small openings retards movement. It is well-known that clay holds water well and can even be used for waterproofing. However, all rocks of Washington County have been folded and altered and most are well consolidated. These primary pore openings are mostly filled or cemented in the process of folding. Water in such rocks occurs and circulates in other openings such as fractures, cavities, and bedding planes. Thus the ground-water conditions in Washington County differ greatly from those in areas underlain by thick deposits of unconsolidated sand and clay, as in the Coastal Plain in eastern Maryland.

With respect to the ground-water distribution, the County consists of three distinctly differing parts: the western mountains beyond the Hagerstown Valley, Hagerstown Valley, and the western slope of South Mountain and Elk Ridge.

GROUND-WATER IN WESTERN MOUNTAINS

The western half of the county consists of shales, sandstones, and thin limestone beds in complex folds which are cut by the Potomac River valley. The depth to water-bearing zones is difficult to predict. That several zones exist is shown by the occurrence of springs at different levels. Most of the home consumption in this area is from springs, but there are also many shallow wells.

At Millstone, wells encounter water in the Jennings formation at various depths from 50 to 112 feet. Some wells obtain water from the Potomac River terrace deposits at shallow depths. Near Hancock water of varying qualities has been reached at depths ranging from 38 to 150 feet. A deeper well has been drilled at Hancock to 440 feet, passing through 400 feet of Romney shale. The well was cased to 430 feet and the bottom 10 feet seem to be in a porous sandstone below the Oriskany formation. The water level is within 9 feet of the surface and the well yields 200 gallons a minute. Several wells near Hancock have reached depths of 200 feet or more and yield considerable quantities of water.

The town water supply at Clear Spring is spring water which is piped from the eastern slope of Fairview Mountain. A typical water analysis as furnished by the

State Board of Health is:

pH	7.2
	parts per million
Total solids	130.0
SiO_2	3.2
Iron	0.1
Calcium	32.0
Magnesium	0.6
Carbonate	0.0
Sulphate	3.5
Chloride	3.1
Nitrate	0.18
Total hardness	123.0

GROUND-WATER IN HAGERSTOWN VALLEY

The valley floor is a gently southward dipping undulating surface. The map (Fig. 40) shows the stations at which information is available, and the configuration of the water table. Where the ground-water level intersects the surface, springs appear.

The strong flow of some of these springs seems to indicate a system of communicating openings through which the water can flow at a relatively high rate.

The water table is higher in the center of the valley and slopes toward Conococheague and Antietam Creeks and Potomac River. It forms a rather smooth broad pillow of water and its level can be quite well predicted from Figure 40. The probable depth of a well is the difference between the water table contour and the land elevation at the well location.

The valley is underlain by limestones which are intensely folded, faulted, and fractured. Wells that penetrate only solid limestone will have a very small yield, but if cavities and fractures are encountered the yield may be large. This variation is discussed in the report on ground-water by the Maryland Geological Survey (Clark, Mathews, and Berry, 1918, p. 463) where the erratic behavior of wells at Hagerstown is described.

WELLS AT HAGERSTOWN

OWNER	DEPTH	WATER LEVEL	YIELD
	feet	*feet below surface*	*gals. per min.*
J. C. Roulette & Son	920	near surface	1
	281	60	18
Hagerstown Table Co.	500	60	56
	281		
	323		
	325		
	323	160	18
	325	275	200
	325	275	116
Hagerstown Brewing Co.	120		150
	137		200
Terminal Ice Co.	193	40	180
	160	154	150

The table shows that the yields of wells cannot be predicted, but depend on the nature of the openings in the rocks penetrated by the drill.

A typical chemical analysis of water from the Hagerstown Valley area is that from the spring at St. James School.

(Except for pH, all values are shown in parts per million)

Chloride	11.0
Nitrate	0.08
Total solids	352.0
Iron	0.2
Total hardness as $CaCO_3$	265.0
M.O. alkalinity	227.0
Magnesium	9.0
Calcium	100.0
SiO_2	25.0
Sulfate	32.0
Manganese	0.0
Aluminum	1.6
pH	7.2

GROUND-WATER ON THE SLOPES OF SOUTH MOUNTAIN

The western slopes of South Mountain and Elk Ridge are in an area of intensely dislocated and fractured shales and sandstones. Numerous springs emerge at contacts of shale and sandstone along the foot of the mountains. Most of the communities, like Boonsboro and Smithburg, draw their water supply from springs.

A water analysis of the Cronise Spring at Boonsboro is:

pH	6.0
	parts per million
Chloride	6.3
Nitrate	0.5
Total solids	62.0
Iron	0.2
Hardness as $CaCO_3$	17.0
Total alkalinity	12.0
Sulfate	8.4
Silica (SiO_2)	26.0
Calcium	2.4
Magnesium	0.24
Carbonate	0.0
Aluminum	2.0

DEPTH AND YIELD OF WASHINGTON COUNTY WELLS

Table 6 gives the records of wells that have been drilled since July 1, 1945, and the records of a number of wells that were drilled prior to 1945.

Nearly all of the wells drilled since 1945 are domestic and farm wells, so that the reported yield may be considerably less than the actual capacity of the well. The only well in this group for which a large yield is reported is that of the Potomac Creamery Company, Inc., permit number 5793. This well is not included in the following analysis of the depth and yield of the wells drilled since 1945. These wells include 260 located in the Hagerstown Valley, 39 in the mountain area west of the Hagerstown Valley, and 11 in the mountain area east of the Hagerstown Valley.

SUMMARY OF REPORTED YIELDS IN HAGERSTOWN VALLEY

	NUMBER OF WELLS, WITH RANGE IN DEPTH, IN FEET				
	Less than 100	100–200	200–300	More than 300	Total
Less than 2 g/m	1	8	5	2	16
2 to 5 g/m	39	25	6	2	72
5 to 20 g/m	127	27	3		157
20 to 50 g/m	13	2	0		15
Total	180	62	14	4	260
Average reported yield	12 g/m	7 g/m	4 g/m	2.5 g/m	

About 70 per cent of farm and domestic wells in the Hagerstown Valley are less than 100 feet deep and 90 per cent are less than 200 feet in depth. The average reported yield decreases with each 100 feet in depth.

SUMMARY OF REPORTED YIELDS IN WESTERN MOUNTAIN AREA

	NUMBER OF WELLS, WITH RANGE IN DEPTH, IN FEET		
	Less than 100	100–200	Total
Less than 2 g/m	0	1	1
2 to 5 g/m	4	4	8
5 to 20 g/m	24	4	28
20 to 50 g/m	2	0	2
Total	30	9	39
Average reported yield	12 g/m	6 g/m	

In the western mountain area 77 per cent of the wells are less than 100 feet in depth and all are less than 200 feet deep. The average reported yield of the wells less than 100 feet deep is twice the average reported yield of those more than 100 feet deep.

SUMMARY OF REPORTED YIELDS IN EASTERN MOUNTAIN AREA

	NUMBER OF WELLS, WITH RANGE IN DEPTH, IN FEET			
	Less than 100	100–200	200–300	Total
Less than 2 g/m	1	0	1	2
2 to 5 g/m	2	0	0	2
5 to 20 g/m	6	1	0	7
Total	9	1	1	11
Average reported yield	9 g/m	10 g/m	1 g/m	

The number of wells drilled in the eastern mountain area is too small to make percentages and average reported yields significant. However, in this area over 80 per cent of the wells are less than 100 feet deep.

The reported yields of large commercial wells more nearly approach the actual capacity of those wells. In Table 6 are nine wells with reported yields of more than 50 gallons per minute. Eight of these wells are at Hagerstown and one is in the eastern mountain area at Highfield. Their geographic restriction is of no significance other than that they are located where there is demand for large industrial wells. One of the wells is less than 100 feet deep, two are between 200 and 300 feet deep, and six are between 100 and 200 feet deep. Table 6 lists only four wells deeper than 300 feet. Three of these wells ranging from 323 to 347 feet in depth have reported yields of 18, 18, and 10 gallons per minute. The fourth with a depth of 910 feet has a reported yield of only 1 gallon per minute.

Since the subsurface geology of Washington County is such that groundwater occurs in fractures, along bedding beds, and in solution channels, one cannot predict in advance of drilling the necessary depth or the yield of a well. The record of wells actually drilled during the last five years records the experience that an ample and satisfactory supply for farm and domestic use is usually obtained at a depth of less than 100 feet and that it is rarely necessary to drill deeper than 200 feet. The record of industrial wells is that a large yield is more likely to be encountered at less than 300 feet than below 300 feet, and that between 100 and 200 feet is the more favorable depth range for large yields.

TABLE 6

RECENT WATER WELL RECORDS IN WASHINGTON COUNTY

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
71	Litten, W. E.	Lydia	1945	40	6	25	
73	Ridenour, C. H.	Hagerstown	1945	70	6	15	30
84	Western Md. R. R.	Williamsport	1945	57	6	50	20
85	Snyder, Frank	Chewsville	1945	47	6	50	
91	Meyer, M.	Hagerstown	1945	35	6	10	
92	Diebert, Chas. E.	Williamsport	1945	43	6	5	23
109	Hoover, L. R.	Chewsville	1945	65	6	8	12
110	S. P. C. A.	Hagerstown	1945	160	6	2½	60
184	Secrest, D. S.	Clear Spring	1945	150	6	2	28
264	Metz, Victor M.	Spielman	1945	60	6	20	17
270	Durbin, Joseph L.	Hagerstown	1945	80	4½	35	18
274	Cavanaugh, C. E.	Fairplay	1946	250	4	1½	45
298	Docksteder, E. S.	Hagerstown	1946	88	90	12	24
299	Robison, B. W.	Hancock	1946	63	4½	20	20
300	Daniels, Roy M.	Hancock	1946	150	4½	6	60
311	Miller, W. D.	Hagerstown	1946	76	6	8	47
312	Harrup, K. Obie	Williamsport	1946	46	6	15	24
313	Sprecker, T. W.	Williamsport	1946	82	6	5	30
314	Laell, Ch. W.	Hagerstown	1946	63	4½	13	22
315	Buchanan, C. J.	Hagerstown	1946	84	4½	10	35
316	Swadley, J. O.	Hagerstown	1946	75	5	8	15
342	Pey, G. R.	Keedysville	1946	75	5	15	66
370	Burgan, R. F.	Hagerstown	1946	60	6	20	28
387	Miner, H. C.	Williamsport	1946	85	6	10	20
388	Myers, R. E.	Hagerstown	1946	70	6	20	36
389	Huffman, E. W.	Hagerstown	1946	60	6	25	37
405	Grim, E. J.	Sharpsburg	1946	75	6	5	62
406	Risser, L. E.	Hagerstown	1946	180	6	8	20
407	Smith, W. C.	Clear Spring	1946	200	5⅝	8	50
408	Carpenter	Hagerstown	1946	55	5	30	15
416	Sprecher, L. K.	Hagerstown	1946	73	6		36
425	Doub, G. D.	Williamsport	1946	76	8–5⅝	6	28
430	Baer, C. D.	Smithsburg	1946	213	8–5⅝	5	121
438	Leatherman, W. B.	Emmertsville	1946	90	8–6	15	44
439	Myers, B. L.	Funkstown	1946	115	5⅝	10	—
463	Kline, William	Big Pool	1946	73	8–6	25	37
475	Thompson, H. R.	Cavetown	1946	85	8–6	12	52
512	Brown, J. M.	Williamsport	1946	60	5⅝	15	19
557	Petre, L. J.	Downsville	1946	244	5⅝	1¼	119
569	Cavender, F. R.	Hagerstown	1946	196	8–6	6	66
570	Smith, Fred	Cavetown	1946	75	8–6	6	—
593	Burleron, A. C.	Hagerstown	1946	120	6	5	—
594	Gehr, Russell	Clear Spring	1946	146	6	5	—
599	Miller, E. S.	Hagerstown	1946	61	6	20	—
601	Calhert, H. B.	Williamsport	1946	80	6	7	—
605	Stonebraker, John	Lydia	1946	64	5⅝	12	29
609	Woodmont Rod & Gun Club	Hancock	1946	175	6	15	65

TABLE 6—*Continued*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
632	Martz, E. E.	Mapleville	1946	200	6	1	75
634	Myers, R. E.	Big Spring	1946	72	5⅝	5	—
648	Garver, L. K.	Wilson	1946	44	5⅝	10	14
649	Huffman, D. M.	Huyett	1946	51	6	12	24½
658	Spessard, Walter	Cavetown	1946	150	5⅝	6	—
672	Pentecostal Assembly of God	Williamsport	1946	56	5⅝	20	—
673	Fox, O. D.	Funkstown	1946	48	5⅝	5	28
685	Nally, G. F.	Downsville	1946	76	5⅝	10	26
686	Nally, W. F.	Downsville	1946	85	5⅝	5	25
687	Donegan, Mrs. Frances	Hancock	1946	75	6	20	35
697	Feigley, R. D.	Huyett	1946	85	5⅝	15	42
718	Caspar, J. P.	Hancock	1946	79	5⅝	10	—
720	Showalter, M. W.	State Line	1946	35	6	5	—
730	Moore, C. W.	Dargan	1946	60	5⅝	5	30
731	Miller, L. A.	Dargan	1946	73	5⅝	5	45
752-A	Warrenfeltz, H. L.	Hagerstown	1946	142	5⅝	6	90
776	Dillion, R. S.	Hancock	1946	60	6	20	21
798	Cline, R. T.	Clear Spring	1946	75	5⅝	5	—
819	Ridgely, R. D.	Halfway	1946	84	6	5	—
831	Shifflett, Ira	Hancock	1946	117	5⅝	4	75
839	Shockey, P. R.	Hagerstown	1946	120	5⅝	5	—
857	Hastings, L. B.	Wilson	1946	90	6	10	60
878	Knight, George	Hancock	1946	82	5⅝	5	50
886	Mizell, R. F., Jr.	Big Pool	1946	150	8–6	2	—
924	Eshelman, John	Hagerstown	1946	100	5⅝	6	—
962	Wolford, Marion	Broadfording	1946	65	6	2	—
963	Wolford, H. I.	Broadfording	1946	68	6	5	—
972	Shockey, Amos	Smithsburg	1946	78½	6	10	53
973	Myers, Howard	Clear Spring	1946	205	6	3	3
1034	Lloyd, B. L.	Hagerstown	1947	80	6	10+	65
1042	Day, G. W.	Hagerstown	1947	79	5⅝	10	—
1048	Schomel, G. C.	St. James	1947	124	5⅝	5	8
1054	Mummart, E. M.	Big Pool	1946	65	6	8	—
1059	Carbaugh, H. L.	Hagerstown	1946	155	5⅝	½	30
1074	Harbaugh, Harry	Hagerstown	1947	127	6	6+	80
1091	Pollock, P. H.	Hagerstown	1947	87	5⅝	5	—
1096	James, Frank	Williamsport	1947	80	5⅝	6	55
1192	Montgomery, Henry	Huyett	1947	47	6	6	—
1195	Athey, H. E.	Keedysville	1947	57	5⅝	10+	25
1211	Sperow, J. W.	St. James	1947	143	6	10	—
1212	Leatherman, Chas.	Smithsburg	1947	47	5⅝	5	28
1233	Murphy, Mrs. E. L.	Smithsburg	1947	122	5⅝	10+	82
1248	Day, D. A.	Hagerstown	1947	125	5⅝	1	90
1252	Hull, Richard	Hancock	1947	70	6	6	—
1253	Letter, D. E.	Clear Spring	1947	200	6	5	—
1254	Shoemaker, T. L.	Hancock	1947	65	6	4	—
1255	Hutson, C. L.	Big Pool	1947	72	6	10	20

TABLE 6—*Continued*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
1256	Murray, C. R., Jr.	Maugansville	1947	42	5	30	23
1257	Reid, Robert	Clear Spring	1947	77	6	20	30
1258	Deatrich, C. R.	Maugansville	1947	135	6	40	18
1262	Hurd, Edward	Security	1947	205	$5\frac{5}{8}$	3	165
1264	Eccard, Mrs. C. G.	Hagerstown	1947	86	$5\frac{5}{8}$	5	55
1270	Shoemaker, John	Boonsboro	1947	100	8	—	No water
1294	Banzhoff, R. V.	Williamsport	1947	100	6	5	—
1348	Karamonas, Anthony	Sharpsburg	1947	132	$5\frac{5}{8}$	2	30
1349	Heffmaster, Mrs. F. M.	Brownsville	1947	52	$5\frac{5}{8}$	4	22
1350	Abbot, Wilbur	Keedysville	1947	37	$5\frac{5}{8}$	6	—
1383	Bowers, Walter	Lappans	1947	55	$5\frac{5}{8}$	5	—
1391	Sier, Joseph	Boonsboro	1947	57	$5\frac{5}{8}$	10+	18
1426	Angle, Kenneth	Cearfoss	1947	68	$5\frac{5}{8}$	5	—
1450	Holder, E. J.	Sandy Hook	1947	70	6	10	—
1460	Richerds, G. D.	Weverton	1947	82	6	8	—
1509	Kirk, Lemuel	Hancock	1947	90	$5\frac{5}{8}$	9	—
1540	Lashley, George	Hancock	1947	113	$5\frac{5}{8}$	1	45
1665	Ward, R. L.	Hancock	1947	90	$5\frac{5}{8}$	10	30
1677	Easterday, John	Williamsport	1947	98	$5\frac{5}{8}$	5	65
1679	Price, C. H.	Hagerstown	1947	75	$5\frac{5}{8}$	5	30
1703	McVean, W. G.	Hagerstown	1947	49	$5\frac{5}{8}$	8	—
1709	Malatt, Earl	Downsville	1947	74	$5\frac{5}{8}$	5	7
1714	Wade, B. A.	Hagerstown	1947	70	$5\frac{5}{8}$	12+	47
1730	Wilkinson, R. F.	Hagerstown	1947	99	$5\frac{5}{8}$	12	35
1731	Nortz, W. H.	Hagerstown	1947	65	$5\frac{5}{8}$	8	—
1744	Johnson, C. D.	Hagerstown	1947	65	$5\frac{5}{8}$	6	45
1745	Flory, Charles	Williamsport	1947	55	$5\frac{5}{8}$	4	25
1754	Cool, Maurice	Smithsburg	1947	146	$5\frac{5}{8}$	6	—
1764	Reese, M. E.	Funkstown	1947	105	$5\frac{5}{8}$	6	—
1804	Kratz, C. I.	Williamsport	1947	140	$5\frac{5}{8}$	2	50
1816	Hornbraker, S. F.	Williamsport	1947	122	$5\frac{5}{8}$	8	—
1817	Whitesel, V. E.	Hagerstown	1947	104	$5\frac{5}{8}$	6	—
1818	Turner, R. E.	Halfway	1947	56	$5\frac{5}{8}$	10	—
1825	Newcomber, H. K.	Cavetown	1948	192	$5\frac{5}{8}$	6	45
1828	Ambrose, Earl	Funkstown	1947	66	$5\frac{5}{8}$	6+	46
1829	Tiller, M. B.	St. James	1947	100	$5\frac{5}{8}$	10	—
1845	Stouffer, Herman	Cavetown	1947	74	$5\frac{5}{8}$	6+	25
1866	Morrison, L. H.	Hagerstown	1947	75	$5\frac{5}{8}$	5	—
1875	Supreme Concrete Block Co.	Hagerstown	1947	73	$5\frac{5}{8}$	10	—
1899	Dehart, E. H.	Chewsville	1947	44	$5\frac{5}{8}$	6+	19
1934	Dehart, Marshall	Chewsville	1947	105	$5\frac{5}{8}$	2	55
1943	Brumbaugh, E. C.	Hagerstown	1947	90	$5\frac{5}{8}$	4	40
1964	Lauricella, Wm.	Hagerstown	1947	$87\frac{1}{2}$	$5\frac{5}{8}$	6+	25
1997	Recher, James	Hagerstown	1947	156	$5\frac{5}{8}$	5	60
2018	Bryant, Mrs.	Bellegrove	1947	80	$5\frac{5}{8}$	5	12
2019	Golden, Marvin	Piney Grove	1947	118	$5\frac{5}{8}$	4	—
2032	Crampton, Albert	Sharpsburg	1947	192	6	10+	65

TABLE 6—*Continued.*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
2095	Snurr, J. O.	Leitersburg	1947	57	6	10	30
2096	Mish, J. D.	Clear Spring	1947	68	8–6	5	20
2198	Deatrich, A. B.?	Sharpsburg	1948	112	5⅝	7	—
2207	Hoover, C. C.	Chewsville	1948	122	5⅝	7	—
2208	Auscherman, W. W.	Hagerstown	1948	133	5⅝	1	—
2209	Hoover, Sherman	Hagerstown	1948	94	5⅝	5	—
2229	Bester, Mary	Fort Frederick	1948	93	5⅝	7	15
2241	Wheelan, D. A.	Hagerstown	1948	65	5⅝	12	—
2250	Wingert, Irene	St. James	1948	76	5⅝	10	—
2284	Tedrick, R. D.	Big Pool	1948	85	6	10	—
2285	Pittman, Herbert	Hancock	1948	85	6	10	—
2286	Huff, C. H., Jr.	Smithsburg	1948	90	6	10	75
2287	Tabler, Charles	Williamsport	1948	95	6	20	12
2299	Shipley, L. A.	Williamsport	1948	39½	5⅝	10	10
2311	Baker, G. R.	Fairplay	1948	191	5⅝	5	63
2323	Finbrock, Harvey	Hagerstown	1948	88	5⅝	10	—
2338	Sweigert, Luther	Hagerstown	1948	70	5⅝	10	30
2339	Maryland Lime & Fertilizer Corp.	Williamsport	1948	88	5⅝	10	32
2361	Creek, C. A.	Hagerstown	1948	90	5⅝	10	35
2370	Flook, J. D.	Sharpsburg	1948	80	5⅝	14	35
2372	Berry, C. R.	Boonsboro	1948	100	5⅝	—	—
2373	Miles, J. G.	Clear Spring	1948	225	6	6	40
2394	Meyers, J. C.	Hagerstown	1948	33½	5⅝	10	25
2395	Heironimus, P. B.	Huyett	1948	79	5⅝	10	25
2408	Fockler, G. S.	Wilson	1948	86	5⅝	10	25
2469	Board of Education	Rohrersville	1948	137	5⅝	10	—
2476	Stockslager, H.	Hagerstown	1948	333	6	1½	—
2476	Stockslager, H.	Hagerstown	1948	140	5⅝	20	40
2493	Stonebraker, Jack	St. James	1948	64	5⅝	10	35
2494	Stine, Braden	Boonsboro	1948	221	5⅝	7	190
2495	Flora, C. A.	Huyett	1948	52	5⅝	10	—
2607	Weinberg, Dan	Hagerstown	1948	98	5⅝	20	5
2691	Wilson, W. E.	Hancock	1948	92	6	6	20
2692	Barnhart, R. J.	Hancock	1948	135	6	5	—
2693	Weller, Edith	Hancock	1948	97	6	7	40
2694	Arnold, A. G., Jr.	Hagerstown	1948	37	6	5	20
2699	Bain, A. C.	Hancock	1948	105	6	8	40
2700	McFadden, K. E.	Hancock	1948	78	6	10	45
2701	Banzhoff, J. W.	Williamsport	1948	62	6	8	20
2715	Conley, W. C., Jr.	Hagerstown	1948	65	5⅝	8	—
2759	Fridinger, Isabel	Hagerstown	1948	35	5⅝	10	15
2760	Berthume, O. A.	Hagerstown	1948	307	5⅝	½	—
2797	Potomac Fish & Game Club, Inc.	Williamsport	1948	92	5⅝	10	18
2808	Sowter, G. E.	Hagerstown	1948	225	6	5	120
2941	Rowland, Norman	Williamsport	1948	303	5⅝	5	75
2961	Horst, J. P.	Maugansville	1948	265	6	4	16
2962	Ridenour, G. C.	Huyett	1948	115	6	5	30

TABLE 6—*Continued*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
2966	Younker, J. L.	Hancock	1948	42	6	10	10
2967	Hurd, C. G.	Hagerstown	1948	105	6	5	20
2968	Younker, Florence	Hancock	1948	67	6	10	20
2983	Light, J. M.	Wilson	1948	70	6	7	30
3015	Myers, Paul	Wilson	1948	70	$5\frac{5}{8}$	10	25
3016	Board of Education	Security	1948	99	$5\frac{5}{8}$	15	20
3094	Russell, W. K.	Hagerstown	1948	120	$5\frac{5}{8}$	12	49
3095	Faith, A. C.	Clear Spring	1948	56	$5\frac{5}{8}$	15	5
3097	Coston Motor Co.	Hagerstown	1948	90	$5\frac{5}{8}$	30	25
3115	Farrie, Frank	Hagerstown	1948	93	$5\frac{5}{8}$	10	50
3116	Jacques, Lancelot	Smithsburg	1948	178	$5\frac{5}{8}$	5	50
3144	Ramaciotti, Nancy	Sharpsburg	1948	150	$5\frac{5}{8}$	10	120
3145	Baer, Martin	Hagerstown	1948	290	$5\frac{5}{8}$	(very small)	—
3215	Coffman, Richard E.	Williamsport	1948	190	$5\frac{5}{8}$	5	100
3218	Haupt, Harlan	Boonsboro	1948	69	$5\frac{5}{8}$	5	—
3253	Myers, W. W.	Dargan	1948	70	6	5	25
3254	Shipley, T. A.	Wagners Cross-roads	1948	212	$5\frac{5}{8}$	5	30
3293	Smith, E. E.	Boonsboro	1948	71	$5\frac{5}{8}$	8	—
3304	Hagerstown Nursery Co.	Halfway	1948	115	6	10	—
3305	Kepner, M. L.	Funkstown	1948	92	$5\frac{5}{8}$	10	85
3306	Leatherman, B. M.	Hagerstown	1948	120	6	3	—
3307	Spickle, C. V.	Hagerstown	1948	110	6	10	—
3308	Sheiss, T. H.	Hagerstown	1948	90	6	6	—
3309	Huffer, E. C.	Boonsboro	1948	100	6	5	20
3328	Smith, Hubert	Myersville	1948	38	$5\frac{5}{8}$	20	11
3339	Barnes, W. M.	Leitersburg	1948	160	$5\frac{5}{8}$	5	155
3341	Hartle, B. E.	Leitersburg	1948	65	$5\frac{5}{8}$	10	60
3355	Shoemaker, Charles	Big Spring	1948	65	6	6	35
3356	Hart, F. M.	Big Pool	1948	110	6	10	—
3357	McCarty, N. T.	Big Pool	1948	60	6	40	40
3358	James, C. C.	Indian Springs	1948	70	$5\frac{5}{8}$	8	30
3374	Board of Education	Fairplay	1948	166	$5\frac{5}{8}$	10	—
3513	Ridenour, C. H.	Wilson	1948	60	$5\frac{5}{8}$	10	32
3518	Mumma, J. B., Sr.	Wilson	1949	59	$5\frac{5}{8}$	10	—
3519	Revell, B. H.	Pecktonville	1948	70	$5\frac{5}{8}$	10	—
3520	Weller, B. V.	Pecktonville	1948	77	$5\frac{5}{8}$	5	—
3537	Hoffman, B. N.	Broadfording	1949	90	6	10	40
3574	Davis, F. M.	Roxbury	1949	180	6	5	128
3597	Giraffa, Vincent	Benevola	1949	304	$5\frac{5}{8}$	$2\frac{1}{2}$	40
3626	Myers, Theodore	Hagerstown	1949	71	$5\frac{5}{8}$	10	20
3649	Delander, C. H.	Hagerstown	1949	61	8–6	6	47
3763	Board of Education	Sandy Hook	1949	235	$5\frac{5}{8}$	1	50
3843	Carbaugh, Jacob	Broadfording	1949	67	$5\frac{5}{8}$	10	24
3844	Colored Elks	Samples Manor	1949	108	$5\frac{5}{8}$	8	25
3881	Mowen, Alvey	Broadfording	1949	78	6	10	38
3947	Parson, Gold	Sandy Hook	1949	100	$5\frac{5}{8}$	8	—
3983	Forney, T. D.	Huyett	1949	40	$5\frac{5}{8}$	15	20

TABLE 6—*Continued*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
3984	McLucas, S. L.	Hagerstown	1949	80	5⅝	10	30
3986	Sampson, Raymond	Clear Spring	1949	160	6	3	—
3987	Barnhart, Julia	Hancock	1949	80	6	8	—
3988	Shirk, Charles	Clear Spring	1949	90	6	40	30
3989	Havernale, —	Big Pool	1949	75	6	20	—
3990	Moore, Thomas	Hagerstown	1949	65	6	40	32
3991	Michael, Boyd	Clear Spring	1949	168	6	5	—
4003	Houser, Earl	Sharpsburg	1949	97	5⅝	20	25
4061	Juel, Mrs. E. R.	Boonsboro	1949	113	5⅝	5	37
4084	Hagen, C. G.	Mt. Lena	1949	111	5⅝	13	4
4085	Dual Drive-In Range, Inc.	Wagners Cross-roads	1949	62	5⅝	16	12
4150	Kidwell, G. S.	Big Spring	1949	72	5⅝	10	57
4169	Ford, Mrs. J. G.	Maugansville	1949	55	5⅝	10	11
4176	Balto. Conference of Methodist Churches	Pleasantville	1949	250	6	12	125
4187	Kidwell, Minnie	Clear Spring	1949	90	6	20	—
4213	Milk, H. L.	Hancock	1949	70	5⅝	20	10
4216	Reeder, J. C.	Mapleville	1949	84	6	20	50
4216	McCauley, Eugene	Williamsport	1949	—	5⅝	10	30
4217	Bussard, W. H.	Funkstown	1949	89	6	16	45
4220	Worthington, Mary W.	Broadfording	1949	45	5⅝	20	15
4240	Hardy, G. W.	Samples Manor	1949	90	5⅝	10	26
4241	Metz, Leon	Samples Manor	1949	60	5⅝	3	10
4245	Martin, Jacob	Maugansville	1949	83	5⅝	20	8
4246	Good, George	Huyett	1949	66	5⅝	4	32
4247	St. James Brethren	Lydia	1949	60	5⅝	20	39
4273	Clark, Herbert	Hagerstown	1949	97	6	—	—
4274	Rinehart, R. R.	Cearfoss	1949	46	6	5	—
4290	Mason, S. H.	Cearfoss	1949	55	6	6	—
4291	Sours, M. T.	Cearfoss	1949	52	6	5	—
4292	Renner, Mason	Huyett	1949	69	6	—	—
4293	Cosgrove, H. L.	Wilson	1949	65	5⅝	10	20
4307	Turner, M. G.	Halfway	1949	75	5⅝	10	20
4325	Park, E. W.	Smithsburg	1949	162	6	10	32
4346	Moats, Gardner	St. James	1949	68	5⅝	20	40
4550	Barnhart, Nevin	Tilghmanton	1949	54	5⅝	15	44
4555	Veterans' Home	Sharpsburg	1949	28	5⅝	20	4
4658	Massey, Cora May	Pen Mar	1949	94	6	¼	55
4739	Jones, Woodrow	Boonsboro	1949	66	5⅝	10	20
4786	Younkins, E. A.	Boonsboro	1949	87	5⅝	10	—
4799	Naille, C. L.	Boonsboro	1949	80	5⅝	5	60
4864	Young, D. R.	Boonsboro	1949	87	5⅝	20	21
4865	Schrines, J. M.	Wilson	1949	85	6	5	75
4933	Weber, E. M.	Smithsburg	1949	110	5⅝	10	50
4964	Rinehart, D. G.	Huyett	1949	55	5⅝	—	20
5033	Mitchel, R. L.	Leitersburg	1949	250	5⅝	1	35
5048	Nave, Eugene	Williamsport	1949	78	5⅝	10	—
5049	Golden, E. E.	Hancock	1949	70	6	10	—

TABLE 6—*Continued*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
5050	Deatrich, Roy	Maugansville	1949	200	6	4	—
5051	Lowery, W. S.	Maugansville	1949	—	6	3	24
5086	Gateway Convalescent Home	Wilson	1949	90	5⅝	10	50
5087	Hutzell, Vernon	Boonsboro	1949	80	6	15	35
5088	Smith, F. W.	Boonsboro	1949	108	6	30	78
5089	House, Harvey	Boonsboro	1949	154	5⅝	2½	48
5156	Sease, Roy	Williamsport	1950	36	5⅝	40	8
5310	Wilson, W. G.	Beaver Creek	1950	43	5⅝	15	12
5316	Robinson, John	Clear Spring	1950	—	—	0	—
5317	Kaylor, J. F.	Clear Spring	1950	41	6	—	10
5322	Shank, Nevin	Hagerstown	1950	100	6	10	35
5457	Holsinger, L. E.	Maugansville	1950	217	—	0	—
5471	Shantz, C. R.	Hagerstown	1950	95	6	—	16
5473	Wilhide, E. J.	Maugansville	1950	130	6	—	—
5489	Bowers, Bertha B.	Wilson	1950	135	5⅝	10	70
5493	Showalter, I. F.	Big Spring	1950	104	6	1	45
5515	Hoffman, J. V.	Camp Ritchie	1950	84	5⅝	5	40
5624	Rowe, D. G.	Mt. Lena	1950	136	—	0	
5729	Foster, G. O.	Charlton	1950	70	6	30	45
5730	Hawlicker, V. C.	Cearfoss	1950	58	6	30	14
5735	Armsparger, R. A.	Halfway	1950	195	5⅝	2	34
5792	Hanes, Alfred	Samples Manor	1950	90	5⅝	5	30
5793	Potomac Creamery Co., Inc.	Hagerstown	1950	150	6	600	8
5794	Parlette, R. H.	Huyett	1950	57	5⅝	20	—
5821	Rhodes, H. L.	Big Pool	1950	—	6	30	30
5830	Beachley, Elmer	Boonsboro	1950	100	5⅝	5	35
5835	Weller, Paul	Leitersburg	1950	70	6	30	58
5889	Lapole, M. D.	Gapland	1950	49	5⅝	16	20
5902	Shaw, A. W.	Hancock	1950	90	6	10	25
5917	Randolph, Jack	Boonsboro	1950	90	6	20	50
5919	Strevig, R. D.	Hagerstown	1950	70	6	20	65
6001	Baker, Fred	Leitersburg	1950	89	5⅝	½	—
6002	Snoddenly, Sherman	Leitersburg	1950	98	5⅝	20	30
6003	Malone, L.	Downsville	1950	109	5⅝	1	40
6005	Southern States Petroleum Coöp., Inc.	Funkstown	1950	175	5⅝	½	40
6014	Sherley, E. C.	Boonsboro	1950	70	6	10	—
6159	Palmer, Donald	Williamsport	1950	—	6	5	20
6266	Stevens, M. L.	Cearfoss	1950	47	5⅝	6	30
6291	Wantz, Hiram	Cearfoss	1950	105	5⅝	10	20
6292	Parson, Gold	Gapland	1950	52	5⅝	6	25
6300	Spates, Geo. P.	Foxville	1950	65	5⅝	15	25
6336	Moser, Bruce	Boonsboro	1950	107	5⅝	3	57
	Creager, Susan	Hancock	—	86	4	—	54
	Dayhoff, A. L.	Indian Springs	—	38	36	—	30
	Western Maryland R. R.	Hagerstown	1940	82	5	24	50
	Western Maryland R. R.	Hagerstown	1940	52	6	6	30
	Sword, Mel	Hagerstown	—	218	—	—	22
	Baer Bros. Cold Storage	Hagerstown	—	137	6	125	—

TABLE 6—*Continued*

PERMIT NO.	NAME OF OWNER	LOCATION	DATE DRILLED	DEPTH	DIAM.	REPORTED YIELD	STATIC LEVEL
				ft.	*in.*	*gals. per min.*	*ft.*
	Baer Bros. Cold Storage	Hagerstown	1904	120	4	—	—
	Baer Bros. Cold Storage	Hagerstown	1904	68	8	125	33
	Baer Bros. Cold Storage	Hagerstown	—	108	—	75	40
	Potomac Edison Co.	Hagerstown	1912	103	6	265	20
	Hagerstown Ice & Storage Co.	Hagerstown	1913	160	6	150	20
	Hagerstown Ice & Storage Co.	Hagerstown	1910	193	6	180	20
	Cromen Silk Mills	Hagerstown	1915	111	6	55	—
	Fairchild Corporation	Hagerstown	1911	281	6	200	6
	Fairchild Corporation	Hagerstown	1913	281	6	116	8
	Fairchild Corporation	Hagerstown	1913	326	6	18	5
	Fairchild Corporation	Hagerstown	1911	323	6	18	3
	Fairchild Corporation	Hagerstown	1911	910	6	1	20
	Artz, H. M.	Hagerstown	—	32	60	6	20
	Murphy, John	Sharpsburg	—	29	36	—	25
	Morgan, J. A.	Harvey	—	127	—	—	—
	Bishop, Mrs. Martha	Harvey	—	72	6	5	—
	Western Maryland R. R.	Pearre	1941	125	6	10	—
	Hennesey, Marvel	Big Pool	1917	62	6	—	45
	Clopper, John	Broadfording	1904	64	6	4	30
	Funkhouser, Raymond	Big Pool	1917	41	6	4	15
	Hagen, Jake	Pinesburg	1916	32	6	2	25
	Smith, John	Huyett	1905	68	6	—	30
	Cushwa's Brick Works	Williamsport	1917	120	6	50	10
	Dorsey, John	Charlton	1905	144	6	6	100
	Strong, D. M.	Falling Waters	1911	122	6	4	40
	Sprecher, J. H.	Grimes	1915	100	6	3	60
	Wingret, Louis	Hagerstown	1904	45	6	5	30
	Western Maryland R. R.	Hagerstown	1940	82	6	24	—
	Western Maryland R. R.	Garfield	—	80	$5\frac{5}{8}$	8–10	30
	Ramsburg, J. E.	Fairplay	1915	80	6	—	50
	Kline, Michael	Wolfsville	1910	85	$5\frac{5}{8}$	5	30
	Wolfsville School	Wolfsville	1931	200	6	5	
	Routson, Elias	Ellerton	—	79	6	8–10	—
	Swain, Benjamin	Mondell	1917	52	6	—	—
	Poffenberger, Otto	Sharpsburg	1917	72	6	4	40
	Poffenberger, Otto	Sharpsburg	1917	115	6	5	55
	U. S. National Cemetery	Sharpsburg	1931	347	6	10	100
	Children's Hospital	Highfield	—	216	6	20	25
	Western Maryland R. R.	Highfield	1937	104	8	104	—
	Maryland National Guard	Cascade	1931	300	8	50	8
	Brown, Roscoe	Sabillasville	—	40	6	1	18

Note: The initials and spelling of owners names are as reported by the well drillers on their applications for well permits.

SURFACE WATER RESOURCES

BY

ROBERT O. R. MARTIN

GENERAL

Human life and progress are closely dependent upon water, and man can exist but a few days without it. The conservation and control of water, therefore, has become one of his vital problems. The demands of an advancing civilization have placed limitations on the use of water, especially after man abandoned his nomadic way of life and established a permanent home rather than moving continually from water hole to water hole. In densely populated areas, the demand for water very often approaches the limit of supply. Areas lacking in water are most often sparsely settled because the expense of transporting water is a burden to the homemaker. An adequate water supply is a prerequisite to the growth of our cities.

With increased demand for water many complex problems arise, such as pollution and contamination from known or unknown sources within the watershed. Water as precipitated on the earth is originally pure, but man has a trying task to maintain this quality. Numerous outbreaks of sickness and epidemics have been traced to impure drinking water. Clean, pure streams and lakes are important assets to a community for recreational purposes aside from their value as possible sources of public water supplies.

Navigation was one of the earliest uses of surface waters, but with increased farming and industry, the use of streams for irrigation and industrial purposes has become more important. There are manifold industrial uses of surface waters in our cities for which temperature and chemical quality have become important factors.

The never-ending circulation of water in various forms from ocean and land surfaces to the atmosphere by evaporation and transpiration, from the atmosphere to the land by precipitation, and then back to the ocean is commonly called the hydrologic cycle. As water travels from the land to the ocean, a part runs off directly into the streams and a part enters ground water storage before later appearing as stream flow.

Although indispensable to man, stream flow in excessive amounts can cause tremendous damage and even loss of life. It has always been the inclination of man to establish his home on or near a stream in order to have a readily accessible supply of water or means of transportation. As river settlements grow, the usual trend is for the flood plains of the stream to be encroached upon, and even for the normal stream channel to be crowded and its carrying capacity reduced by structures of all kinds. Thus, the tendency toward flooding is aggravated, and the actual or potential flood damages are vastly increased. The problem of flood control then arises. For the proper planning of flood control works such as dams, levees, or channel improvements, and the designing of bridges with adequate waterways, it is necessary that records of stream flow be available for sufficient number of years to establish the flood-flow characteristics of the stream.

STREAM-FLOW MEASUREMENT STATIONS

In order to study systematically the range of stream-flow so as to derive maximum benefits from it, the U. S. Geological Survey has installed numerous stream-gaging stations throughout the country. In cooperation with the State Department of Geology, Mines and Water Resources, and other State, Federal, and municipal agencies, many such gages are in operation in Maryland. Most of these are equipped with automatic water-stage recorders, which collect a continuous record of the stage of the stream (Fig. 41). In conjunction with the stage record, flow determinations must be made periodically by means of a precise instrument known as a current

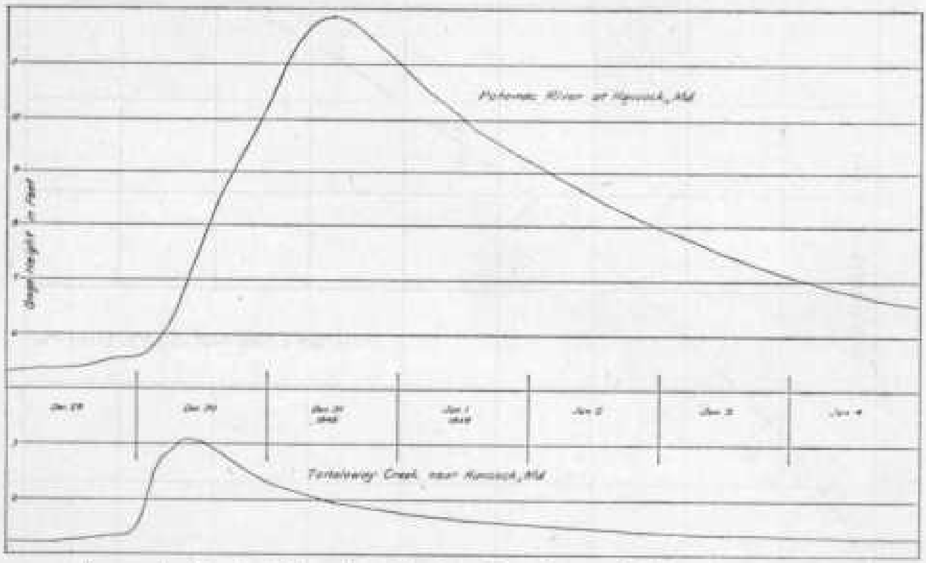

FIGURE 41. Graph of River Stage Obtained from Automatic Water-Stage Recorder

meter in order to correlate stage with discharge. With an established stage-discharge relationship, the discharge corresponding to a given stage can be determined by interpolation, provided the channel conditions of the stream remain unchanged.

The selection of a site for a gaging station requires a careful appraisal of the stream channel to be assured that hydraulic conditions are stable and that a fixed relation between stage and discharge will be maintained. Consideration must be given also to the accessibility of the gage under adverse conditions of storm and high water and that the measurement of discharge of the stream be possible at all stages. In order to avoid building expensive structures it is economical to benefit by the proximity of a bridge suitable for discharge measurements. In some cases there is no alternative except to erect a cableway across a stream. This cableway is generally suspended from high A-frames on each bank and is used to support a cable car. The elevation of the cableway must be sufficient to support an engineer and his measuring equipment with sufficient clearance above the stages of anticipated floods.

Present-day construction practice favors a permanent-type recording-gage structure. The usual gage well and house in Maryland is constructed of concrete block or reinforced concrete and has inside dimensions of about 4 feet square. The structure is provided with steel doors for house and well and is connected to the stream by one or more horizontal pipes or intakes to permit the water in the well to fluctuate simultaneously with the stream. The height of the structure is governed by the height of the maximum anticipated flood (Pl. 21, fig. 1).

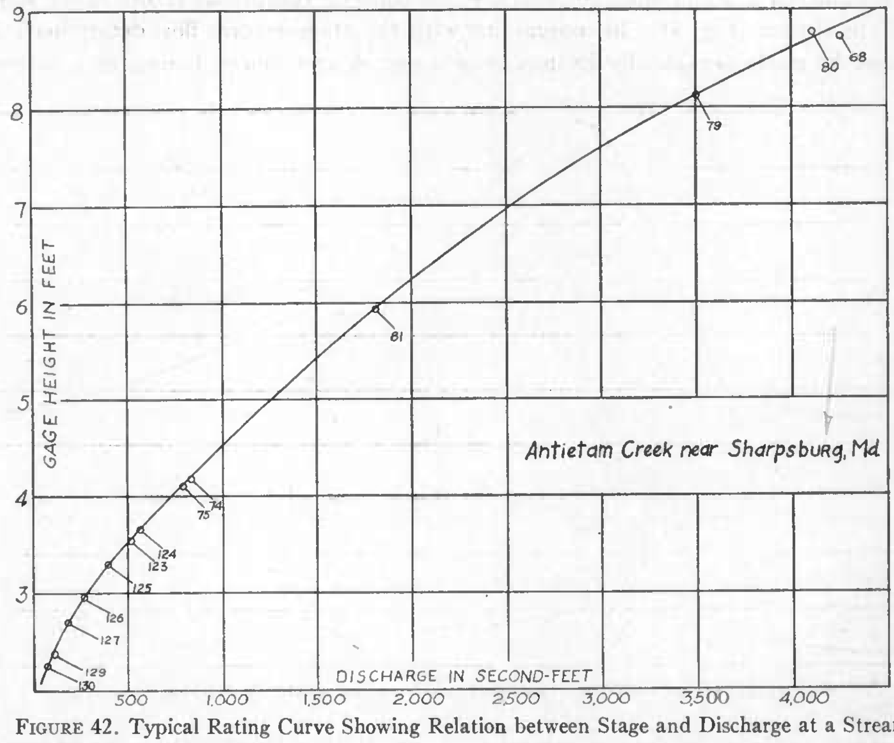

FIGURE 42. Typical Rating Curve Showing Relation between Stage and Discharge at a Stream-gaging Station.

A continuous graphic record of stage with respect to time is obtained by means of a water-stage recorder installed in the gage house to record the fluctuations of the water level in the gage well (Fig. 41). The modern water-stage recorder requires very little attention. Inspections to change the continuous recorder charts can be made once a month or even less frequently. Plate 21, figure 2, shows an automatic recorder in operation. In most silt-laden streams it is necessary to clean the intake pipes by forcing water through them by means of a flushing device. In Washington County most of the streams contain enough silt to require an intake-pipe flushing system.

The rate of flow of a stream, or the discharge, is the quantity of water, passing any point in a given time. This quantity is expressed in terms of cubic feet per second, commonly called second-feet. Discharge varies with precipitation and with basin characteristics such as depth and texture of the soils and steepness of the terrain. The discharge at any point on a stream can readily be determined by multiplying the cross-sectional area of the water by its velocity. Stream-flow measurements are made periodically by means of a Price current meter which determines the velocity of the water. Plate 22, figure 1, shows a standard Price current meter mounted on a rod for use in making a discharge measurement by wading a stream. The smaller Pygmy meter is designed for shallow streams. Plate 22, figure 2, shows the heavier crane and reel equipment used to measure deep swift streams. The purpose of a discharge measurement is to define the stage-discharge relation existing at that time (Fig. 42).

Daily discharge records for the gaging-stations are published in annual water-supply papers of the United States Geological Survey, in Part 1 of the series called "Surface-Water Supply of the United States".

DEFINITION OF TERMS

Several technical terms are used in stream-flow records that may be unfamiliar to the reader. Brief explanations are as follows:

Second-feet.—An abbreviation for "cubic feet per second." A second-foot is the rate of discharge of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second.

Discharge.—A rate of flow of water, usually expressed in second-feet.

Second-feet per square mile.—An average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the runoff is distributed uniformly as regards both time and area.

Runoff in inches.—The depth to which an area would be covered if all the water draining from it in a given period were uniformly distributed on its surface.

Drainage basin.—The area drained by a stream or stream system, usually expressed in square miles.

Water year.—A special annual period selected to facilitate water studies, commencing October 1 and ending September 30.

SURFACE WATER RESOURCES OF WASHINGTON COUNTY

The principal streams within Washington County flow southward or south-southwestward from their headwaters in Pennsylvania, and all are tributary to the Potomac River. The meandering course of the Potomac River as it flows eastward has placed the south boundary of Maryland (and Washington County) within 1.8 miles of the Pennsylvania State line at one point. This is noteworthy in that it forms the narrowest portion of any of the States. Washington County is practically a triangle, with its base and greatest area toward the east. The short west boundary of Washington County is formed by Sideling Hill Creek. The east boundary is the crest of South Mountain, the divide separating the drainage basins of Antietam Creek and Catoctin Creek.

The county lies mostly in the Valley and Ridge physiographic province, a region characterized by long, ridge-like, parallel mountains and intervening valleys. Streams in the western and more mountainous section of the county have rather flashy runoff, reflecting the effect of their comparatively steep gradients and the rough topography of the valleys. Farther east the valleys are broader with less relief, and streams are correspondingly less flashy.

TABLE 7

DRAINAGE AREAS OF STREAMS SHOWN ON FIGURE 43

NAME OF STREAM (POTOMAC RIVER BASIN)	TRIBUTARY TO:	DRAINAGE AREA, IN SQUARE MILES			
		At mouth	In Maryland	At State line	At U.S.G.S. Gage
In Maryland and Pennsylvania					
Antietam Creek	Potomac	292	187		
near Waynesboro, Pa.	Potomac				93.5
at Penna. line	Potomac		7.4	93.3	
Burnside Br. near Sharpsburg	Potomac		176		281
Bear Creek near Belle Grove, Md. (at U. S. Highway 40)	Sideling Hill	9.1			
Beaver Creek	Antietam	33.5			
Conococheague Creek	Potomac	563	65.8		
at Penna. line	Potomac		0.46	491	
at Fairview, Md.	Potomac		2.5		495
Great Tonoloway Creek	Potomac	114	2.08		
Grove Creek	Antietam	25.0			
Licking Creek	Potomac	213	27.6		
at Penna. line	Potomac		3.23	188	
near Sylvan, Pa.	Potomac		1.0		158
Little Antietam Creek	Antietam	32.2			
Little Conococheague Creek	Potomac	18.0	16.7		
Marsh Run	Antietam	31.2	13.0		
Marsh Run	Potomac	20.2			
Potomac River at Hancock, Md.	Chesapeake				4073
Potomac River at Shepherdstown, W. Va.	Chesapeake		895		5936
Sideling Hill Creek	Potomac	104	23.1		
at Penna. line	Potomac		2.42	74.9	
near Belle Grove (U. S. Highway 40, Md.)	Potomac	83.7		74.9	
Tonoloway Creek	Potomac	25.9	16.0		
near Hancock, Md.	Potomac		16.0		16.9
In West Virginia					
Back Creek	Potomac	274			
Cacapon River	Potomac	681			
Opequon Creek	Potomac	340			
Shenandoah River	Potomac	3053			

The drainage area of the Potomac River practically triples in size between the west and east boundaries of the County, and is approximately 3350 and 9500 square miles, respectively. Of the increase of 6150 square miles, about 4400 square miles drains from the south through West Virginia and Virginia. The remaining 1750 square miles constitutes the approximate drainage area to the north of the Potomac River, of which 459 square miles is in Washington County and the balance in Pennsylvania.

Rainfall is generally ample for farming, so irrigation is no economic problem; the use in Washington County of the streams for hydroelectric power is confined to one small plant on Antietam Creek. Stream flow from this area is important, however, as water supply for points of concentrated population, such as Hagerstown in Washington County and Washington, D. C., outside the area.

The important streams in Washington County and their drainage areas at selected points are listed in Table 7. These determinations are based chiefly on data in a

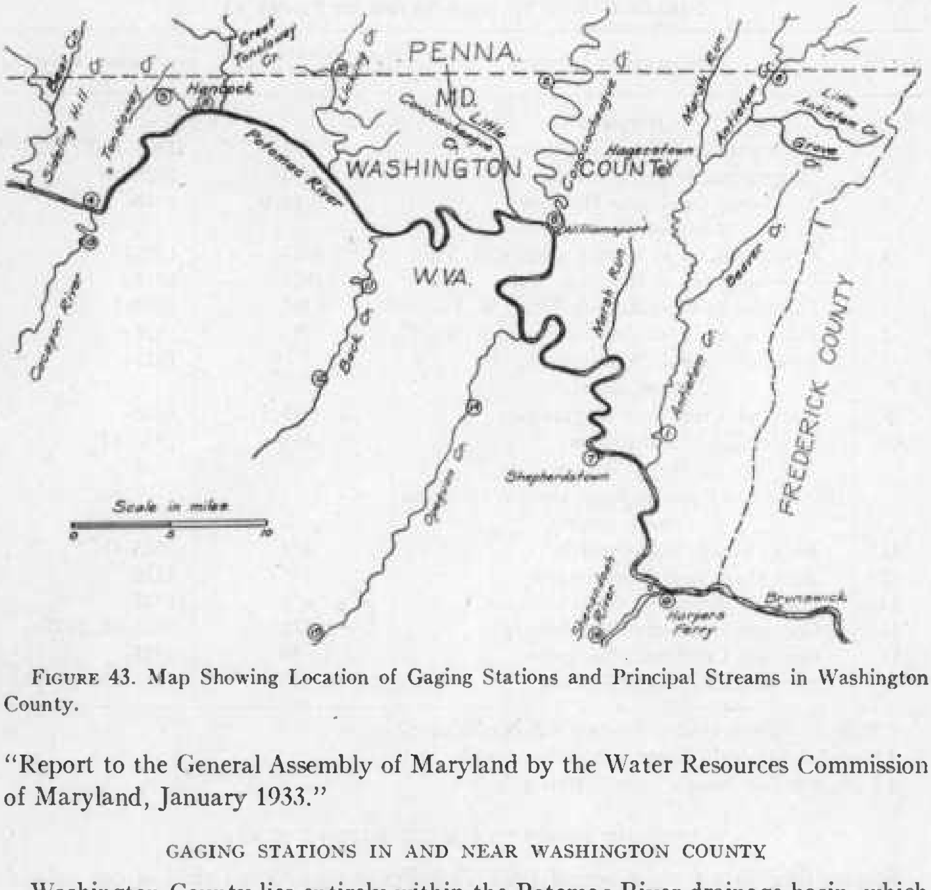

FIGURE 43. Map Showing Location of Gaging Stations and Principal Streams in Washington County.

"Report to the General Assembly of Maryland by the Water Resources Commission of Maryland, January 1933."

GAGING STATIONS IN AND NEAR WASHINGTON COUNTY

Washington County lies entirely within the Potomac River drainage basin, which drains into Chesapeake Bay. Records of stream flow are available for four gaging stations within Washington County and for one in Pennsylvania just north of the State line. Two gaging stations are situated along the southern boundary of the County on the Potomac River, the flow of which is augmented by substantial inflow from several large tributaries flowing northeastward out of West Virginia and Virginia. The major of these tributaries are Cacapon River, Back Creek, Opequon Creek, and Shenandoah River.

In Bulletin No 1, Department of Geology, Mines and Water Resources, State of Maryland, "Summary of Records of Surface Waters of Maryland and the Potomac River Basin," 1944, monthly discharge records are given of the maximum, mean, and minimum flow, discharge in cubic feet per second per square mile, runoff in inches, and discharge in million gallons per day per square mile for all gaging station records for Washington County from their dates of establishment to September 30, 1943.

The drainage areas and years of records available for all gaging stations on the Potomac River and tributaries in and near Washington County are presented in the following table. The locations of those stations are shown on Figure 43.

STREAM GAGING STATIONS SHOWN ON FIGURE 43

MAP NO.	STREAM GAGING STATION	DRAINAGE AREA SQUARE MILES	RECORDS AVAILABLE*
	Maryland		
1	Antietam Creek near Sharpsburg	281	1897–1905; 1928–
2	Conococheague Creek at Fairview	494	1928–
3	Tonoloway Creek near Hancock	16.9	1947–
	Maryland-West Virginia		
4	Potomac River at Great Cacapon, W. Va.	4027	1895†
5	Potomac River at Hancock, Md.	4073	1932–
6	Potomac River at Harpers Ferry, W. Va.	9361	1889–‡
7	Potomac River at Shepherdstown, W. Va.	5936	1928–
8	Potomac River at Williamsport, Md.		1925†
	Pennsylvania		
9	Antietam Creek near Waynesboro	93.5	1948–
10	Licking Creek near Sylvan	158	1930–42
	West Virginia (tributary to Potomac River along Washington County border)		
11	Back Creek near Hedgesville	252	1928–31
12	Back Creek near Jones Springs	243	1938–
13	Cacapon River near Great Cacapon	677	1922–
14	Opequon Creek near Martinsburg	272	1905–06; 1947–
15	Opequon Creek near Berryville	58	1943–
16	Shenandoah River at Millville	3040	1895–1909; 1928–

* Stations without closing date are still in operation.
† Gage heights or discharge measurements only.
‡ U. S. Weather Bureau; gage heights only.

AVERAGE RUNOFF IN WASHINGTON COUNTY

Stream-flow data for the period 1928–49 indicate an average yield of one second-foot per square mile of drainage area for the streams of Washington County.

STREAM GAGING STATION	DRAINAGE AREA IN SQ. MILES	MEAN DISCHARGE C.F.S.	C.F.S. / SQ. MI.
Conococheague at Fairview, Md.	494	553	1.12
Antietam Creek near Sharpsburg, Md.	281	250	.89
Potomac River at Shepherdstown, W. Va.	5936	5572	.94

This yield is consistent with comparable nearby stream-flow records at gaging stations to the west and to the east of Washington County.

EXTREMES OF RUNOFF IN WASHINGTON COUNTY

The maximum flood recorded for this reach of the Potomac River occurred in March 1936. Pertinent data on all major floods on main rivers and tributaries are given in Water-Supply Paper 800, which deals primarily with the flood of March 1936.

The most severe drought period occurred in 1930 when the precipitation for the State of Maryland averaged only 24 inches as compared with a 54-year average of nearly 42 inches. Extreme drought conditions prevailed from 1930 to 1934. For details on drought studies see Water-Supply Paper 680, "Droughts of 1930–34."

DISCHARGE RECORDS

The monthly discharge records prior to October 1943 for the gaging stations included in this report, are published in Bulletin 1, Department of Geology, Mines and Water Resources, State of Maryland. Similar records for the water years 1944–49 are contained on pages 203 to 217 for the following stations:

Antietam Creek near Sharpsburg, Md.
Antietam Creek near Waynesboro, Pa.
Conococheague Creek at Fairview, Md.
Potomac River at Shepherdstown, W. Va.
Potomac River at Hancock, Md.
Tonoloway Creek at Hancock, Md.
Licking Creek near Sylvan, Pa. (Discontinued)

QUALITY OF SURFACE WATER

Information about the quality of the surface waters of Washington County is of importance in regard to both industrial development and sanitation. No detailed studies have been made of the amount of dissolved minerals in the Potomac River in this area. The concentration is known to vary continuously depending on the amount of rainfall over the watershed and the season of the year. The concentrations in the Potomac River along the south boundary of Washington County would probably average slightly less than at Washington, D. C., where the Potomac has an average concentration of dissolved solids of about 130 parts per million and a hardness of about 90 parts per million.

A large amount of pollution in the Potomac River upstream from Washington County is detrimental to its use for industrial and domestic purposes. Some pollution also originates in Washington County.

Analyses of monthly samples from principal tributary streams near the Pennsylvania State line over a 2-year period show that the dissolved solids ranged from about 110 to 200 parts per million in Antietam Creek and from about 130 to 210 parts per million in Conococheague Creek. During the same period their hardness ranged from about 90 to 175 parts per million and from 85 to 180 parts per million respectively. These streams carry a considerable amount of pollution into the Potomac River.

The analytical data for Antietam and Conococheague Creeks were obtained by the U. S. Geological Survey in cooperation with the Department of Forest and Waters in the State of Pennsylvania as a part of the studies of the sanitary quality of the Potomac River Basin sponsored by the Interstate Commission on the Potomac River Basin. Many more data are needed both for the Potomac River and for Antietam and Conococheague Creeks to evaluate properly quality-of-water problems.

The amount of sediment carried by surface streams in Washington County is virtually unknown. They become muddy during storm periods but comprehensive factual data have never been obtained. As sediment is one of the major sources of pollution in the Potomac River Basin, as well as representing a loss of soil cover in farm areas, a program for making quantitative measurements of the sediment carried by the major streams of the County would be useful in determining its sources.

SURFACE WATER RECORDS OF WASHINGTON COUNTY

POTOMAC RIVER BASIN

Antietam Creek near Sharpsburg, Md.

Location.—Water-stage recorder and concrete control, lat. 39°27′01″, long. 77° 43′ 52″, 400 feet downstream from Burnside Bridge, 1 mile southeast of Sharpsburg, Washington County, and 4 miles upstream from mouth. Datum of gage is 311.00 feet above mean sea level (adjustment of 1912).

Drainage area.—281 square miles.

Records available.—August 1928 to September 1949. June 1897 to August 1905, at site at Middle Bridge, 1.2 miles upstream.

Average discharge.—21 years (1928–49), 250 second-feet (adjusted since 1940).

Extremes.—1928–49: Maximum discharge, 7,720 second-feet July 18, 1949 (gage height, 11.23 feet) from rating curve extended above 4,300 second-feet; minimum, 35 second-feet Jan. 15, 1931; minimum daily, 50 second-feet Sept. 29, 1930, Feb. 1, Oct. 4, 1931.

Maximum stage known, 11.9 feet sometime in July 1928, from floodmarks.

Remarks.—Flow slightly regulated by power plant. Records include pumpage from the Potomac River for municipal supply of Hagerstown. This water later enters Antietam Creek above station as sewage. Records of inflow furnished by City of Hagerstown.

Monthly discharge of Antietam Creek near Sharpsburg, Md.

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	188	84	104			
November	298	95	118			
December	200	63	88.1			
January	2700	80	247			
February	137	97	116			
March	1050	119	337			
April	502	286	355			
May	625	189	314			
June	606	139	183			
July	137	99	119			
August	153	75	93.5			
September	148	71	92.6			
The year	2700	63	181			
1944–45						
October	235	75	106			
November	150	73	87.0			
December	840	92	192			
January	450	130	186			
February	845	125	308			
March	720	282	439			
April	658	271	381			
May	745	253	355			
June	260	146	200			
July	178	123	142			
August	332	110	147			
September	862	119	233			
The year	862	73	231			

Monthly discharge of Antietam Creek near Sharpsburg, Md.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1945–46						
October	203	132	156			
November	1010	123	205			
December	828	260	396			
January	492	267	361			
February	426	242	265			
March	399	294	340			
April	301	186	228			
May	749	172	249			
June	1560	219	405			
July	226	141	177			
August	271	130	165			
September	309	99	136			
The year	1560	99	257			
1946–47						
October	200	128	148			
November	148	114	130			
December	155	103	119			
January	340	139	186			
February	330	150	201			
March	540	160	251			
April	229	170	195			
May	334	186	257			
June	567	197	289			
July	309	189	230			
August	321	146	175			
September	155	106	129			
The year	567	103	192			
1947–48						
October	132	88	98.8			
November	278	97	136			
December	123	94	109			
January	656	115	191			
February	635	123	219			
March	412	246	324			
April	940	309	462			
May	795	301	431			
June	399	219	270			
July	305	162	203			
August	401	132	175			
September	148	106	118			
The year	940	88	228			

Discharge of Antietam Creek near Sharpsburg, Md.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	301	99	168			
November	420	144	239			
December	1480	298	456			
January	1640	459	777			
February	820	570	656			
March	565	294	394			
April	670	286	357			
May	359	194	255			
June	242	146	171			
July	3490	123	586			
August	363	194	263			
September	582	160	207			
The year	3490	99	377			

YEAR	YEAR ENDING SEPT. 30				CALENDAR YEAR			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1898	245	0.881	11.96	0.569	294	1.06	14.39	0.685
1899	402	1.45	19.64	.937	349	1.26	16.91	.814
1900	195	.701	9.55	.453	192	.691	9.30	.447
1901	243	.874	11.90	.565	—	—	—	—
1902	—	—	—	—	409	1.47	19.85	.950
1903	524	1.88	25.56	1.22	504	1.81	24.49	1.17
1929	267				297			
1930	229				183			
1931	125				120			
1932	168				217			
1933	347				325			
1934	173				178			
1935	251				233			
1936	340				342			
1937	336				376			
1938	209				172			
1939	251				246			
1940	280				335			
1941	270				207			
1942	242				321			
1943	357				279			
1944	181				187			

Yearly discharge of Antietam Creek near Sharpsburg, Md.—Continued

YEAR	YEAR ENDING SEPT. 30				CALENDAR YEAR			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1945	231				262			
1946	257				227			
1947	192				188			
1948	228				272			
1949	377				—			
1928–43								
Highest	377				376			
Average	253				248			
Lowest	125				120			

Potomac River Basin

Antietam Creek near Waynesboro, Pa.

Location.—Wire-weight gage, lat. 39°43′00″, long. 77°36′25″, on County highway bridge at Rock Forge, Md., 0.5 mile downstream from Maryland-Pennsylvania state line, 0.9 mile downstream from confluence of West and East Branches of Antietam Creek, 1.85 miles northeast of Leitersburg, Md. and 2.5 miles southwest of Waynesboro, Pa.

Drainage area.—93.5 square miles.

Records available.—May 1948 to September 1949.

Extremes.—1948–49: Maximum discharge, 1,200 second-feet July 18, 1949 (gage height, 7.48 feet); minimum, 35 second-feet Sept. 27, Oct. 3–5, 1948 (gage height, 1.62 feet).

Maximum stage known, 6.5 feet sometime in August 1933.

Remarks.—Gage read twice daily. Some regulation from grist mills upstream

Monthly discharge of Antietam Creek near Waynesboro, Pa.

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1948						
May 12–31	240	111	152	1.63	1.21	1.05
June	159	76	101	1.08	1.21	.698
July	106	55	74.2	.794	.91	.531
August	130	47	60.9	.651	.75	.421
September	52	36	41.6	.445	.50	.288
1948–49						
October	178	35	63.9	0.683	0.79	0.441
November	164	51	86.9	.929	1.04	.600
December	497	105	160	1.71	1.98	1.11
January	570	161	264	2.82	3.26	1.82
February	284	197	226	2.42	2.52	1.56
March	189	98	132	1.41	1.63	.911
April	276	102	136	1.45	1.63	.937
May	133	67	93.7	1.00	1.16	.646
June	139	50	61.6	.659	.74	.426
July	917	42	206	2.20	2.54	1.42
August	225	62	93.9	1.00	1.16	.646
September	342	54	80.0	.856	.96	.553
The year	917	35	133	1.42	19.41	.918

POTOMAC RIVER BASIN

Conococheague Creek at Fairview, Md.

Location.—Water-stage recorder, lat. 39°42′57″, long. 77°49′28″, 0.7 mile upstream from highway bridge in Fairview, Washington County, 2 miles upstream from Rockdale Run and 6½ miles northwest of Hagerstown. Datum of gage is 391.77 feet above mean sea level, adjustment of 1912.

Drainage area.—494 square miles, prior to Oct. 7, 1933, 495 square miles.

Records available.—June 1928 to September 1949.

Average discharge.—21 years, 553 second-feet.

Extremes.—1928–49: Maximum discharge, 16,300 second-feet Dec. 1, 1934 (gage height, 14.8 feet); minimum, 22 second-feet Dec. 16, 1930; minimum daily, 25 second-feet Nov. 28, 1930.

Maximum stage known, about 16.5 feet sometime in 1889, from statements of local residents (discharge, about 22,000 second-feet).

Remarks.—Low flow partially regulated by small power plants near Mercersburg, Pa.

Monthly discharge of Conococheague Creek at Fairview, Md.

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLON PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	550	62	149	0.302	0.35	0.195
November	2580	127	358	.725	.81	.469
December	674	85	151	.306	.35	.198
January	3320	160	667	1.35	1.56	.873
February	905	210	376	.761	.82	.492
March	4260	454	1453	2.94	3.39	1.90
April	2200	700	1104	2.23	2.49	1.44
May	2980	330	878	1.78	2.05	1.15
June	1390	202	322	.652	.73	.421
July	189	105	138	2.79	.32	.180
August	195	73	99.1	.201	.23	.130
September	150	58	84.2	.170	.19	.110
The year	4260	58	482	.976	13.29	.631
1944–45						
October	973	74	194	0.393	0.45	0.254
November	344	85	120	.243	.27	.157
December	1660	168	431	.872	1.01	.564
January	1390	170	337	.682	.79	.441
February	3470	150	968	1.96	2.04	1.27
March	2240	432	993	2.01	2.32	1.30
April	1710	411	742	1.50	1.68	.969
May	4670	472	1023	2.07	2.39	1.34
June	563	155	314	.636	.71	.411
July	169	108	134	.271	.31	.175
August	616	90	185	.374	.43	.242
September	6130	92	739	1.50	1.67	.969
The year	6130	74	512	1.04	14.07	.672

Monthly discharge of Conococheague Creek at Fairview, Md.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1945–46						
October	344	137	207	0.419	0.48	0.271
November	5570	135	850	1.72	1.92	1.11
December	2630	429	1016	2.06	2.37	1.33
January	2880	390	942	1.91	2.20	1.23
February	2210	301	420	.850	.89	.549
March	1780	678	1065	2.16	2.48	1.40
April	654	281	413	.836	.93	.540
May	5830	250	890	1.80	2.08	1.16
June	4700	367	1200	2.43	2.71	1.57
July	532	143	249	.504	.58	.326
August	2900	125	352	.713	.82	.461
September	604	101	209	.423	.47	.273
The year	5830	101	653	1.32	17.93	.853
1946–47						
October	1560	142	418	0.846	0.98	0.547
November	373	155	212	.429	.48	.277
December	870	120	233	.472	.54	.305
January	2530	327	675	1.37	1.57	.885
February	1630	167	467	.945	.98	.611
March	2740	231	699	1.41	1.63	.911
April	452	310	367	.743	.83	.480
May	2790	387	800	1.62	1.87	1.05
June	1720	327	673	1.36	1.52	.879
July	3420	264	695	1.41	1.62	.911
August	1280	174	345	.698	.81	.451
September	268	108	159	.322	.36	.208
The year	3420	108	480	.972	13.19	.628
1947–48						
October	167	89	106	0.215	0.25	0.139
November	2220	108	472	.955	1.07	.617
December	336	138	218	.441	.51	.285
January	3300	170	489	.990	1.14	.640
February	1400	180	532	1.08	1.16	.698
March	1090	637	816	1.65	1.90	1.07
April	3110	534	1071	2.17	2.42	1.40
May	2790	401	965	1.95	2.25	1.26
June	1800	243	499	1.01	1.13	.653
July	802	142	263	.532	.61	.344
August	574	106	177	.358	.41	.231
September	132	78	96.1	.195	.22	.126
The year	3300	78	474	.960	13.07	.620

Discharge of Conococheague Creek at Fairview, Md.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	539	76	169	0.342	0.40	0.221
November	1880	110	436	.883	.99	.571
December	5280	384	983	1.99	2.29	1.29
January	5230	527	1554	3.15	3.63	2.04
February	1620	755	1123	2.27	2.37	1.47
March	838	313	490	.992	1.14	.641
April	1500	338	572	1.16	1.29	.750
May	808	229	354	.717	.83	.463
June	782	136	224	.453	.51	.293
July	5110	134	804	1.63	1.88	1.05
August	436	130	221	.447	.51	.289
September	244	112	139	.281	.31	.182
The year	5280	76	587	1.19	16.15	.769

YEAR	YEAR ENDING SEPT. 30				CALENDAR YEAR			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1929	533	1.08	14.64	0.698	692	1.40	19.00	0.905
1930	470	.949	12.86	.613	267	.539	7.29	.348
1931	320	.646	8.80	.418	328	.663	9.03	.429
1932	342	.691	9.42	.447	520	1.05	14.31	.679
1933	842	1.70	23.07	1.10	694	1.40	19.03	.905
1934	418	.846	11.47	.547	573	1.16	15.71	.750
1935	579	1.17	15.91	.756	468	.947	12.86	.612
1936	737	1.49	20.31	.963	740	1.50	20.40	.969
1937	787	1.59	21.62	1.03	873	1.77	23.97	1.14
1938	430	.870	11.81	.562	316	.640	8.69	.414
1939	497	1.01	13.66	.653	503	1.02	13.83	.659
1940	559	1.13	15.40	.730	628	1.27	17.30	.821
1941	463	.937	12.73	.606	385	.779	10.56	.503
1942	662	1.34	18.19	.866	855	1.73	23.49	1.12
1943	782	1.58	21.47	1.02	577	1.17	15.85	.756
1944	482	.976	13.29	.631	490	.992	13.51	.641
1945	512	1.04	14.07	.672	622	1.26	17.11	.814
1946	653	1.32	17.93	.853	552	1.12	15.16	.724
1947	480	.972	13.19	.628	474	.960	13.02	.620
1948	474	.960	13.07	.627	546	1.11	15.03	.717
1949	587	1.19	16.15	.769	—	—	—	—
Highest	842	1.70	23.07	1.10	873	1.77	23.97	1.14
Average	553	1.12	15.20	.723	555	1.12	15.26	.726
Lowest	320	.646	8.80	.418	267	.539	7.29	.348

POTOMAC RIVER BASIN

Potomac River at Shepherdstown, W. Va.

Location.—Water-stage recorder, lat. 39°26′04″, long. 77°48′07″, 0.1 mile downstream from Rumsey Bridge at Shepherdstown, Jefferson County, and 3.3 miles upstream from Antietam Creek. Datum of gage is 281.00 feet above mean sea level, adjustment of 1912.

Drainage area.—5936 square miles.

Records available.—August 1928 to September 1949.

Average discharge.—21 years, 5,571 second-feet.

Extremes.—1928–49: Maximum discharge, 335,000 second-feet Mar. 19, 1936 (gage height, 42.1 feet from floodmarks), by slope-area determination; minimum, 231 second-feet Aug. 17, 19, 1930; minimum daily, 252 second-feet Oct. 2, 1932.

Remarks.—Some regulation at low stages by power plants above station.

Monthly discharge of Potomac River at Shepherdstown, W. Va.

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	1,760	458	790	0.133	0.15	0.086
November	4,550	850	1,482	.250	.28	.162
December	1,550	325	769	.130	.15	.084
January	23,900	1,270	4,357	.734	.85	.474
February	24,200	1,570	5,872	.989	1.07	.639
March	46,200	8,670	18,360	3.09	3.57	2.00
April	27,200	6,260	10,940	1.84	2.06	1.19
May	44,800	4,140	10,380	1.75	2.02	1.13
June	4,780	1,620	2,628	.443	.49	.286
July	1,760	681	990	.167	.19	.108
August	802	524	677	.114	.13	.074
September	1,770	335	904	.152	.17	.098
The year	46,200	325	4,849	.817	11.13	.528
1944–45						
October	19,100	620	2,944	0.496	0.57	0.321
November	3,090	846	1,225	.206	.23	.133
December	19,000	1,880	4,662	.785	.91	.507
January	17,200	2,500	5,010	.844	.97	.545
February	43,600	1,940	12,220	2.06	2.14	1.33
March	36,600	4,900	13,560	2.28	2.63	1.47
April	16,000	4,020	6,582	1.11	1.24	.717
May	15,600	4,020	7,239	1.22	1.41	.789
June	4,140	1,730	2,674	.450	.50	.291
July	6,280	990	1,727	.291	.34	.188
August	10,600	945	3,269	.551	.63	.356
September	72,900	1,350	9,848	1.66	1.85	1.07
The year	72,900	620	5,871	.989	13.42	.639

Monthly discharge of Potomac River at Shepherdstown, W. Va.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1945–46						
October	5,560	1,300	2,371	0.399	0.46	0.258
November	25,500	1,230	5,151	.868	.97	.561
December	21,200	3,200	7,599	1.28	1.48	.827
January	23,000	3,430	9,086	1.53	1.76	.989
February	16,000	3,320	6,063	1.02	1.06	.659
March	21,200	6,990	10,410	1.75	2.02	1.13
April	12,600	2,420	4,658	.785	.88	.507
May	21,600	2,630	8,598	1.45	1.67	.937
June	34,700	2,980	7,955	1.34	1.50	.866
July	3,320	900	1,956	.330	.38	.213
August	6,120	975	2,090	.352	.41	.228
September	1,600	665	956	.161	.18	.104
The year	34,700	665	5,580	.940	12.77	.608
1946–47						
October	6,700	765	1,858	0.313	0.36	0.202
November	2,420	778	1,188	.200	.22	.129
December	6,850	678	1,373	.231	.27	.149
January	14,900	2,980	6,060	1.02	1.18	.659
February	9,960	1,400	3,180	.536	.56	.346
March	25,200	1,500	6,881	1.16	1.34	.750
April	7,140	2,980	4,072	.686	.77	.443
May	10,100	3,430	5,699	.960	1.11	.620
June	7,870	1,620	3,480	.586	.65	.379
July	8,990	1,330	3,402	.573	.66	.370
August	5,330	900	2,359	.397	.46	.257
September	1,940	652	1,099	.185	.21	.120
The year	25,200	652	3,400	.573	7.79	.370
1947–48						
October	975	552	705	0.119	0.14	0.077
November	4,640	806	2,605	.439	.49	.284
December	2,590	880	1,592	.268	.31	.173
January	25,500	1,190	4,443	.748	.86	.483
February	29,800	1,200	7,006	1.18	1.27	.763
March	23,100	5,300	10,720	1.81	2.08	1.17
April	67,600	5,160	13,690	2.31	2.57	1.49
May	23,300	2,630	9,608	1.62	1.87	1.05
June	7,900	2,320	3,719	.627	.70	.405
July	4,520	1,380	2,402	.405	.47	.262
August	3,090	2,150	1,904	.321	.37	.207
September	1,900	860	1,204	.203	.23	.131
The year	67,600	552	4,952	.834	11.36	.539

Discharge of Potomac River at Shepherdstown, W. Va.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	11,000	1,300	3,778	.636	.73	.411
November	11,600	1,220	4,410	.743	.83	.480
December	55,700	5,040	14,740	2.48	2.86	1.60
January	44,100	6,160	15,930	2.68	3.09	1.73
February	18,800	8,990	12,770	2.15	2.24	1.39
March	9,310	4,490	6,056	1.02	1.18	.659
April	18,800	3,710	7,284	1.23	1.37	.795
May	11,000	2,960	4,477	.754	.87	.487
June	63,100	1,110	7,905	1.33	1.49	.860
July	40,000	3,000	11,140	1.88	2.16	1.22
August	11,000	1,690	3,475	.585	.68	.378
September	7,290	755	1,878	.316	.35	.204
The year	63,100	755	7,806	1.32	17.85	.853

YEAR	YEAR ENDING SEPT. 30				CALENDAR YEAR			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1929	5,210	0.989	11.91	0.567	6,750	1.14	15.41	0.737
1930	4,200	.708	9.59	.458	2,310	.389	5.28	.251
1931	3,440	.580	7.88	.375	3,600	.606	8.22	.392
1932	4,710	.793	10.79	.513	5,710	.962	13.07	.622
1933	7,670	1.29	17.53	.834	6,840	1.15	15.63	.743
1934	3,130	.527	7.18	.341	3,778	.636	8.65	.411
1935	6,166	1.04	14.08	.672	5,780	.974	13.21	.630
1936	8,389*	1.41	19.25*	.911	8,593	1.45	19.72	.937
1937	7,678	1.29	17.56	.834	8,865	1.49	20.26	.963
1938	5,078	.855	11.61	.553	3,477	.586	7.95	.379
1939	5,574	.939	12.75	.607	5,651	.952	12.93	.615
1940	5,677	.956	13.01	.618	6,273	1.06	14.37	.685
1941	4,583	.772	10.47	.499	3,755	.633	8.58	.409
1942	4,696	.791	10.74	.511	7,431	1.25	16.99	.808
1943	8,338	1.40	19.05	.905	5,515	.929	12.60	.600
1944	4,849	.817	11.13	.528	5,341	.900	12.26	.582
1945	5,871	.989	13.42	.639	6,394	1.08	14.62	.698
1946	5,580	.940	12.77	.608	4,682	.789	10.71	.510
1947	3,400	.573	7.79	.370	3,438	.579	7.88	.374
1948	4,952	.834	11.36	.539	6,474	1.09	14.84	.704
1949	7,806	1.32	17.85	.853	—	—	—	—
Highest	8,389*	1.41	19.25*	.911	8,865	1.49	20.26	.963
Average	5,571	.939	12.75	.607	5,533	.932	12.66	.602
Lowest	3,130	.527	7.18	.341	2,310	.389	5.28	.251

* Revised.

POTOMAC RIVER BASIN

Potomac River at Hancock, Md.

Location.—Water-stage recorder, lat. 39°41′49″, long. 78° 10′ 39″, half a mile downstream from new highway bridge at Hancock, Washington County, 1.1 miles upstream from Great Tonoloway Creek. Datum of gage is 383.46 feet above mean sea level, adjustment of 1912.

Drainage area.—4,073 square miles.

Records available.—October 1932 to September 1949.

Average discharge.—17 years, 4,009 second-feet.

Extremes.—1932–49: Maximum discharge, 340,000 second-feet Mar. 18, 1936 (gage height, 47.6 feet), by slope-area determination; minimum observed, 180 second-feet Oct. 4, 1932 (gage height, 2.01 feet).

Maximum stage known prior to 1932, about 40 feet in May 1889 (discharge about 220,000 second-feet).

Remarks.—Slight regulation at low stages from power plants upstream.

Monthly discharge of Potomac River at Hancock, Md.

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	840	243	391	0.096	0.11	0.062
November	1,190	492	704	.173	.19	.112
December	1,200	295	467	.115	.13	.074
January	21,700	840	2,862	.703	.81	.454
February	19,200	1,170	4,600	1.13	1.22	.730
March	33,700	6,480	13,180	3.24	3.73	2.09
April	18,100	4,220	7,749	1.90	2.12	1.23
May	38,600	2,680	7,382	1.81	2.09	1.17
June	4,570	1,000	1,733	.425	.47	.275
July	1,020	356	566	.139	.16	.090
August	380	300	342	.084	.10	.054
September	1,750	295	581	.143	.16	.092
The year	38,600	243	3,381	.830	11.29	.536
1944–45						
October	19,700	590	2,418	0.594	0.68	0.384
November	3,170	700	968	.238	.27	.154
December	19,400	1,370	3,585	.880	1.01	.569
January	12,500	2,100	3,780	.928	1.07	.600
February	31,800	1,500	9,234	2.27	2.36	1.47
March	28,000	3,280	9,724	2.39	2.75	1.54
April	8,180	2,470	4,188	1.03	1.15	.666
May	8,390	2,190	4,377	1.07	1.24	.692
June	2,680	970	1,551	.381	.42	.246
July	8,180	453	1,160	.285	.33	.184
August	7,130	495	2,149	.528	.61	.341
September	56,000	750	6,756	1.66	1.85	1.07
The year	56,000	453	4,124	1.01	13.74	.653

Monthly discharge of Potomac River at Hancock, Md.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1945–46						
October	3,580	678	1,357	0.333	0.38	0.215
November	15,300	646	3,543	.870	.97	.562
December	10,900	1,750	4,196	1.03	1.19	.666
January	20,000	1,990	6,229	1.53	1.76	.989
February	12,000	1,990	4,653	1.14	1.19	.737
March	13,200	4,530	7,030	1.73	1.99	1.12
April	10,400	1,510	3,174	.779	.87	.503
May	15,300	1,860	6,532	1.60	1.85	1.03
June	22,900	1,860	4,859	1.19	1.33	.769
July	2,330	471	1,093	.268	.31	.173
August	3,720	365	875	.215	.25	.139
September	418	273	329	.081	.09	.052
The year	22,900	273	3,655	.897	12.18	.580
1946–47						
October	4,160	345	882	0.217	0.25	0.140
November	1,090	447	559	.137	.15	.089
December	4,990	386	887	.218	.25	.141
January	10,200	1,800	4,099	1.01	1.16	.653
February	5,740	900	1,987	.488	.51	.315
March	19,200	960	4,841	1.19	1.37	.769
April	5,930	1,920	3,028	.743	.83	.480
May	7,760	2,400	3,847	.945	1.09	.611
June	4,530	726	1,933	.475	.53	.307
July	3,660	540	1,636	.402	.46	.260
August	3,730	441	1,394	.342	.39	.221
September	1,060	355	632	.155	.17	.100
The year	19,200	345	2,152	.528	7.16	.341
1947–48						
October	408	303	328	0.081	0.09	0.052
November	3,980	447	1,661	.408	.45	.264
December	1,490	678	1,054	.259	.30	.167
January	18,000	800	3,031	.744	.86	.481
February	22,500	840	5,560	1.37	1.47	.885
March	24,800	3,500	7,992	1.96	2.26	1.27
April	58,300	3,430	10,310	2.53	2.82	1.64
May	16,500	1,480	6,313	1.55	1.79	1.00
June	5,930	1,260	2,330	.572	.64	.370
July	3,280	750	1,566	.384	.44	.248
August	2,120	662	1,202	.295	.34	.191
September	1,860	477	842	.207	.23	.134
The year	58,300	303	3,501	.860	11.69	.556

Discharge of Potomac River at Hancock, Md.—Continued

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	10,600	734	2,762	0.678	0.78	.438
November	10,400	898	3,153	.774	.86	.500
December	49,700	3,500	10,730	2.63	3.04	1.70
January	29,300	4,050	10,920	2.68	3.09	1.73
February	13,000	6,200	8,915	2.19	2.28	1.42
March	6,120	3,200	4,240	1.04	1.20	.672
April	18,100	2,470	5,331	1.31	1.46	.847
May	8,430	1,800	2,936	.721	.83	.466
June	77,600	710	7,285	1.79	2.00	1.16
July	29,900	1,580	6,825	1.68	1.93	1.09
August	9,070	1,100	2,672	.656	.76	.424
September	3,890	588	1,115	.274	.31	.177
The year	77,600	588	5,561	1.37	18.54	.885

YEAR	YEAR ENDING SEPT. 30				CALENDAR YEAR			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1933	5,130	1.26	17.12	0.814	4,678	1.15	15.60	0.743
1934	2,070	.508	6.91	.328	2,378	.584	7.92	.377
1935	4,388	1.08	14.61	.698	4,281	1.05	14.26	.679
1936	5,813	1.43	19.43	.924	5,964	1.46	19.93	.944
1937	5,202	1.28	17.35	.827	6,055	1.49	20.19	.963
1938	3,623	.890	12.08	.575	2,422	.595	8.08	.385
1939	3,940	.967	13.13	.625	3,955	.971	13.18	.628
1940	3,982	.978	13.31	.632	4,331	1.06	14.48	.685
1941	2,986	.733	9.95	.474	2,524	.620	8.40	.401
1942	2,985	.733	9.96	.474	4,902	1.20	16.34	.776
1943	5,652	1.39	18.83	.898	3,688	.905	12.29	.585
1944	3,381	.830	11.29	.536	3,838	.942	12.82	.609
1945	4,124	1.01	13.74	.653	4,298	1.06	14.32	.685
1946	3,655	.897	12.18	.580	3,089	.758	10.29	.490
1947	2,152	.528	7.16	.341	2,210	.543	7.35	.351
1948	3,501	.860	11.69	.556	4,649	1.14	15.53	.737
1949	5,561	1.37	18.54	.885	—	—	—	—
Highest	5,813	1.43	19.43	.924	6,055	1.49	20.19	.963
Average	4,009	.985	13.37	.637	3,954	.970	13.19	.627
Lowest	2,070	.508	6.91	.328	2,210	.543	7.35	.351

POTOMAC RIVER BASIN

Tonoloway Creek near Hancock, Md.

Location.—Water-stage recorder and concrete control, lat. 39°42′45″, long. 78°13′55″, at county highway bridge, 100 feet downstream from Little Tonoloway Creek and 2.8 miles northwest of Hancock, Washington County.

Drainage area.—16.9 square miles.

Records available.—August 1947 to September 1949.

Extremes.—1947–49: Maximum discharge, 764 second-feet July 17, 1949 (gage height, 4.45 feet); no flow at times.

Monthly discharge of Tonoloway Creek near Hancock, Md.

MONTH	DISCHARGE IN SECOND-FEET				RUNOFF IN INCHES	DISCHARGE IN MILLION GALLONS PER DAY PER SQUARE MILE
	Maximum	Minimum	Mean	Per square mile		
1947						
August 27–31	0.6	0.2	0.45	0.027	0.005	0.017
September	.4	0	.12	.0071	0.008	.005
The year						
1947–48						
October	1.6	0.0	0.09	0.0053	0.006	0.003
November	13	.3	2.47	.146	.16	.094
December	2.1	.3	.97	.057	.07	.037
January	140	.8	12.1	.716	.83	.463
February	50	.2	15.5	.917	.99	.593
March	59	9.6	29.6	1.75	2.02	1.13
April	170	6.5	38.3	2.27	2.53	1.47
May	111	3.8	31.1	1.84	2.12	1.19
June	7.9	.8	2.40	.142	.16	.092
July	1.4	0	.24	.014	.02	.009
August	.5	0	.03	.0018	.002	.001
September	.6	0	.05	.0030	.004	.002
The year	170	0	11.1	.657	8.91	.425
1948–49						
October	13	0	2.73	0.162	0.19	.105
November	40	1.6	9.65	.571	.64	.369
December	274	6.5	43.0	2.54	2.94	1.64
January	226	7.0	49.2	2.91	3.35	1.88
February	48	17	32.0	1.89	1.97	1.22
March	17	5.0	10.4	.615	.71	.397
April	31	5.5	15.2	.899	1.00	.581
May	37	3.0	8.27	.489	.56	.316
June	6.0	.2	1.44	.085	.10	.0549
July	330	0	28.3	1.67	1.93	1.08
August	37	.2	3.72	.220	.25	.142
September	2.7	.2	.86	.051	.06	.0330
The year	330	0	17.1	1.01	13.70	.653

POTOMAC RIVER BASIN

Licking Creek near Sylvan, Pa.

Location.—Chain gage, lat. 39°43′20″, long. 78°03′35″, at highway bridge 200 feet north of Pennsylvania-Maryland State line, 3 miles southwest of Sylvan, Franklin County, and 10 miles upstream from mouth. Datum of gage is 434.16 feet above mean sea level, adjustment of 1907.

Drainage area.—158 square miles.

Records available.—June 1930 to January 1942 (discontinued).

Average discharge.—11 years (1930–41), 166 second-feet.

Extremes.—1930–41: Maximum discharge, 20,700 second-feet Mar. 18, 1936 (gage height, 17.4 feet, from floodmark), by contracted-opening method; minimum observed, 3.0 second-feet Aug. 8, 1930 (gage height, 0.64 foot).

Remarks.—Gage read twice daily.

Yearly discharge of Licking Creek near Sylvan, Pa.

YEAR	YEAR ENDING SEPT. 30				CALENDAR YEAR			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1931	114	0.722	9.75	0.467	116	0.734	10.00	0.474
1932	119	.753	10.26	.487	165	1.04	14.20	.672
1933	240	1.52	20.60	.982	201	1.27	17.20	.821
1934	94.8	.600	8.13	.388	129	.816	11.04	.527
1935	168	1.06	14.48	.685	142	.899	12.18	.581
1936	230	1.46	19.79	.944	234	1.48	20.20	.957
1937	237	1.50	20.38	.969	271	1.72	23.24	1.11
1938	137	.867	11.78	.560	104	.658	8.97	.425
1939	161	1.02	13.85	.659	164	1.04	14.09	.672
1940	184	1.16	15.85	.750	195	1.23	16.76	.795
1941	139	.880	11.95	.569	112	.709	9.61	.458
Highest	240	1.52	20.60	.982	271	1.72	23.24	1.11
Average	166	1.05	14.26	.679	167	1.06	14.32	.685
Lowest	94.8	.600	8.13	.388	104	.658	8.97	.425

SOILS OF WASHINGTON COUNTY

BY

M. F. HERSHBERGER AND R. S. LONG

INTRODUCTION

Soil is a relatively thin mantle of weathered material covering the surface of the earth and coming from a wide variety of parent rocks. This material has been modified in many ways by climate, vegetation, water, chemical and biological activity, and other soil-forming forces. Due to the great variety of parent materials in Washington County, upon which the soil-forming processes are active, a wide variety of soils occurs. The topography presents nearly every variation from flat bottom lands along the streams to high mountain slopes. Narrow ridges, with steep side slopes, are mixed with hilly and hummocky land, with no regularity in their occurrence.

Many of the soils mapped in the county were separated on the basis of kind of rock materials from which they were derived. Soils from widely different materials have varying degrees of fertility. Other soil separations were based upon depth, degree of stoniness, and natural drainage of the land, all of which determine the use that should be made of the land. Many of the soils on the steeper slopes have been eroded, leaving soils that are too shallow for good root development. Other soils along streams are still receiving deposits of soil material washed from the higher land. With increased knowledge of the soil in recent years has come increased realization of the significance of the soil in relation to land use and its importance in relation to other elements in agriculture.

SOIL SURVEYS OF WASHINGTON COUNTY

The first soil survey of Washington County was made in the summer of 1917 by field men of the United States Department of Agriculture, Bureau of Soils, and the Maryland Agricultural Experiment Station, in cooperation with the Maryland Geological Survey. A survey report, prepared by R. T. Avon Burke of the Bureau of Soils, and O. C. Bruce of the Maryland Agricultural Experiment Station, was published in 1919 by the Bureau of Soils. The work was done by using U. S. Geological Survey topographic quadrangles as a base on which the soil types were mapped. These soil maps, on a scale of approximately one inch to the mile, give a good general picture of the soils of the county as classified at that time. County soil maps based on this survey are available from the Department of Geology, Mines and Water Resources (The Johns Hopkins University, Baltimore, 18) or the Maryland Agricultural Experiment Station (College Park).

In 1935, a soil conservation project was established in the southeastern part of Washington County to demonstrate practices that could be applied to conserve soil and water on individual farms. The area consisted of approximately 30,000 acres comprising the watersheds of Little Antietam Creek and Israel Creek. It was necessary to obtain individual farm maps on a large scale, showing soil type, slope, erosion conditions, and land use in sufficient detail to serve as a guide in the planning, field by field. The farms and all other lands in the area were mapped in detail, using aerial photographs as a base. The maps were on the scale of eight inches to the mile.

In 1939, the farmers of Washington County organized a soil conservation district embracing the entire county. As part of the assistance requested from the Soil Conservation Service, a soil, slope, erosion, and land use survey was started in 1940 and completed in 1943. Aerial photographs on a scale of four inches to the mile were used. The survey excluded the demonstrational area already mapped on a scale of eight inches to the mile. The object of the survey is to supply a detailed accurate map of land conditions as an aid in planning soil and water conservation programs. Maps of individual farms are copied photographically for the farmers as they work out farm conservation plans. No provision has been made for publication of a county map. The large scale of the soil conservation survey field sheets made it possible to supply detailed soil information, along with slope and erosion conditions and other physical facts about the land. This information was needed for conservation planning of individual farms and fields.

TABLE 8

SUMMARY OF LAND CONDITIONS IN WASHINGTON COUNTY

(Exclusive of cities)

	SOUTH MOUNTAIN	PLEASANT VALLEY	GREAT VALLEY LIMESTONE	GREAT VALLEY SHALE	RIDGE AND VALLEY	ENTIRE AREA
Total area (acres)	48,079	3,835	163,306	10,225	66,558	292,003
Per cent in crops	25.2	76.6	79.9	70.6	31.9	59.6
Per cent in land-capability classes I–IV (suited for cultivation)	53.0	95.3	86.3	71.0	70.3	77.1
Per cent in very steep slopes	6.4	2.6	3.7	14.6	12.8	6.1
Per cent severely eroded	0.7	2.2	1.0	6.1	2.6	2.3
Per cent stony soils	44.1	2.4	26.4	0	12.5	24.9
Fertility	Moderate	Moderately high	High	Moderate	Low	—
Per cent of cropland in land-capability classes VI and VII (not suited for cultivation)	7.7	2.9	9.2	20.7	12.7	9.9

LAND CAPABILITY CLASSIFICATION

The conservation survey supplies the basic facts concerning depth, texture, permeability, available moisture capacity, inherent fertility, organic matter content, and other characteristics that affect the use and treatment of the land. It gives facts as to slope, erosion conditions, and natural drainage of the land. These recorded facts, along with other recorded data, research findings, technical information, and practical experiences are used to classify the land according to its capability or its ability to produce permanently under specified uses and treatments.

The land capability classification used in Washington County has the following classes and subclasses:

Land suited for cultivation

Class I—Land of this class is subject to no more than very slight limitations in use. It is very good land that can be cultivated safely with ordinary methods of good farming.

Class II—Land of this class is subject to moderate limitations in use for crop production. It is good land that can be cultivated safely with special practices of easy application.

Class III—Land of this class is subject to severe limitations in use for crop production. It is subject to serious damage from the standpoint of crop production, if used without adequate protection or treatment. It is moderately good cultivable land that can be used regularly for crops when properly treated.

Class IV—Land of this class is subject to very severe limitations in use for crop production. It is fairly good land, which can be maintained best by keeping it in perennial vegetation. It can be cultivated occasionally for plowed crops if handled with great care.

Land not suited for cultivation

Class V—Land of this class is not suited for cultivation, but is suited for grazing, forestry, and wildlife. It has only slight limitations in use. (Does not occur in Washington County.)

Class VI—Land of this class is subject to moderate limitations for grazing or woodland use.

Class VII—Land of this class is subject to severe limitations for grazing or woodland use.

Class VIII—Land of this class has limitations that make it unsuitable for cultivation, grazing, or forestry. It has use, however, for wildlife, recreation, or watershed purposes. (Class VIII, in Washington County, includes only quarries and rock outcrops that are usually of limited extent and are too small to show on the maps.)

In Washington County land capability classes II, III and IV are each subdivided into three subclasses according to the kind of land limitations. The subclasses recognized, and the symbols used to designate them, are as follows:

e—Dominant limitation is susceptibility to erosion.

w—Dominant limitation is excess water, such as that produced by seepage, high water table, or floods.

s—Dominant limitation is an outstandingly unfavorable soil characteristic, such as low moisture capacity, excess gravel or stones, shallow effective depth, etc.

General agricultural and land conditions

Before a suitable land capability classification for the county could be prepared it was necessary to collect detailed and general information regarding the soils and land use. It was also necessary to define, classify, and analyze all of the data collected in order to determine the proper treatment for the land.

According to the 1945 agricultural census the value of agricultural products was $7,980,393 in this county. This was produced on 229,496 acres of land on farms that had an average value of $78.85 per acre.

The county extends from South Mountain on the east, across the Great Valley and into the folded areas of the Ridge and Valley section to the west. From an agricultural standpoint, the county includes five areas that differ considerably in topography and in the character of the rocks and the soils that have developed on them. These differences are reflected in the type and intensity of agriculture in each area.

The five areas are (Fig. 44):

1. South Mountain—Elk Ridge.

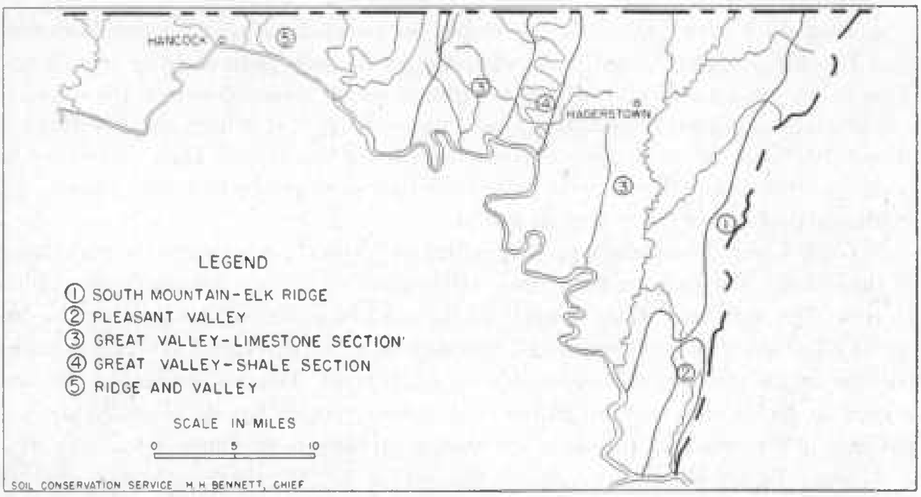

FIGURE 44. Map of Washington County Showing Agricultural Areas Based on Topographic and Soil Differences.

2. Pleasant Valley, which lies between these two mountain ridges.
3. The limestone area of the Great Valley.
4. The Martinsburg shale area along the western edge of the Great Valley.
5. The Ridge and Valley area.

The soil conservation survey of the county, which was completed in 1943, resulted in a map showing the kind of soil, the steepness of slope, the degree to which soil erosion had developed, and land use at the time of mapping for every acre in the county. The maps have been measured and the data recorded, showing the number of acres having each combination of the conditions considered in the survey. An analysis of these data brings out clearly some of the significant characteristics of each area. Plates 23 to 28 are samples of these maps illustrating the five areas.

1. South Mountain-Elk Ridge Area—The soils in this area of more than 50,000 acres are derived from quartzites and slates with some metabasalt and phyllites.

The area also includes some colluvial and alluvial areas covered by materials from the same sources. Most of the rocks give rise to soils with mediocre native fertility. The soils are shallow to rock and there are large areas in which rock outcrops are so frequent as to interfere with cultivation.

About 6 per cent of the land lies on slopes with a gradient steeper than 25 per cent (one foot rise in four feet horizontally). This land is too steep for cultivation. Other factors, primarily stoniness of the soil, have a much greater influence on the suitability of land for cultivation, so that only 52 per cent of the area can be used for that purpose with varying degrees of difficulty or hazard. Soil erosion is not a major factor, only a few hundred acres being so severely eroded that they should not be tilled. The erosion problem is moderate over the entire area.

About one-fourth of the land is used for the production of cultivated crops and nearly two-thirds is covered with woods. Permanent pastures occupy a small part of the area.

2. *Pleasant Valley*—The valley is locked between the ridges of South Mountain and Elk Ridge. It is floored with relatively fertile soils derived from metabasalt. This valley has an area of nearly 4000 acres, of which about 95 per cent is suited to the production of field crops. More than three-fourths of it is used for that purpose. About 100 acres lie on slopes too steep for cultivation, and 85 acres have been so severely eroded that they should not be used for crop production. Soil erosion is a moderate problem over the area as a whole.

3. *Great Valley-Limestone Area*—This area of 160,000 acres covers the major part of the county. The soils are very fertile although some of them are relatively shallow to rock. The agricultural use of much of the shallow soil is further impeded by frequent outcrops of parallel rock ribs. Although only 80 per cent of the land is under cultivation, 87 per cent of it is suitable for cultivation. About 4 per cent of the land occurs on slopes of more than 25 per cent. Severe erosion has developed on only 1 per cent of the area and in general the erosion problem is moderate.

4. *Great Valley-Martinsburg Shale Area*—This belt of shallow, highly erodible soils lies near the western edge of the Great Valley. The soils are only moderately fertile. Only 70 per cent of the area of 10,000 acres is suited to cultivation, and the same proportion is used for that purpose. The choice of cropland has not always been well made, however, and more than one-fifth of the present cropland is on land not physically suited for cultivation.

More than one-seventh of the land is on slopes steeper than 25 per cent. About 6 per cent of the land has been made unfit for cultivation by severe erosion. Very shallow soils also impose a limitation on the use of some of the land. The erosion problem is serious over the entire section.

5. *Ridge and Valley Area*—This area of more than 60,000 acres covers the western end of the county. The country is strongly rolling and about an eighth of it lies on slopes steeper than 25 per cent. Severe erosion, limiting agricultural use, has developed on 1700 acres. Shallow and stony soils also limit the use of some areas. About one-third of the land is not suited to cropping.

Agriculture has not developed extensively in this section. The soils are developed from sandstones and shales, and have a low native fertility. Less than one-third of the area is used for crop production, and nearly 60 per cent is wooded. Erosion is a serious problem especially on the soils of shale origin.

SOIL GROUPS

Land-capability classes are general groups of land arranged according to the degree that land use is limited by physical characteristics. One land-capability class may include several different soils, each occurring on a specified range of slope. Within each land-capability class it is necessary to refer to significant variations in soils, slopes, and other physical land features in order to make precise recommendations for use, management, and conservation of the land. This is done by recognizing subclasses and significant variations within subclasses. As an aid in organizing information about these significant variations in land, the soils in the county may be placed in 25 groups. These groups are subject to revision as knowledge of the soils increases.

The soils in any group have limited differences in depth of weathering, character of parent material, natural drainage, texture, and permeability. They are near enough alike that fairly detailed recommendations on type of farming, type of crop, and type of treatment may be made by slope classes for the entire group. By considering the land capability class and the soil group, proper recommendations may be made for good agricultural use and treatment of any tract of land in the county.

DESCRIPTION OF SOILS

Soils that have similar physical characteristics are grouped together. Designations of the groups indicate effective soil depth, texture, natural drainage, permeability, and available moisture capacity.

Soil Group 1

The soils in Group 1 are deep, well-drained, medium to heavy-textured, slightly acid, and moderately permeable. They have a high available moisture capacity and high inherent fertility, and are moderately erodible. They are derived from and underlain by limestone. They are adapted to a wide variety of crops and are particularly well adapted to all legumes. Included are:

Hagerstown silt loam
Hagerstown silty clay loam
Duffield silt loam

These three soils constitute the largest single group of cropland soils in the county. They are capable of producing high yields of corn, wheat, barley, clover, timothy, alfalfa, and most canning crops. More than 85 per cent of these soils occur on less than an 8 per cent slope.

The Hagerstown soils are developed from very pure massive limestones of the Beekmantown and Stones River geological formations. Limited areas of Conococheague and Elbrook limestones and Tomstown dolomitic limestone also comprise some of the rock from which the soils are derived.

The Duffield soil occurs on the Elbrook and Conococheague limestones and Tomstown dolomitic limestone. Limited areas of that soil are developed on the Beekmantown limestone. The Duffield soil is slightly deeper and more mellow and friable than the Hagerstown, especially in the subsoil. The average per cent slope is higher on the Duffield than on the Hagerstown.

These soils have been cropped regularly in the past. They seldom lay bare over winter. Some small grain is always sown. Although erosion on the three soils is only moderate, the use of new methods of farming makes erosion control imperative.

Soil Group 2

The soils of Group 2 are deep, well-drained, and medium-textured. They need very little lime. They are moderately permeable and have high available moisture capacity and inherent fertility. They have been formed on flood plains and at the base of slopes in limestone areas on materials derived chiefly from limestone with some shale and sandstone. They may be subject to occasional flooding, being restricted in use because of this hazard. They are well adapted to corn and a wide variety of crops. They are:

Huntington gravelly loam
Huntington silt loam
Emory silt loam

These are the most productive soils of the county. More than 90 per cent of the area occurs on less than 3 per cent slope. The cropping intensity is limited by flooding. Corn and truck crops make their highest yields on these soils.

The Huntington soils generally occur along stream bottoms in limestone areas. The Emory soil occurs at the base of slopes or in basins in all of the limestone areas. These soils are made up of topsoil accumulated from the steeper sloping limestone soils.

Soil Group 3

The soils in Group 3 are deep, well drained, medium textured, and moderately acid. They are moderately permeable, have moderate available moisture capacity, moderately high inherent fertility, and are moderately erodible. They are derived from underlying metabasalt rock. They are well adapted to general farm crops, but from present knowledge alfalfa is likely to fail. They are:

Fauquier channery loam
Fauquier silt loam
Myersville channery loam
Myersville silt loam

These soils comprise the major portion of the cropland of Pleasant Valley. Yields of corn, wheat, barley, clover, timothy, and canning crops are very good. The soils are chiefly derived from the Catoctin metabasalt.

The Fauquier soils have a light brown to moderate brown topsoil over a reddish-brown heavier subsoil. The Myersville soils have a light yellowish-brown or yellow to yellowish-brown friable subsoil. Eighty-five per cent of soil group 3 occurs on 10 to 15 per cent slopes.

Erosion is slightly greater than that of soils in Group 1.

Soil Group 4

The soils in Group 4 are deep, well-drained, medium-textured, moderately acid, and moderately permeable. They have moderately high inherent fertility and available moisture capacity. They are developed on flood plains from soil materials derived from shale, sandstone, and metabasalt. They are adapted to a wide variety of crops but restricted in use because of flood hazard. They are:

Pope gravelly loam
Pope silt loam
Congaree gravelly loam
Congaree silt loam

These soils are almost equal to Soil Group 2 in crop production where not subject to damaging stream overflow. The Pope soils occur in the shale and sandstone areas of the western part of the county, and the Congaree soils occur in the eastern part of the county. The latter are associated with the Catoctin metabasalt, Harpers phyllite, Loudon formation, and the Antietam and Weverton quartzites. Over 90 per cent of these soils occur on less than 3 per cent slope and 60 per cent in cropland.

Soil Group 5

The soils in Group 5 are deep, well-drained, medium-textured, slightly to moderately acid, moderately permeable, and erodible. They have a moderate to high available moisture capacity and inherent fertility. They are derived chiefly from sandstone and shale material on terraces or lower slopes. They are adapted to a wide variety of crops and are particularly well adapted to deep-rooted crops, such as alfalfa and orchard trees. They are:

Elk gravelly loam
Elk silt loam
Murrill gravelly loam
Murrill gravelly silt loam
Murrill silt loam
Holston silt loam
Holston gravelly loam

The Elk soils are developed on terraces in limestone areas from water-transported material adjacent to streams, chiefly along Antietam Creek. The gravel is water-rounded and in good cuts the layers of sand and gravel material are evident. Ninety-nine per cent of this soil is cleared and 70 per cent of the area is on less than 8 per cent slope.

The Murrill soils consist largely of colluvial material of sandstone and shale origin.

They are derived from the McKenzie formation, Clinton shale, Martinsburg shale, Tuscarora sandstone east of Powell Mountain, and Antietam quartzite west of South Mountain. These materials have moved down over the limestone soils so that the subsoil is of limestone origin whereas the soil is of sandstone and shale origin. In most places partially rounded gravel and stones occur on the surface and throughout the soil. The internal drainage is generally very good. Hummocky topography is characteristic of the surface. Ninety per cent is cleared, 10 per cent is on less than 3 per cent slope, and 65 per cent is on less than 8 per cent slope.

The Holston soils are developed on terraces adjacent to streams. They are deposited from soil materials washed from other soils that were originally formed from Oriskany, Purslane and Tuscarora sandstones, Martinsburg and Romney shales, and the Jennings formation. Holston soils differ from Elk soils in being more acid and yellowish-brown instead of reddish-brown in subsoil, and occur on sandstone and shale soils. About 90 per cent is cleared, 10 per cent is in woodland, and 75 per cent of the area occurs on slopes of 4 to 15 per cent.

All soils of this group are capable of high production and respond to good treatment.

Soil Group 6

The soils in Group 6 are well-drained, light-textured, slightly to moderately acid, and moderately permeable. They have a moderate available moisture capacity and moderate inherent fertility. They developed on flood plains derived from limestone, shale, and sandstone materials, and may be subject to occasional flooding. They are adapted to a wide variety of crops, particularly truck crops, but are restricted for use due to flooding. They include:

- Pope gravelly sandy loam
- Pope fine sandy loam
- Cacapon fine sandy loam
- Huntington fine sandy loam
- Ashton fine sandy loam

The Pope soils in this group differ from those in Soil Group 4 in that they are lighter textured and leaching of plant food is more rapid. Also, soils of this group warm up earlier in the spring and have a lower water-holding capacity in the surface layer. They are derived from yellow and gray sandstones and shales and are predominant on the flood plains in the western part of the county.

The Cacapon series is derived from soils formed from Wills Creek shale and the Catskill formation, locally called red shale. They are found in the western part of the county, are mostly forested, and occur on less than 3 per cent slope.

Huntington and Ashton series occur along Antietam Creek and Potomac River where limestone soils have played a large part in their formation. The Huntington soil is generally slightly alkaline or "sweet" throughout the surface and subsoil and is subject to stream overflow. The Ashton soil is a high-bottom phase of Huntington, more developed, not as sweet, and is seldom flooded, making it the most ideal truck soil in the county.

Soil Group 7

The soils in Group 7 are moderately deep to deep, well-drained, medium-to-heavy-textured, slightly acid, moderately permeable, and moderately erodible. They are developed from underlying massive and thin-bedded limestones with silt, stone, and chert layers and interbedded calcareous sandstones, cherty limestones, shales, and sandstones. They are adapted to general farm crops, and require more treatment to till and maintain high productivity. They are:

Chilhowie clay loam
Westmoreland silt loam
Hagerstown clay loam
Frankstown cherty silt loam
Frankstown channery silt loam
Frederick cherty silt loam
Benevola clay loam
Dunnmore cherty silt loam

The heavier-textured clay loam soils in this group may be grouped separately for treatment where they are extensive.

The Chilhowie clay loam is derived from the Chambersburg formation. It is a limestone soil found largely along either side of the Martinsburg shale area. It is heavy and not as easily tilled as some of the other limestone soils.

The Westmoreland silt loam is derived chiefly from the Wills Creek shale, and occurs in the western part of the county east of Tonoloway Ridge and west of Powell Mountain. Fifty per cent of the area occurs on a 15 per cent slope and 70 per cent is cleared. The average slope on 99 per cent of the area is 12 per cent.

The Hagerstown clay loam is found only on the highly pure limestone of the Stones River formation. It is difficult to till although not as plastic as Chilhowie.

Frankstown cherty silt loam and Frankstown channery silt loam are found chiefly east of Hagerstown and in limited areas east of Powell Mountain. They are formed chiefly on the Elbrook formation. They have some of the characteristics of Duffield soils but are not as deep. Ninety-five per cent is cleared with the channery silt loam occurring on steeper slopes than the cherty phase.

Frederick cherty silt loam occurs in the western part of the county. It is derived from the cherty limestone part of the Oriskany formation and from parts of the Helderberg limestone. Fifty-five per cent of the area is still in forest. The average slope is between 15 and 20 per cent. The chert is very hard on farm equipment.

Benevola clay loam is a limestone-derived soil coming from a hard sandy-like limestone that effervesces only slightly or not at all with hydrochloric acid. The soil occurs only near Benevola, Wagners Crossroad, and southeast of Sharpsburg. It was the only residual soil in the county that showed no need for lime in the surface layer.

Dunnmore cherty silt loam occurs in a limited area north of Hancock on the Helderberg limestone. Dunnmore differs from Frederick cherty silt loam in that it has a slightly lower permeability in the subsoil and is yellowish-brown, whereas

Frederick has a pink or salmon-red color. Those soils as a group are of lower natural fertility and heavier textured, with stone fragments. They are shallower than soil in Group 1.

Soil Group 8

The soils in Group 8 are deep, well-drained, medium-textured, moderately acid, moderately permeable, and erodible. They have a moderate to low available moisture capacity and moderate inherent fertility. They are derived from metabasalt, quartzite, sandstone, shale, diabase, and cherty limestone. They are adapted to general farm crops and orchards. Included are:

Allen gravelly loam
Laidig gravelly loam
Highfield channery loam
Clifton channery loam
Thurmont gravelly loam
Montalto silt loam
Waynesboro gravelly loam
Elliber cherty loam

Allen gravelly loam occurs along the base of the slopes of South Mountain, on colluvial material coming from the Catoctin metabasalt, Weverton quartzite, and Harpers phyllite. Fifty-five per cent is cleared and 90 per cent is on 6 to 10 per cent slopes.

Thurmont gravelly loam occurs generally in the same position and is derived from the same kind of material as Allen. It is 60 per cent cleared. The Allen subsoil is reddish-brown, whereas the Thurmont is yellowish-brown. Both are well adapted to fruit trees and berries.

Laidig gravelly loam is a colluvial soil that occurs throughout the county. The larger areas are in the western part. The material is chiefly from gray sandstones, quartzites, and yellow shales worked down near the base of the slopes. The underlying material is generally derived from shale. Small areas were mapped adjacent to Murrill soils toward the mountain, where the limestone becomes too deep to have any influence on the growth of vegetation. Fifty per cent of the area is wooded and the remainder is cleared. The average slope is 12 per cent.

Highfield channery loam is found in the South Mountain and Elk Ridge area and is derived from the Catoctin metabasalt. Fifty per cent of the area mapped is cleared, and 50 per cent is on a 6 per cent slope.

Clifton channery loam is associated with Highfield soils, occurring in the same areas and derived from the same geologic formation. Fifty per cent of the area is cleared with about 50 per cent on a 7 per cent slope. The Highfield has a yellowish-brown subsoil. The Clifton has a reddish-brown.

Montalto silt loam is derived from a diabase that has protruded through the geologic strata at several points from Boonsboro south through Pleasant Valley to the Potomac River. It is not extensive. The soil here does not have the red color typical of other areas of Montalto soils.

Waynesboro gravelly loam is on an old high terrace along the Potomac River about 80 to 100 feet above the present stream. Origin of material is chiefly gray shales and sandstones similar to Holston. The Waynesboro soil is on an older terrace than the Holston. It has a reddish-brown subsoil in contrast to yellowish-brown for the Holston. Sixty-five per cent of this soil is cleared with 65 per cent on 5 to 6 per cent slopes.

Elliber cherty loam is very high in chert, difficult to plow, and very abrasive on tillage tools. It is derived from the Helderberg limestone. It differs from Frederick soil in that the surfaces are generally higher in chert content and the subsoil is yellowish-brown whereas the Frederick is more pink to reddish-brown. It occurs in scattered areas in the western part of the county from Powell Mountain to Tonoloway Ridge.

The soils in this group in general can be made very productive but stone fragments are generally a problem for some truck crops.

Soil Group 9

The soils in Group 9 are deep, imperfectly-drained, medium-textured, non-acid, and moderately to slowly permeable. They have a moderate available moisture capacity and moderate inherent fertility. Because they are subject to frequent stream overflow, use for crops is limited. They are not adapted to crops requiring well-drained soils. Included are:

Lindside silt loam
Lindside gravelly loam
Algiers silt loam
Warners loam
Wiltshire silt loam

Lindside silt loam is found in limestone areas along streams. It is subject to periodic overflow and produces good yields of crops that grow well on rather wet land. It produces excellent Ladino clover-grass pasture. Over 95 per cent is on less than 3 per cent slope, 92 per cent is cleared, and 55 per cent is farmed.

Algiers silt loam is found in limestone areas where recent deposition on bottom land has changed the soil from a dark, poorly-drained surface soil to a grayish-yellow to yellow well-drained surface soil over a dark-gray to black (original surface) subsoil. Over 95 per cent is cleared and 98 per cent is on less than 3 per cent slope.

Warners loam is in reality a marl deposit. These deposits are scattered throughout the limestone area with varying amounts of calcium carbonate. Ninety-nine per cent of the area is cleared with 95 per cent on less than 3 per cent slope. Several commercial pits are in operation. The moisture content varies considerably at different periods of the year. The soil varies from being well-drained to droughty or poorly-drained, depending on the season of the year.

Lindside gravelly loam is similar to Lindside silt loam and is not extensive.

Wiltshire silt loam occupies areas at the base of slopes in the limestone area. It is the imperfectly-drained counterpart of Emory silt loam. Eighty-eight per cent of the area occurs on less than 3 per cent slope, and 96 per cent is cleared. The soil is adapted to most crops not hampered by wet feet.

The soils in this group are best suited to hay-pasture mixtures.

Soil Group 10

The soils in Group 10 are deep, imperfectly-drained, medium-textured, moderately acid, and moderately permeable. They have a moderate available moisture capacity and moderate inherent fertility. They are developed on flood plains and are subject to frequent stream overflow. They are limited in crop use because of the hazard of stream overflow and natural drainage condition. They are:

Largent silt loam
Philo silt loam
Codorus silt loam

Largent silt loam is the imperfectly-drained counterpart of Cacapon series found in the red shale and sandstone areas of the western part of the county. They are limited in extent and use. The best land use is pasture. Fifty per cent is cleared.

Philo silt loam is the imperfectly-drained counterpart of the Pope series from gray sandstone and gray and yellow shales. Eighty-five per cent is cleared and 92 per cent is on slopes of less than 3 per cent.

Codorus silt loam is the imperfectly-drained separation of Congaree. Ninety per cent of this soil is cleared and 90 per cent is on slopes less than 3 per cent.

Over a period of years these soils would give their best returns in pasture as they are all subject to periodic flooding.

Soil Group 11

The soils in Group 11 are deep, imperfectly drained, light textured, moderately acid, and rapidly permeable. They have a moderate inherent fertility and low available moisture capacity. They are deposited along streams and are subject to frequent stream overflow. They are limited in crop use because of flooding and natural drainage condition. Some truck crops are adapted. Included are:

Philo gravelly sandy loam
Codorus gravelly sandy loam

Philo gravelly sandy loam is similar to Philo silt loam except that it has a lower available moisture capacity and warms up earlier in the spring. Seventy-five per cent of this soil is cleared and all the area is on less than 3 per cent slope.

Codorus gravelly sandy loam is limited in extent and is similar to Congaree except for drainage. It has a lower available moisture capacity and warms up earlier in the spring than Codorus silt loam. Sixty-five per cent of this soil is cleared with 98 per cent on less than 3 per cent slope.

Soil Group 12

The soils in Group 12 are imperfectly drained, medium textured, moderately acid, and moderately permeable. They have a moderate available moisture capacity and moderate inherent fertility. They are derived from sandstone and shale soil material that has been deposited at the base of surrounding sloping land. They are not adapted to crops requiring a well-drained soil Included are:

Ernest gravelly silt loam
Buchanan gravelly loam
Kedron silt loam

Ernest gravelly silt loam is a colluvial soil found at the base of slopes in areas of the Romney shale, Jennings formation, Martinsburg shale, and some of the McKenzie formation. It is associated with the Ashby, Berks, and Brinkerton series. Seventy-five per cent of this soil is cleared and 80 per cent is on 4 per cent slope.

Buchanan gravelly loam is generally found in the western part of the county associated with the Laidig series. It differs from Ernest in that the material comes from sandstone and some shale, whereas Ernest is chiefly from shale. Forty-five per cent of this soil is cleared and 80 per cent averages 10 per cent slope. Pasture would be the proper land use unless drainage were provided.

Kedron silt loam is a colluvial soil material from Calvin, Lehew, and Ungers soils that have formed from Juniata formation, Clinton shale, and Catskill formation in the western part of the county. Ninety-five per cent is cleared and 40 per cent is on less than 3 per cent slope.

Soil Group 13

The soils in Group 13 are moderately deep to shallow, imperfectly drained, medium textured, and moderately acid. They have a moderately permeable subsoil over a very slowly permeable substratum. They have a low available moisture capacity and a low inherent fertility. A hardpan is found at a depth of about 20 inches. They are limited in crop use and yield because of their drainage condition and shallow rooting zone. They are:

Monongahela gravelly loam
Monongahela silt loam
Trego gravelly silt loam
Blairton silt loam
Landisburg cherty silt loam

Monongahela gravelly loam is found chiefly along Potomac River and Conococheague Creek, and is developed from materials similar to those of the Holston soils. The profile is similar except for the hardpan at about 20 inches. Ninety-two per cent of this soil is cleared and the average slope is about 6 per cent.

Monongahela silt loam is developed in areas similar to those of the gravelly loam. Eighty-five per cent is cleared and the average slope is about 5 per cent.

Trego gravelly silt loam has a compact layer at about 20 inches and is developed from materials similar to the Allen and Thurmont series in the South Mountain area. Eighty per cent is cleared and the slopes average about 5 per cent.

Blairton silt loam is an imperfectly-drained shallow soil found in Berks soil areas from the Martinsburg shale. Forty per cent is cleared and slopes average 7 per cent.

Landisburg cherty silt loam is an imperfectly-drained colluvial soil derived from material washed from soils of the Frederick, Elliber and Dunmore series. It is found chiefly between Powell Mountain and Tonoloway Ridge in the western part of the county. Seventy-five per cent is cleared, and 50 per cent is on a 10 per cent slope.

Soil Group 14

The soils in Group 14 are deep, well drained, light textured, moderately acid, rapidly to moderately permeable, and moderately erodible. They have a low available moisture capacity and low inherent fertility. They are limited in crop use because they tend to be droughty and plant food is easily leached. They are best adapted to deep-rooted crops, but may be used for truck crops. Included are:

Murrill gravelly sandy loam
Ungers channery fine sandy loam
Waynesboro gravelly sandy loam
Holston gravelly sandy loam
Laidig gravelly sandy loam

Murrill gravelly sandy loam is found close to the base of the mountains, especially where coarse sandstone formations have worked down over limestone soils. It is more leached, more droughty, and warms up earlier in the spring than the heavy-textured phases of the Murrill series. Several scattered areas on a terrace position along the Potomac River were included because of limestone influence in the subsoil. Sixty-five per cent is cleared and the average slope is about 10 per cent.

Ungers channery fine sandy loam is found associated with the Calvin and Lehew series of the Catskill formation and limited areas of the Juniata formation. It is the deepest soil of the three. It is found chiefly west of Tonoloway Ridge. Fifty per cent is cleared, and most of it is on slopes less than 6 per cent.

Waynesboro gravelly sandy loam is found in areas of the gravelly loam type. It is more leached, more droughty, and warms up earlier in the spring. Eighty per cent is cleared and the slopes average about 6 per cent.

Holston gravelly sandy loam is found in areas similar to the silt loam and gravelly loam types. Physical characteristics are similar to Murrill and Waynesboro soils. Eighty-five per cent is cleared and the slopes average about 9 per cent.

Laidig gravelly sandy loam is similar to the gravelly loam, but occurs closer to the mountains, especially where the influences of hard, coarse, gray sandstones are present.

Soil Group 15

The soils in Group 15 are moderately deep to shallow, well drained, medium textured, and moderately to strongly acid. They are moderately permeable in the subsoil and moderately to slowly permeable in the substratum. They have moderate to low inherent fertility and moderate to low available moisture capacity. They are developed from underlying quartzite, phyllite, sandstone and shale. Crop use is limited. Included are:

Edgemont-Chandler channery loam
Dekalb silt loam
Dekalb channery loam
Enders silt loam
Chandler silt loam
Berks silt loam
Berks shaly silt loam
Edgemont channery loam

The Edgemont-Chandler channery loam is found where the Harpers phyllite and Antietam quartzite types of material are too mixed to separate. The main areas occur along South Mountain and Elk Ridge. It is adapted to fruit and berries and cultivation is limited. Forty-five per cent is cleared and the slopes average 12 per cent.

Dekalb silt loam and Dekalb channery loam are scattered on ridge tops throughout the county. They are derived from the Romney shale (sandstone area), Tuscorora sandstone, and Weverton quartzite.

The Edgemont and Dekalb are somewhat similar except for quartz and schist phyllites of the Edgemont. Thirty-five per cent is cleared, and the slopes average 12 per cent. They are limited in crop use. They have possibilities for growing potatoes where not too shallow.

Enders silt loam is derived from Romney shale that weathers to a reddish-brown subsoil. It is found mostly in the western part of the county. Eighty per cent is cleared and the slopes average 12 per cent. The soil is moderately deep and crop production is limited.

Chandler silt loam is found in the eastern part of the county along South Mountain and Elk Ridge, coming from the Harpers phyllite. It is a moderately deep soil and capable of fair production. Seventy per cent is cleared and the slopes average 8 per cent.

Berks silt loam and Berks shaly silt loam occur on the Martinsburg shale which the Conococheague Creek meanders through from the Pennsylvania line to the Potomac River and on both sides of Powell Mountain. The soils are easily tilled and moderate production of all farm crops is obtained. Eighty-five per cent is cleared and slopes average 8 per cent.

Edgemont channery loam occurs over the Antietam quartzite along South Mountain and Elk Ridge. Crop production is limited because of low fertility and abundance of fragments. Fifteen per cent is cleared with slopes averaging 16 per cent.

The inherent fertility of these soils is not high. With good farm practices, yields are fairly good except in dry years.

Soil Group 16

The soils in Group 16 are shallow, well drained, medium textured, slightly acid, and moderately erodible. They have a moderately permeable subsoil over a moderately to slowly permeable substratum. They have a moderate to low available moisture capacity and moderate inherent fertility. They are developed from underlying calcareous shale, thin-bedded limestone, and interbedded limestone and shale. Crop use is limited because of lack of soil depth and moisture capacity. They are:

Litz channery loam
Litz shale loam
Edom silt loam
Frankstown channery silt loam (purple phase)

Litz channery loam and Litz shale loam are shallow soils occurring on the Wills Creek shale and some Tonoloway limestone. Production is limited because of shallowness. Forty per cent is cleared and the slopes average about 15 per cent.

Edom silt loam is a shallow limestone soil derived from the purer limestone part of the Wills Creek shale, and is found in limited areas in the western part of the county. Eighty-five per cent is cleared and the slopes average 12 per cent.

Frankstown channery silt loam (purple phase) occurs in parts of a two-mile strip from Antietam in a northerly direction to Ringgold and Midvale on the Waynesboro formation. Ninety per cent of this soil is cleared and the slopes average 10 per cent. Production is limited because of shallowness.

Soil Group 17

The soils in Group 17 are shallow, well drained, medium textured, moderately acid, and rapidly to moderately permeable over slowly permeable substratum. They have a low available moisture capacity and moderate inherent fertility. They are developed from underlying sandstone and shale. Crop use is limited because of the shallow depth and low moisture capacity. They are:

Enders gravelly loam
Calvin shale loam
Calvin channery loam

Enders gravelly loam occurs in limited areas of the Romney shale. Its characteristics are similar to the Enders silt loam.

Calvin shale loam and Calvin channery loam are found on the Catskill formation, Juniata formation, and Bloomsburg red sandstone, in the western part of the county. Forty per cent is cleared and the average slope is 15 per cent. The shallowness of the soils limits crop production.

Soil Group 18

The soils in Group 18 are shallow to very shallow, well drained, medium textured, moderately erodible, and acid. They have a rapidly to moderately permeable surface or subsoil over a slowly permeable substratum. They have a low to very low available moisture capacity and moderate to low inherent fertility. They are developed from underlying sandstone, shale, and phyllite. Crop use is limited because of depth and the low moisture capacity. Included are:

Ashby channery loam
Ashby shale loam
Ashby silt loam
Calvin-Ashby shale loam
Calvin-Ashby channery loam
Berks shale loam
Chandler shale loam shallow phase
Calvin-Edom silt loam

Ashby shale loam, Ashby channery loam, and Ashby silt loam occur in the western part of the county on the Romney shale, Jennings formation, and limited areas of the Clinton shale and Rockwell formation. It is one of the poorer soils. Its inherent fertility is low and its moisture-holding capacity is limited. The soils are very droughty. Forty per cent is cleared and the slopes average 18 to 20 per cent.

Calvin-Ashby shale loam and Calvin-Ashby channery loam occur in the western part of the county. They are derived from the underlying Juniata and Catskill formations occurring in bands of red and gray shales too narrow to separate for mapping. Fifty per cent is cleared and the slopes average 18 to 20 per cent.

Berks shale loam occurs in areas similar to the silt loam and shaly silt loam areas of the Martinsburg shale. Production is moderate to poor as the soil is very droughty. Seventy per cent is cleared and the slopes average 15 to 18 per cent.

Chandler shale loam shallow phase is found on the Harpers phyllite in the eastern part of the county near South Mountain and Elk Ridge. Forty-five per cent is cleared but 10 per cent is now idle. The slopes average 15 to 18 per cent. Crop production is very poor.

Calvin-Edom silt loam is a shallow soil with narrow bands of red shale and sandstone. Thin-bedded limestone occurs in the Wills Creek shale formation. Forty-five per cent is cleared and the slopes average 15 to 18 per cent.

Soil Group 19

The soils in Group 19 are moderately deep, poorly drained, medium to heavy textured, and non-acid. They have a moderately to slowly permeable subsoil over a slowly permeable substratum. They have a high available moisture capacity and high inherent fertility. They are on bottom land derived from limestone materials. Because they are subject to stream overflow and have poor natural drainage, they are very limited in crop adaptation. Included are:

Melvin silt loam
Melvin silty clay loam
Dunning silty clay loam
Guthrie silt loam

Melvin silt loam and Melvin silty clay loam are found in all of the limestone areas bordering streams. They are subject to frequent overflow and are poorly drained. They are at best limited to good grass production unless improved by drainage. Ninety-nine per cent is cleared and on less than 1 per cent slope.

Dunning silty clay loam is found in areas with Melvin, and is darker in the profile throughout. Ninety-seven per cent of the area is cleared and the slopes average less than 1 per cent.

Guthrie silt loam is a poorly-drained soil found in areas with the Wiltshire and Emory series. Ninety-eight per cent is cleared and the slopes are about 1 per cent.

Sixty per cent of the soils of this group are in cultivation but yields are not too good except in dry years.

Soil Group 20

The soils in Group 20 are moderately deep, poorly drained, medium to heavy textured, and moderately acid. They have a moderately permeable subsoil over a moderately to very slowly permeable substratum. They have a moderately high available moisture capacity and moderate to low inherent fertility. They are on bottom land developed from sandstone, shale, metabasalt, and phyllite. Use of the soils is limited because of flooding and poor natural drainage. They are:

Atkins silt loam
Tyler silt loam
Brinkerton silt loam
Rohrersville silty clay loam
Wehadkee silt loam

Atkins silt loam is a poorly drained soil associated with the Pope and Philo series. It occurs on first bottomlands of streams in the gray sandstone and shale areas, chiefly in the western portion of the county. The problem of drainage is difficult because of the heavy subsoil and high watertable. Keeping the land in pasture with surface drainage is the best use because it is subject to frequent flooding. Seventy-five per cent is cleared and 35 per cent is in pasture.

Tyler silt loam is old river alluvium from yellow and gray sandstones and shales. It is associated with the Holston, Monongahela, and Waynesboro series. It occurs along Potomac River and Conococheague Creek in a terrace position. Drainage is fair to poor but can be improved by diverting upland water. Eighty per cent is cleared.

Brinkerton silt loam is a poorly drained colluvial soil associated with the Berks and Blairton series that are formed from the Martinsburg shale. It differs from the Andover in that it is predominately from shale, while the Andover is predominately from sandstone and shale. Seventy per cent is cleared and slopes average 4 per cent.

Rohrersville silty clay loam is a poorly drained, colluvial soil associated with Thurmont, Allen and Trego soils. It occurs throughout Pleasant Valley. It is difficult to drain internally. Surface drainage and retiring to pasture are the best treatments. Seventy-five per cent is cleared and 35 per cent is in pasture.

Wehadkee silt loam is a poorly drained first-bottomland soil, associated with the Congaree and Codorus series. It was mapped in the South Mountain, Pleasant Valley, and Elk Ridge areas. Where drainage is improved, good pasture will be produced. Eighty-five per cent is cleared and 50 per cent is in pasture.

Soil Group 21

The soils in Group 21 are moderately deep to shallow, well drained, non-acid, medium to heavy-textured, and stony. They are moderately permeable. They have a high available moisture capacity and high inherent fertility. They are developed from underlying massive limestone, shale, and limestone interbedded with some chert. Adaptation of cultivated crops to these soils is limited. They are best adapted to legumes, mixed hay, and pasture. Included are:

Hagerstown stony silt loam
Hagerstown stony loam
Hagerstown stony silty clay loam
Hagerstown stony clay loam
Duffield stony silt loam
Chilhowie stony clay loam
Frankstown stony loam

Hagerstown stony silt loam, Hagerstown stony loam, Hagerstown stony clay loam, and Hagerstown stony silty clay loam are scattered throughout the limestone areas associated with the non-stony Hagerstown soils. They are derived from the same limestones. They are very difficult to plow and cultivate with modern machinery and to control erosion. They are best used for long-term hay and cultivation is limited. Alfalfa is best suited. Ninety-eight per cent are cleared, with 15 per cent in pasture. The slopes average 8 per cent.

Duffield stony silt loam is associated with Duffield silt loam. The agricultural use is limited as it is for the Hagerstown types. Ninety-three per cent is cleared and the slopes average about 8 per cent.

Chilhowie stony clay loam is found on the Chambersburg limestone along the Martinsburg shale areas. The agricultural use is limited as it is for the Hagerstown stony types. Seventy per cent is cleared, 50 per cent is in pasture, and the slopes average 8 per cent.

Frankstown stony loam occurs throughout areas where Frankstown soils are mapped. Ninety per cent is cleared, 15 per cent is in pasture, and the slopes average 12 per cent.

The soils of this group are separated as explained for the Hagerstown stony types. They are best suited to a long-term hay rotation.

Soil Group 22

The soils in Group 22 are moderately deep to shallow, well drained, medium textured, and generally stony. They are moderately acid, moderately permeable, and have a moderate to low available moisture capacity and inherent fertility. They are developed on metabasalt and phyllite. They are best adapted to hay or pasture. They are:

Fauquier stony loam
Fauquier silt loam, shallow phase
Myersville stony loam
Chandler channery silt loam

Fauquier stony loam and Fauquier silt loam, shallow phase, are derived from the Catoctin metabasalt in Pleasant Valley and along South Mountain. They are suitable for long-term hay. They require different treatment than soils in Group 2, especially the liming needs. Eighty-five per cent of this land is forested and slopes average 15 per cent.

Myersville stony loam is found in areas associated with the other Myersville types and differs from Fauquier in the yellowish-brown subsoil. Ninety per cent is forested.

Chandler channery silt loam was included with this group because the medium-sized flat stone fragments of the Harpers phyllite would cover part of the cultivated crop during cultivation. It is found in the Harpers phyllite area east of South Mountain and in the vicinity of Elk Ridge. Sixty per cent is cleared and the slopes average 12 per cent.

Soil Group 23

The soils in Group 23 are moderately deep to shallow, well drained, medium to heavy textured, and very stony. They are nonacid. They are moderately permeable and have a moderate available moisture capacity and moderately high inherent fertility. The soils are developed upon underlying massive limestone, shale and some chert. They are adapted for good pastures. Included in this group are:

Hagerstown very stony silt loam
Hagerstown very stony loam
Hagerstown very stony clay loam
Hagerstown very stony silty clay loam
Duffield very stony silt loam
Benevola very stony clay loam
Frankstown very stony silt loam
Chilhowie very stony clay loam

Hagerstown very stony silt loam, Hagerstown very stony loam, Hagerstown very stony clay loam and Hagerstown very stony silty clay loam are found throughout the limestone valley associated with the Hagerstown series as mapped in other groups. Here the separation is based chiefly on the fact that the land use would be pasture at best, or trees. Eighty-five per cent is cleared and 45 per cent is in pasture.

Duffield very stony silt loam is associated with the other Duffield types and separated for the same reason as the Hagerstown types. Eighty-five per cent is cleared and about 45 per cent is in pasture.

Benevola very stony clay loam is found in areas of limestone similar to the other Benevola types mapped.

Chilhowie very stony clay loam is found in the areas of the Chambersburg limestone formation with the other Chilhowie soil types. Eighty-two per cent is cleared and 75 per cent is in pasture.

Frankstown very stony loam is separated from the non-stony counterparts. Sixty-five per cent is cleared and 35 per cent is in pasture. The slopes average 10 per cent.

The soils in this group, as mentioned in the description of the Hagerstown soils, are best suited for pasture or trees. As the speed of farming is increasing, more of this land is being returned to pasture, but the need for erosion control would have warranted leaving these soils in pasture from the time of clearing.

Soil Group 24

The soils in Group 24 are deep to moderately deep, predominately well-drained, medium-textured, stony, and moderately to strongly acid. They vary in permeability, available moisture capacity, and inherent fertility. They are developed from underlying metabasalt, sandstone, shale, and quartzite. They are best adapted to pasture and woodland. They are:

Highfield stony loam
Clifton stony loam
Pope stony gravelly loam
Laidig stony loam
Edgemont-Chandler stony loam
Dekalb flaggy silt loam
Lantz stony loam (Clifton-Highfield material)

Highfield stony loam is derived from the Catoctin metabasalt, as is the Clifton stony loam. They are separated, on the basis of stoniness, from the loam and silt loam counterparts. The slopes average better than 20 per cent and are 98 per cent forested.

Pope stony gravelly loam is mapped along some mountain streams in gray sandstone areas. It should remain in pasture or woods. Fifty-two per cent is cleared and slopes average 4 to 5 per cent.

Clifton-Highfield-Lantz stony loam occurs at the base of slopes or stream heads where poorly drained soils have formed from colluvial materials of the three soils. Fifty-five per cent is cleared and slopes average 4 to 5 per cent.

Laidig stony loam is found associated with Laidig gravelly loam but generally is closer to the base of the mountain. Ninety-five per cent is forested and slopes average 15 per cent.

Edgemont-Chandler stony loam is similar to the Edgemont-Chandler channery loam in origin and profile except for degree of stoniness. Ninety-nine per cent is forested and the slopes average 18 per cent.

Dekalb flaggy silt loam is mapped in a small area. All is forested and the slopes average 20 per cent.

The soils of this group are best suited to woodland but they can be used for pasture.

Soil Group 25

The soils in this group are variable with respect to depth, inherent fertility, and available moisture capacity. They are predominantly well drained and of stony loam texture. They are developed from sandstone, shale, metabasalt, quartzite, and cherty limestone. They are best suited for woodland use. They are:

Dekalb material, rough stony land
Dekalb stony sandy loam
Dekalb stony loam
Catoctin material, rough stony land
Dekalb-Lehew stony loam
Andover stony loam
Edgemont-Chandler material, rough stony land
Elliber stony loam
Lehew stony loam
Leetonia stony sandy loam
Edgemont stony loam

Dekalb material, rough stony land, Dekalb stony sandy loam, and Dekalb stony loam are found along and on top of mountains, chiefly in the western part of the county. They are derived from the Oriskany sandstone, Tuscorora sandstone, and some areas of the Purslane sandstone, and also from some areas of the Weverton quartzite in the eastern part of the county. Ninety-nine per cent is forested and the slopes average 25 per cent.

Catoctin material, rough stony land, occurs in the Elk Ridge and South Mountain areas and is associated with the Clifton and Harbaugh types. It was included with the Edgemont-Chandler soil material, rough stony land. Over 99 per cent is forested and the slopes average 25 per cent.

Dekalb-Lehew stony loam is a mixture of gray sandstone and red sandstone soils that are too mixed to map separately. Lehew stony loam is from the red sandstone. Both are found in the western part of the county along the mountain tops. They are derived from Catskill formation and Juniata formation. They are entirely forested.

Elliber stony loam is found along the ridge tops of the Helderberg formation in the western part of the county. Ninety-nine per cent is forested and the slopes average about 20 per cent.

Andover stony loam is a poorly-drained, stony Laidig type found along the base of slopes in the western part of the county.

Leetonia stony sandy loam is found largely in the Bear Pond Mountain area or mountain tops. The slopes are about 12 per cent and are all forested. It is the most acid soil in the county and is a post-mature soil.

Edgemont stony loam is found along the Elk Ridge and South Mountain areas. It is 98 per cent forested and the slopes average 20 per cent or steeper.

FORESTS OF WASHINGTON COUNTY

BY

KARL E. PFEIFFER

INTRODUCTION

Washington County, one of the four mountain counties of the State, is more or less triangular in shape with the Mason and Dixon Line dividing Maryland from Pennsylvania on the north side, the crest of the South Mountain range on the east side, and the Potomac River as the hypotenuse on the south side, which is also the boundary between West Virginia and Maryland. A short boundary following Sideling Hill Creek divides Allegany County from Washington County on the west. This County has the distinction of having the narrowest part of Maryland at Hancock where the distance across the State from Pennsylvania to West Virginia is less than two miles.

When the early settlers came practically the entire area now comprising Washington County was in forests. As the settlements sprang up and the settlers began tilling the soil, the better soils, especially in the fertile Hagerstown Valley, came under the plough, and the forest area began to recede until now only about 24 per cent of the surface is wooded. Of its 350,122 acres, some 98,000 acres are now in woodland.

This wooded area is divided into two parts: the slopes of South Mountain and Maryland Heights on the east, and the rugged area from Fairview or North Mountain westward. This western section contains by far the largest percentage of forest land. The intervening section of the County, embracing the Hagerstown Valley, contains but a small percentage of scattered woodland.

Several large streams traverse the county. Antietam Creek, with Beaver Creek a large tributary, drains from the north into the Potomac River. Conococheague Creek, Licking Creek, and Sideling Hill Creek with their headwaters in Pennsylvania, also flow through the County into the Potomac River.

The forests in the mountainous sections, both east and west, are confined for the most part to the rocky ridges and steep slopes. The better types of soils of the valleys and more rolling land are cleared for agricultural crops.

THE FORESTS

Hardwoods are the predominant species of the County consisting primarily of oak, hickory, maple, tulip poplar, and black gum with a small proportion of many other species. There is little pine in the eastern and central portions of the County, but there are some considerable stands in the western part where it grows in mixture with hardwoods and in a few pure pine stands. Nowhere does it constitute an important part of the forest. Virginia or scrub pine is the prevailing pine, although white pine is found to a small extent in the extreme western part. There are also several other pine species scattered mostly in the western section.

Chestnut formerly comprised a large portion of the hardwood stands, particularly in the eastern part. This now has given way to other species such as chestnut oak, scarlet oak, and black oak.

The wooded areas can be separated into three general types which are determined by the soil and moisture content.

The Ridge Type consists largely of chestnut oak and scarlet oak and extends along the top and upper portions of the ridges. Here the growth is very slow, and the trees are of poor form because of the thinness and dryness of the soil. The stumpage value in this type is the lowest because of the inferior quality of the product and the inaccessible location.

The Slope Type, on the upper slopes, is predominantly of black oak, white oak and to a lesser extent of chestnut and scarlet oak, and on the lower slopes, white oak, red oak, hickory, and tulip poplar predominate. Here the soils are somewhat deeper and have a greater moisture content than on the ridges and, therefore, produce a better growth and form.

The Bottom Type is composed principally of ash, elm, willow, and sycamore, together with some white oak, red oak, hickory and walnut. This type is found on the flats along ravines and streams, and comprises a much smaller percentage than the other two types.

The highest elevation in Washington County is found at Quirauk in the northeastern part not far from the Pennsylvania line being 2145 feet above sea level; the lowest elevation is the southeastern portion along the Potomac River with an elevation of only 260 feet. The soils in the eastern section along South Mountain are generally sandy loams and those in the western part are somewhat stiffer due to a greater proportion of clay. In the Hagerstown Valley the soils are of a clay loam type and are among the most productive in the State.

LIST OF TREES IN WASHINGTON COUNTY

A number of forest trees are indigenous to the County, and some have escaped cultivation and are growing wild. Most species growing to a height of 15 feet or more are cited in the following list:

Conifers

White Pine	Pinus strobus (Linneaus)
Pitch Pine	Pinus rigida (Miller)
Virginia Pine	Pinus virginiana (Miller)
Table Mountain Pine	Pinus pungens (Lambert)
Shortleaf Pine	Pinus echinata (Miller)
Hemlock	Tsuga canadensis (Linnaeus) (Carriers)
Red Cedar	Juniperus virginiana (Linnaeus)

Hardwoods

Butternut	Juglans cinerea (Linnaeus)
Black Walnut	Juglans nigra (Linnaeus)
Mockernut Hickory	Hicoria alba (Linn) (Britton)
Pignut Hickory	Hicoria glabra (Miller)
Small Pignut Hickory	Hicoria ovalis (Wangenheim) (Sudworth)

Bitternut Hickory	Hicoria cordiformis (Wangerheim) (Britton)
Big Shellbark Hickory	Hicoria laciniosa (Michaux f.) (Sargent)
Shagbark Hickory	Hicoria ovata (Miller) (Britton)
Cottonwood	Populus deltoides (Marshall)
Aspen	Populus tremuloides (Michaux)
Large Toothed Aspen	Populus grandidentata (Michaux)
Black Willow	Salix nigra (Marshall)
Blue Beech	Carpinus caroliniana (Walter)
Hop Hornbeam	Ostrya virginiana (Miller) (Koch)
Black Birch	Betula lenta (Linnaeus)
Yellow Birch	Betula lutea (Michaux)
River Birch	Betula nigra (Linnaeus)
Smooth Alder	Alnus rugosa (DuRoi) (Sprengel)
Beech	Fagus grandifolia (Eberhart)
Chestnut	Castnea dentata (Marshall) (Borkhausen)
Chinquapin	Castanea pumila (Linneaus) (Miller)
White Oak	Quercus alba (Linnaeus)
Chestnut Oak	Quercus montana (Willdenow)
Post Oak	Quercus stellata (Wangenheim)
Swamp White Oak	Quercus bicolor (Willdenow)
Northern Red Oak	Quercus borealis maxima (Marshall) (Ashe)
Southern Red Oak	Quercus rubra (Linnaeus)
Pin Oak	Quercus palustris (Muenchhausen)
Shingle Oak	Quercus imbricaria (Michaux)
Scrub Oak	Quercus ilicifolia (Wangenheim)
Black Jack Oak	Quercus marilandica (Muenchhouse)
Black Oak	Quercus velutina (La Marck)
Willow Oak	Quercus phellos (Linnaeus)
Scarlet Oak	Quercus coccinea (Muenchhausen)
Chinquapin Oak	Quercus muehlenbergii (Engelmann)
American Elm	Ulmus americana (Linnaeus)
Slippery Elm	Ulmus fulva (Michaux)
Hackberry	Celtis occidentalis (Linnaeus)
Red Mulberry	Morus rubra (Linnaeus)
Cucumber	Magnolia acuminata (Linnaeus)
Tulip Poplar	Liriodendron tulipifera (Linnaeus)
Paw Paw	Asimina triloba (Linnaeus) (Duval)
Sassafras	Sassafras variifolium (Salisbury) (Kuntze)
Witch Hazel	Hamamelis virginiana (Linnaeus)
Sycamore	Platanus occidentalis (Linnaeus)
Mountain Ash	Sorbus americana (Marshall)
Service Berry	Amelanchier canadensis (Linnaeus) (Medicus)
Thorn	Crataegus species
Wild Black Cherry	Prunus serotina (Ehrhart)
Fire Cherry	Prunus pennsylvania (Linnaeus)
Sweet Cherry	Prunus avium (Linnaeus)
Red Bud	Cercis canadensis (Linnaeus)
Black Locust	Robinia pseudoacacia (Linnaeus)
Staghorn Sumach	Rhus hirta (Linnaeus) (Sudworth)
Holly	Ilex opaca (Aiton)
Red Maple	Acer Rubrum (Linnaeus)
Sugar Maple	Acer saccharum (Marshall)
Silver Maple	Acer saccharinum (Linnaeus)
Striped Maple	Acer pennsylvanicum (Linnaeus)

Black Maple	Acer nigrum (Michaux)
Mountain Maple	Acer spicatum (La Marck)
Box Elder	Acer negundo (Linnaeus)
Basswood	Tilla species
Black Gum	Nyssa sylvatica (Marshall)
Dogwood	Cornus florida (Linnaeus)
Persimmon	Diospyros virginiana (Linnaeus)
White Ash	Fraxinus americana (Linnaeus)
Black Ash	Fraxinus nigra (Marshall)
Red Ash	Fraxinus pennsylvania (Marshall)

Introduced trees that have become common

Red Pine	Pinus resinosa (Solander)
Paulownia	Paulownia tomentosa (Thurnberg) (Stendel)
Silver Poplar	Populus alba (Linnaeus)
Honey Locust	Gleditsia triacanthos (Linnaeus)
Ailanthus	Ailanthus glandulosa (Desfontaine)
Osage Orange	Toxylon pomiferum (Rafinesque)

IMPORTANT TIMBER TREES AND THEIR CHIEF USES

Most of the trees in the foregoing list are used for timber, but the list of extensively used trees may be reduced to a few well recognized species.

White Oaks—This group without distinction of species is usually cut and sold as white oak. Probably 80 per cent of what is cut and sold for white oak is the true white oak Quercus alba. Chestnut oak, swamp white oak, and post oak are the other species in this group. The wood of this group is heavy, strong, hard, tough, close-grained, and durable and is found in all sections of the County. Its uses include construction timbers, tight cooperage, railroad ties, furniture, veneer, and a variety of other uses which call for high-grade wood.

Red Oaks—A number of species are included also in the red oak group. The more important of these include the northern and southern red oak, black oak, scarlet oak, and pin oak. Sometimes the latter are not included and are sold at a slightly lower price. The wood is hard, strong, and coarse-grained, and is used for construction, furniture, interior furnishing, and railroad ties. This group is not as durable as the white oak group and hence does not command as high a price. The chestnut oak bark is used to a limited extent for tannic acid in tanneries.

Tulip Poplar—This species also called yellow poplar is often separated by mill men into two classes: one in which the trees contain a very large percentage of yellowish heart wood and is called "yellow poplar," the other containing considerable sap wood principally white is called "white poplar." It is the same tree botanically, the difference in the color of the wood being primarily due to the rate of growth and to soil conditions. The wood is light, soft, easily worked, but not durable in contact with the soil. The better grades of "yellow poplar" are used in construction, interior finish, furniture, veneer, and wooden ware. The "white poplar" or poorer grades are used mostly for low grade lumber and pulpwood.

Black Locust—This species is found throughout the County. The wood is coarse-grained, very heavy, very hard, strong and very durable in contact with the soil.

It is used extensively for fence posts, and under particular specifications it is used in the making of cross-arm insulator pins and tree nails.

LUMBER PRODUCTION

In 1949 the lumber production amounted to about 2,000,000 board feet, practically all hardwoods. Some of the hardwood and practically all of the pine was cut for pulpwood. Some locust for insulator pins and oak tan-bark was also cut. This cutting was done by 28 mill and timber men who were registered with the Department of State Forests and Parks.

Next to Baltimore County, Washington County has the largest railroad mileage in the State having 91 miles of steam rails, and about 6 miles of electric. This network of railways probably accounts for the large number of wood-using industries in the principal city Hagerstown. There are a number of lumber yards and some planing mills in some of the other towns in the County, but the sizeable and important industries, with the exception of Byrons Tannery at Williamsport, are located in Hagerstown. The principal ones are Brandt Cabinet Works, Colonial Hardwood Flooring Company, Fairchild Aircraft Division of Fairchild Aviation and Engineering Corporation, Hagerstown Wood Products Company, M. P. Moeller Inc. (pipe organs), Statton Furniture Manufacturing Company, Western Maryland Railway Company, Wood Preserving Corporation (Division of Koppers Company), Jamison Cold Storage Door Company, Pangborn Corporation, Victor Products Corporation and K & S Plywood Company.

Some of the large firms that manufacture other products, such as the Pangborn Corporation and Fairchild Aircraft, use quantitites of wood as crating for shipments. Probably they use more lumber in this way than some of the so-called wood-using industries consume as raw materials.

DESTRUCTIVE INFLUENCES

The forests of the County have suffered seriously in the past from destructive agencies. These are chiefly forest fires, insects, diseases, and destructive cutting and management practices.

Forest fires

The most serious enemy of the forest is fire. Where fires are permitted to run uncontrolled through the woods there can be no satisfactory tree growth. Fires burn the leaves and litter which is needed to preserve the moisture, protect the seed, and to fertilize the soil. Fire not only kills the seed and seedlings but burns the cambium or living wood of young trees on the most exposed side causing the bark to peel off and exposes the wood to decay and renders the tree practically worthless. Fire also destroys the protective cover and food for game, and frequently much wild life itself is destroyed. The most prevalent causes of fires have been brush-burning and carelessness of campers and smokers.

Washington County in the past 10 years has had an average annual record of 193 fires which burned over an annual average of 198.1 acres. In 1949 there were only 3 fires and only 5 acres burned. This drop in fires and acreage to a great extent has been brought about by the better fire-fighting organizations and methods and by Regulation 4 which limits brush burning during March, April, May, and September 15 to December 15 between the hours of 4:00 P.M. and midnight E.S.T. There is likely to be less wind and more humidity during the evening and after dark, so that fires are less likely to get out of control. Wide paths and hauling roads through the woods act as effective checks to the spread of fire and should be kept clean of leaves and dry brush.

Practically all forest fires are the result of carelessness or thoughtlessness and are therefore preventable if everybody is careful with fire in and near the woods.

Insects and diseases

There are numerous insects which damage the forest trees, but normally they are kept in check by their natural enemies and the damage is seldom serious. The forests, with the exception of pine, are not in pure stands, and most insects have a special host species that they attack. The white pine weavel which attacks the leaders of the white pine is quite prevalent in the County.

The tree diseases usually appear on individual species and only attack like trees. The "Chestnut blight" which wiped out the chestnuts appeared about 1911 in this County and in about 1925 had killed or seriously affected all the trees of this species. The "Dutch Elm disease" is now working through the County, but because of comparatively low value of elm as a forest tree and the scattered location of the species in the forest it is not felt that it will be serious.

The control of forest-tree insects and diseases is rather difficult as they cannot be combated as they can on shade or fruit trees. The cost would be prohibitive. Therefore, preventive measures should be used such as the cleaning up of the woods after cutting and the prompt removal of dead, dying, and defective trees, because insects and disease are harbored in the dead trees and attack trees in a weakened condition.

Management

It is the purpose of forestry to grow successive timber crops on forest lands and maintain their productiveness. This means that when stands of timber or trees are mature they should be cut to make way for another generation of trees. The selection system has been found to be the best in the hardwood stands and in the mixed pine and hardwood stands. By this method the forests can be brought back to a higher state of productivity than they now have as a result of the poor cutting practices of the past.

It is poor policy to cut only the better trees and leave the more undesirable ones because the less valuable, undesirable trees will soon take over the stand. The undesirable trees should be cut along with the desirable and thus at least keep the balance in the stand. It is better to take out more and smaller undesirable trees than of the more desirable ones. In this way the forest can be made to yield more of the better trees and improve itself.

The Department of Forests and Parks still maintains its plan of cooperation with the woodland owners and will examine woodland holdings and give reports on the best handling of the areas. If the owner desires and the report warrants a cutting, the Department representative will mark the trees that should be removed and furnish the owner with detailed estimate and valuation of his timber. A list of sawmill owners who may be interested in the purchase of the timber will also be furnished. Prior to 1948, 44 tracts of timber totaling 7244 acres had been examined, but in 1948 and 1949, 38 tracts totaling 2025 acres were examined. Also in 1948, 3 tracts totaling 60 acres, and in 1949, 7 tracts totaling 209 acres, were marked and estimates given.

The Conservancy District Act was passed in 1943. A local County Forestry Board is in the process of being formed. It will probably formulate regulations similar to those established in the neighboring counties as the forest types are similar.

FOREST PLANTING

Approximately 13 per cent of the total land area of Washington County is waste land, producing nothing or crops of very little value. Practically all this land could be made to produce a tree crop, for land that is too poor to produce an agricultural crop can produce trees. Most of this waste land consists of rocky, barren hillsides, once cleared and cultivated but from which the soil has been washed away or badly gullied so as to be unfit for agricultural use. Small trees suitable for forest planting are not expensive, and the work can be done at a reasonable cost with the assurance that waste land may be reclaimed and made productive. The Department of Forests and Parks maintains a forest nursery from which suitable trees may be obtained at nominal cost.

The City of Hagerstown has done some extensive planting on its watershed on the west slope of South Mountain near Smithsburg in the Warners Gap Hollow section. About 40,000 evergreen trees were planted in 1940.

WINDBREAKS

In the Hagerstown Valley there are many open sections where there is little or no woodland and much discomfort and damage results from the unhindered sweep of the winds especially in winter. By planting trees as windbreak on the windward side of the house, farm buildings, and places where the live-stock are kept, this condition can be largely remedied. This windbreak should consist of two or more rows of trees, preferably evergreens. The rows should be 6 to 10 feet apart and the trees 6 to 10 feet apart and in an alternate arrangement in the rows.

The density, length and the height of the trees regulate what influence the windbreak will have on the area behind. Usually the influence is effective for a distance equal to ten times the height of the trees.

STATE PARKS

There are no State Forests in Washington County but there are two State Parks.

Washington Monument State Park, consisting of 96 acres, is situated in the eastern part of the County, 2 miles northeast of Boonsboro, by the famous Blue Rocks on the west slope of South Mountain at an elevation of 1600 feet. Here is a restored 30-foot monument and observation tower, originally built in 1827 by the people of

Boonsboro as the first completed memorial to George Washington. Extensive views can be had from the top of the monument of the Hagerstown Valley on the west and Catoctin Range on the east. Picnicking is another attraction.

Old Fort Frederick State Park, comprising 279 acres, is located on the north bank of the Potomac River at Big Pool, 5 miles southwest of Clear Spring. Here is a restored old frontier stone fort built by the colony of Maryland in 1756 during the French and Indian Wars. It was also used during the Revolutionary and Civil Wars. A museum contains artifacts from around the fort and illustrations of the historical events in its existence. Also in 1924, through the generosity of the D.A.R. and other organizations, plantations of approximately an acre each were made of a number of varieties and species of trees. The object was to find out how different trees would grow in the locality. Much valuable data will be obtained when final counts are made. Picnicking, camping and fishing in season are other attractions.

WILDLIFE RESOURCES OF WASHINGTON COUNTY

BY

EDWIN M. BARRY

INTRODUCTION

At the time when the thirteen original colonies were organizing to become the United States of America, the frontiersmen of Western Maryland, then Frederick County, received legislative approval to become a County and they named it in honor of our first President.

Few men had ever gone beyond the Conococheague Creek prior to 1770. George Washington as a surveyor had followed the course of the Potomac and reported the abundance of wild game. Mason and Dixon in extending their line westward had asked for troop reinforcements for protection from hostile Indians in the uncharted wilderness of Allegany.

The productive soil and fine hardwood timber stands of the new lands were a rewarding challenge to the industrious German settlers of Washington County.

As settlement grew and more land was tilled on great limestone valleys, there was a pressing demand for salt. Traders risked their lives to pack salt from the coast to the interior and caches of food and ammunition were placed for their three weeks journey.

Deer, bears, elk, squirrels, wolves, foxes, beavers, otter, minks and muskrats were common forest inhabitants. Grouse, turkeys, doves, waterfowl and woodcocks provided abundant food for the daily needs of the settlers.

Fish life of the great Potomac and its tributaries was very abundant in that portion of the Washington County watershed. Pike, pickerel, catfish, carp, suckers, eels, herring, fallfish, crappies, and trout were found.

So numerous were some of the spawning runs of the anadromous fish that settlers along the waterway caught them in great numbers and used them for fertilizer as did the Indians in their crop fields.

RELATIONS OF WILDLIFE LAND PATTERNS TO PHYSIOGRAPHY

Washington County presents the outline of a giant boot with the historic Potomac River forming the instep. The western boundary is formed by the steep gradients of Sideling Hill Creek at the base of the west slopes of Sideling Hill. The entire northern boundary of the County is along the Mason and Dixon line. The eastern boundary follows the watershed ridge of South Mountain, beginning at a point on the Pennsylvania-Maryland line near Highfield at an elevation of 1400 feet and extending in a southerly direction to the Potomac River near Weverton at an elevation of 260 feet.

The entire surface water system of this County is embraced within the Potomac River Basin. The major tributary streams in Washington County are Antietam

Creek which includes Beaver and Little Beaver Creeks, Landis Spring Branch, Little Antietam Creek, Grove Creek, and Marsh Run (north of Hagerstown); Marsh Run (south of Hagerstown); Conococheague Creek with Rush Run, Toms Run, Rockdale Run, Meadow Brook as its major branches; Little Conococheague Creek with tributaries of Toms Run and Polecat Hollow Run; Camp Spring Run; Licking Creek with tributaries of Lanes Run and minor branches on Pigskin Ridge; Great Tonoloway Creek; Tonoloway Creek and Little Tonoloway Creek; and Sideling Hill Creek with Bear Creek as its only large tributary.

Major surface water impoundments of the County are the C. & O. Canal with its supplemental storage reservoirs at Little Pool and Big Pool, Hagerstown Reservoir, Cavetown Reservoir, Smithsburg Reservoir (Buzzard Knob), Lake Royer (Camp Ritchie, National Guard), North American Cement Company Reservoir, and numerous farm ponds from 0.2 to 1.5 acres in extent. These important waterways, although limited in volume and flow during the critical summer months, form an important wildlife environment.

REGIONAL FAUNA AND FLORA

Washington County is located in the Transition Life Zone of the Alleghanian and Carolinian faunas. The tempering effect of the Potomac River and its tributaries at lower elevations give them a more diverse fauna-flora equation than that found in the higher elevations. This is clearly shown in the elevations which run from 1900 feet on Hearthstone Mountain in the Indian Springs District to 260 feet on the Potomac River as it leaves the southeastern boundary near Weverton. A rolling terrain with limestone outcrops, resulting in broad fertile valleys and productive flood plains of the Potomac, makes this County important as a potential area for producing wildlife. The meandering character of the Potomac River, eroding and depositing top soil in the valley, creates favorable habitat for species such as the wood duck, woodcock, snipe, raccoon, muskrat, mink, otter, quail, rabbit and squirrel together with migrating waterfowl and many species of song birds. Trees and shrubs which grow abundantly along the water courses, despite intense farming practices even on the more rugged terrain, afford excellent travel lanes for the various ecological types of wildlife with which the County is amply provided.

Productive limestone soils have made Washington County a farming region from its earliest settlement. The 1945 Agricultural census places Washington County fifth largest of Maryland counties in land in farms totaling 229,496 acres giving a 77.6 per cent agriculture land pattern. Farms number 2446 with an average 93.8 acres per farm, 75.8 per cent of which are owner operated. The fertile well-drained soils give the County a number one rating in fruit production and excellent rating in livestock, corn, wheat, barley, alfalfa, potatoes and cabbage.

This diversified farm program of staple agricultural crops creates a land capable of producing the important small game species such as rabbit, squirrel, fox, raccoon and to a lesser extent dove, deer, waterfowl, pheasant, turkey, grouse and woodcock. On the other hand intensive grazing on woodlots, rock outcrops, stream banks, swamps, and marshes deplete wildlife habitat. Present farm practices tend toward developing the better land for greater yields, and this wise land-use program will be of increasing value to farm wildlife management in the County.

CLIMATE AND WILDLIFE

Washington County has an average annual precipitation of from 36 inches in the western part to 44 inches in the northeastern part, providing sufficient rainfall over an average growing season of from 155 to 180 days depending on land elevations. The average annual temperature over most of the County is 53°F. and the average minimum temperature is 41°F. The average annual snowfall, which is so important a factor in the management of wildlife, ranges from 35 inches in the northwest to 25 inches in the extreme southeast. Temperature, rainfall, and snowfall blend into a favorable long term climatic pattern for the economic fauna and flora of the region.

FOREST WILDLIFE RELATIONSHIPS

Active land clearing projects were begun by the hardy German pioneer farmers at the beginning of the 18th century. By 1790, 15,825 people had settled Washington County; and, by 1890, the majority of the 39,782 citizens, most of whom were industrious farmers, had cleared 200,000 acres of agricultural land mostly for wheat, corn and livestock. Thus out of the wilderness of valuable hardwoods composed of walnut, oak, hickory and poplar, inhabited by a wilderness type of wildlife of rattlesnakes, wolves, elk, deer, bears, beavers, otter, minks, muskrats, wild turkeys, grouse and numerous others, came in the relatively short period of three generations a farm economy which depleted wilderness game and gave precedence to an increase in the small-farm game species.

The cutting and re-cutting of forest mountain sides has rapidly brought about the depletion of the wild turkeys, elk and grouse which favor a secluded forest area. Another decimating factor to wildlife has been the construction of 993 miles of road covering 1986 acres. These roads traversed by modern trucks and cars bring people from all parts of the State and nation to hunt and fish in a once wilderness land. So little forest cover has been left as a result of intensive farming practices that Washington County farms average only 14 acres of woodlot compared to the State average of 25 acres of woodlot per farm. Despite these trends in scientific farming, present soil conservation practices have increased and will continue to increase white-tailed deer populations together with rabbits, doves, pheasants, and raccoons. Diversion terraces, strip cropping, filter strips, field and woods border, tree, shrub and annual and perennial grass plantings, and a multitude of other modern soil-water conservation practices provide optimistic hope for the reclaiming of stream, forest and field for the once abundant fish and game species. The five-fold increase in population from 1790 to 1950 with a present population pressure of 158.8 persons per square mile brings added revenue to the conservation agency in the way of hunting and fishing income. But constant planning and wildlife management effort is required to combat the human encroachment on the small amount of wildlife habitat left in the County.

The lands which show the greatest possibility for permanent forest wildlife management for the purpose of protecting watersheds and for the scientific harvest of forest and wildlife products are: South, Elk Ridge, Fairview, Sword, Powell, and Richards Mountains; Pigskin, Elbow and Tonoloway Ridges; Sideling Hill; and limited areas of the Potomac River Bottom.

MARSH AND SWAMP WILDLIFE RELATIONSHIPS

Very little sub-marginal agricultural land is found in Washington County and therefore marshes and swamps are not as extensive as elsewhere in the State. The Potomac River margins, reservoirs, small ponds, and stream bottoms are the only areas, limited in extent, which fall into these catagories. Inhabiting the swamps and marshes are the nesting waterfowl such as the wood duck and in some instances the Mallard and Blue-winged Teal. The woodcock and snipe together with raccoon, squirrel, grouse, fox, duck and rabbit seek the margins of these areas for protection and rearing their young. Furbearers such as the mink, otter, and muskrat are residents of this land type.

Drainage to improve farm lands has made rapid inroads on this land pattern and has given wildlife authorities concern regarding the future of an already alarming loss in several of the above mentioned species. A new movement in conservation circles to establish farm ponds, small marshes with control structures to maintain normal water levels, together with shrub, tree, and grass plantings in watersheds, for inland fish development are promising signs on the wildlife conservation horizon.

PRESENT WILDLIFE POPULATIONS

Wildlife as an integral part of the agricultural economy has until recent years been considered a part of the income of trappers, farmers and hunters. With the increase in demand for recreation, hunting and fishing with pole, gun, and camera have become an important national avocation. The State of Maryland is charged with the ownership, protection and propagation of nearly all species of wildlife. Land ownership in Washington County is vested in the individual, with the State's legal jurisdiction expressed within the protective ownership of fish and game species. The land owner upon whose holdings the wildlife exists, subject only to State regulation, can harvest this wildlife crop which by its very nature is highly volatile and difficult to control on an ever-changing farm pattern of diverse agricultural crops. Wildlife is no longer considered an economic industry in this region with the exception of the fur resource but has become an important phase of the recreational life of the State.

Waterfowl

Migrations of waterfowl have never visited Washington County in large numbers as they do in the counties to the east bordering the Chesapeake Bay Flyway. With the exception of the resident nesting birds of the Potomac River Basin only a small number on the west periphery of the Atlantic Flyway find their way into the streams, reservoirs and Potomac River bottoms on their flights North and South. The more common of these transit visitors are the Grebes, Loons, Mergansers, Canvasbacks, Redheads and Mallard ducks.

Shore and marsh birds

The rapid decline in shore bird populations leaves even the best of habitat low in population of these species. Since only the Potomac River and occasionally wet farm fields are likely nesting places for this group, it is not surprising that we find only the Plover, Snipe and the King and Virginia Rails in this County.

Predacious birds and mammals

The Owls, Hawks, Buzzards, Eagles, Red and Grey Fox, Weasels and other species have been mismanaged for many years under the misapprehension that they were highly destructive to more useful wildlife. With the advent of scientific research and education, it is found that under normal conditions, a favorable balance can be secured with proper land practices and controlled cropping of the economic forms. Protection is now afforded only to the eagle. At various periods in the development of the County bounties have been paid, beginning in early times with the wolf and panther and in more recent years on hawks and buzzards.

Song birds

The north and south ridges paralleled by productive fields and meandering streams afford ideal habitat for more than 250 species of song birds. Public interest has been aroused through bird watching activities. The Maryland Ornithological Society has established organizations in this County, and observations have been recorded particularly through the Christmas census and the spring breeding bird counts established by the National Audubon Society. Lookouts along South Mountain have recorded all of the species of birds of prey native to this region and large numbers of migrating hawks. These records compare favorably with studies and observations at the famous Hawk Mountain Sanctuary in Pennsylvania.

Other fauna

Natural scientists have explored the mountains, caves, river bottoms, and valleys of this beautiful County and their observations and studies have been recorded in numberous publications. The limestone caves have produced nocturnal forms such as the bats and owls. Intensive farming practices have reduced greatly the number of rattlesnakes and copperheads so prevalent in this County a century ago. Amphibians are common in the Potomac River Bottom. A recent summer survey and taxonomic classification of the fishes of Washington County included the following important species: Dace, Chub, Shiner, Darter, Minnow, Sunfish, Sucker, Bass, Crappie, Trout, Pickerel, Bullhead, Catfish, Carp and Eel. The limestone (hard) waters of this region favor the warm water fish but limit the reproductive capacity of the trout.

The improvement of surface water habitat which is now under way through State conservation effort together with watershed planting and other environmental controls should do much in assisting the fresh water inland fisheries. Any environmental improvement of habitat for the important economic game and fish species will of course create better physical, chemical, and biological conditions for the lower forms.

THE CLIMATE OF WASHINGTON COUNTY

PREPARED UNDER THE DIRECTION OF

G. N. BRANCATO

ELEMENTS DETERMINING WEATHER AND CLIMATE

The state of the atmosphere at a particular time and place is expressed in terms of temperature, precipitation, state of the sky, wind direction and velocity, humidity, fog, frost, etc. These elements go to make up what is called 'weather.' Weather varies from day to day and throughout the various hours of the day because of the changes in one or more of these elements. When we obtain a generalization of the day to day weather conditions, we have values which make up 'climate.' A sharp line of distinction cannot be drawn between climate and weather. It is difficult to say where one leaves off and the other begins. A satisfactory and adequate description of both is difficult.

Washington County, as do all of Maryland and practically all of the United States, lies in what is known as the "belt of the prevailing westerlies." That is, the prevailing direction of the wind is from some westerly direction. Therefore, most of the weather experienced in this area comes from some westerly direction, borne along by the prevailing direction of the wind.

Cold air masses reach Washington County from two primary directions. Those moving directly southward from eastern Canada produce the lowest temperatures because of their more direct journey from the Arctic source region. Those moving from central Canada into the Midwest and then eastward moderate considerably before reaching the Maryland area. During the summertime, these cold air masses bring practically all the cool periods which provide relief from the hot, sultry conditions which frequently prevail in this section. Another type of cool air mass reaches Maryland after a long journey over the Pacific Ocean, the high western mountains of the United States, and the central and eastern portions of the country. This type generally brings cool and dry weather to Washington County.

Warm masses of air have their origin over the Gulf of Mexico, off the south Atlantic Coast, and over the desert and plateau sections of northern Mexico and southwestern United States. The over-water warm air masses are moist and are good producers of precipitation, whereas those originating in the desert and plateau regions are dry and produce very little, if any, precipitation. The warm, dry air masses reach Washington County rather infrequently. The action between cold and warm air masses, and within the air masses themselves, produces the weather of a locality.

The large scale air masses are subject to modifications imposed by the geographical features of the area. The character of the soil, the configuration of the land, elevation, soil covering, presence of large bodies of water, presence of mountain barriers, latitude, and prevailing direction of the wind all exert influences which enter into the composite picture of weather and climate.

Soil is an aggregation of small particles of matter, separated from each other by particles of air or water. The heat capacity and the ability to conduct heat are much smaller for air than for the particles which make up the soil. If the air is replaced by water, the heat capacity and conductivity of the soil are increased. Therefore, during the daylight hours, coarse soils, such as sandy ones with a high percentage of air, do not conduct the heat received into the ground to a high degree. Instead, the surface layers become very warm which heats the air layers in contact. At night there is little heat stored in the ground and temperatures quickly drop to low levels. Fine soils, such as clay and loam, have a higher heat capacity, are able to store heat better when the sun is shining, and thus have a supply of heat to help offset the heat losses by radiation at night. Other conditions being equal, this type of soil will be less likely to have frost. Air over fine soils has a lower daily range in temperature than air over a coarse soil. The soil of Washington County is predominantly loam, modified in different areas by clay, sand, gravel and shale fragments. However, variations in types of soil conditions are insufficient to produce appreciable variations in temperature.

The configuration of the land affects the formation of fog and frost. During a clear night, the ground loses heat by radiation at varying rates, cooling the air in contact with it. If the movement of the wind is so light that the air near the ground is not mixed with air a hundred or more feet above the ground, the air near the ground becomes heavier and begins to flow to lower levels, in much the same manner that a stream of water would. The colder air tends to pool in lower levels. The greater the slope and depth of the depression, the greater will be the lowering of nighttime temperatures. Washington County is in the physiographic province known as the Valley and Ridge, except the portion adjacent to Frederick County which is in the Blue Ridge Province. It is a region of long, ridge-like mountains and broad intervening valleys. Elevations range from about 260 feet near Weverton, on the Potomac River in the extreme southeastern portion of the county, to about 2145 feet at Quirauk Mountain in the northeastern part of the county. The eastern portion of the county between South Mountain on the east and Fairview and Powell Mountains on the west is rolling, whereas the western portion is hilly or mountainous with much less rolling ground. The principal streams, some gorge-like in places, are Antietam Creek, Conococheague Creek, Licking Creek, Great Tonoloway Creek, and Little Tonoloway Creek. They originate in Pennsylvania and flow generally from north to south to the Potomac River, the southern boundary of the county. Thus, ideal conditions are provided for the pooling of cold air on clear nights with light winds, particularly in the Hancock area. With pockets of air which are several degrees colder than temperatures at higher elevations, frost occurrences are more frequent and more intense. This makes the successful development of agricultural crops on Washington County lowlands and smaller valleys much more difficult than on the higher ground.

Temperatures decrease about 3°F. for each 1000 feet of increase of elevation. With the elevation of Washington County varying about 2000 feet, as stated above, if other factors were equal, this would produce a temperature variation of about six degrees between the extreme elevations.

Although temperatures decrease slowly with change of latitude from south to north, Washington County is too small to produce any noticeable effect from this condition.

More intense radiation from a snow cover at night and absorption of the heat of the sun by day in melting snow tends to lower the temperature of the air near a snow layer. However, a snow cover prevents radiation of heat from the earth and the penetration of frost into the ground, thereby protecting winter grains and other vegetation.

Compared with most Maryland counties, the effect of water surfaces on Washington County's weather is small. The effect of large water areas to minimize the variation of temperatures from day to night exists to an extremely limited extent only near the Potomac River. South Mountain, although only a low mountain, provides some damming effect to the free flow of moist air from the Atlantic Ocean to the east and southeast.

Air which is forced to rise over mountain barriers as it flows with the general circulation of the atmosphere is cooled by expansion as the air pressure decreases. The amount of cooling is dependent upon the change of elevation of the air. Frequently, this cooling is such that the supply of moisture cannot be contained and some is dropped out as rain or snow. When the direction of the winds is predominantly west or northwest, air reaching Washington County has crossed the Allegheny Mountains. These mountains are sufficiently high to cause some moisture to be precipitated as rain or snow and the heat of condensation to be added to the air. After crossing the mountains, the air sinks slowly to lower levels. The compression provides a warming effect. The removal of moisture and the heat of compression reduce the amount of cloudiness on the leeward side of the mountains. Since clouds reflect back to space some of the sun's heat, a decrease in cloudiness allows more heat to reach the ground layers. The effect of the Allegheny Mountains in the colder months is more sunshine, slightly higher temperatures, and less precipitation in Washington County. During the warmer months, much of the moisture comes from the Atlantic Ocean as the result of a higher percentage of southerly and southeasterly winds.

The climate and weather depend, to a large extent, on characteristics assumed by air before it reaches Washington County. Thus, air from surrounding sections flows over Washington County in proportion to the prevailing direction of the wind.

Thus the general trends of climate and weather are set up by the extensive masses of cold and warm air which flow over the country, but the small variations which can be observed over a relatively limited area, such as Washington County, are due to local conditions.

WEATHER OBSERVATIONS

Sporadic and unorganized weather observations were entered in the journals of many of the early settlers of Washington County. Near the end of the 19th Century, the United States Weather Bureau began the establishment of cooperative weather stations in Washington County to collect systematic observations which would serve for comparison with reports from other localities. In Washington County, there are several outstanding records of climatological observations by various people. Mr.

J. A. Miller compiled a record of forty-five years at Keedysville before failing eyesight forced him to relinquish the work. Mr. D. Paul Oswald at Chewsville has completed well over forty years and is still taking observations. Other long records are continuing under Mrs. Leo A. Cohill at Clear Spring and Mr. S. H. Dillon at Tonoloway.

The periods of observation by the various stations and observers are listed in Table 9. The climatological records of the U. S. Weather Bureau have resulted largely from the interest and civic pride of these volunteer observers.

Temperatures are recorded on instruments enclosed in a louvered housing. However, the readings thus obtained are in the shade and are not in themselves indicative of the effect of temperatures on human behavior and activities. Whether or not the sun is shining, the degree of saturation of the air, and the velocity of the wind, are factors which have effects to be considered. A heavy layer of clouds overhead during the day has the capacity to reflect back to space well over half the solar heat which would otherwise be received. During the night, the cloud layer serves as a blanket to prevent the escape of heat from the air near the ground, in many cases eliminating the formation of frost. The rate of evaporation of perspiration from the body is inversely proportional to the degree of saturation of the air, and is directly proportional to the velocity of the wind. These are prime factors in comfort of the human body.

TABLE 9

LIST OF WEATHER REPORTING STATIONS

1. *Chewsville, Maryland*	
February, 1898–January, 1909	E. Ingram Oswald
February, 1909–	D. Paul Oswald
2. *Clear Spring, Maryland*	
February, 1898–July, 1914	W. W. Frantz
August, 1914–May, 1917	Miss M. W. Frantz
July, 1923–	Mrs. Leo A. Cohill
3. *Edgemont, Maryland* (Precipitation only)	
December, 1938–	Lee G. Harne
4. *Green Spring Furnace, Maryland*	
January, 1872–November, 1873	Edwin G. Kinsell
May, 1895–January, 1917	Edwin G. Kinsell
5. *Hancock, Maryland**	
January, 1895–April, 1896	J. S. Diehl
June, 1898–August, 1905	J. D. Stottlemeyer
February, 1921–March, 1924	Theodore P. Jenkins
June, 1946–	C. O. Dunbar
6. *Keedysville, Maryland*	
November, 1904–November, 1946	J. A. Miller
December, 1946–	Travis D. Knode
7. *Tonoloway, Maryland*	
May, 1924–	S. H. Dillon
8. *Williamsport, Maryland* (Precipitation only)	
December, 1938–	R. C. Willson

* Some short breaks in record.

Based on detailed data for Washington, D. C., in January the lowest temperature occurs about 6:30 A.M. and the highest about 3:00 P.M. In July, the lowest reading occurs about 5:30 A.M. and the highest about 3:00 P.M. Cloudiness tends to decrease the daily variation in temperature by reflecting back to space some of the daytime heat and by preventing the escape of heat by nighttime radiation. The change in temperature from night to day diminishes in direct proportion to the thickness of the clouds.

Detailed data on temperature observations are found in Table 10. The annual averages for the stations are between 52 and 53 degrees, except at Keedysville where the annual average is 54.1°F. Since the average of monthly maximum and minimum temperatures at Keedysville are higher almost without exception than comparable data from other Washington County stations, it appears that this slight difference is due to its more southerly location and to a larger number of clear days, as indicated in Table 13. Normally, a gradual lowering of average temperatures would be expected across the county from east to west due to the more mountainous terrain in the west. The average mean temperature data do not show such variation. Average minimum temperatures decrease from east to west, and Hancock and Tonoloway have a considerably larger number of days with freezing temperatures than Hagerstown. However, the average maximum temperatures at Tonoloway and Hancock are higher than they are at Hagerstown. This can be explained by an examination of Table 13 which shows the number of clear, partly cloudy and cloudy days for the various stations in the county. The number of clear days at Tonoloway is greater than at Chewsville, indicating a greater amount of sunshine for the western end of the county. The annual number of days on which the temperature reaches or exceeds 90° is considerably more at Hancock than at any other station. This increased sunshine west of Fairview Mountain is due to the area being more distant from the Atlantic Ocean, having more protection from the inflow of moist air from the east, and the effect of the higher Allegheny Mountains to the west. Thus the average of the more extreme temperatures of the western part of the county shows little difference from the average temperature of the eastern part.

Extreme maximum temperatures for Maryland areas are generally near 105° except in Garrett County and in the immediate vicinity of the larger water areas. As a rule, Washington County fits into that pattern. But on August 6, 1918, the mercury at Keedysville soared to 109°, to equal the highest temperature ever recorded in the State. Other dates of establishment of record high temperatures of the various communities of the county are: Tonoloway 107°, July 25, 1934; Clear Spring, 107°, July 3, 1898; Hancock, 106°, July 1, 1901; Green Spring Furnace, 106°, July 17, 1900; and Chewsville, 104°, August 4, 1930. Maryland's extremely lowest temperatures occur in Garrett County where the State's record of 40° below zero was set at Oakland on January 13, 1912. Farther east, the severity of cold weather decreases and most of Washington County's lowest temperatures have been about 25° below zero. The coldest period ever recorded in Washington County was January 13–14, 1912. On the 13th, the temperature at Chewsville dropped to 27° below zero, the lowest of record in the county, and Keedysville reported 25° below zero. On the 14th, minimum temperatures were 26° below zero at Keedysville and 25° below zero at

Chewsville. Later extremely cold periods were near January 28, 1925 and January 28, 1935, but they did not set records close to the period mentioned above. An earlier extremely cold period occurred on February 10–11, 1899, which produced minimum temperature records in some portions of Maryland and made records for some Washington County stations, but lack of comparable data for many areas diminish its impact on the meteorological chronicles of the county as a whole.

GROWING SEASON

The interval between the last killing frost of spring and the first killing frost of autumn is called the "growing season". It is generally considered to be a safe-from-frost period for growing vegetation. However, the length of this period in Washington County has varied considerably, as indicated in Table 11. This table contains a summary of frost observations which is of great importance to the horticulturist, and it is to be noted that, in general, the longest frost-free period occurs at the stations on relatively level ground. For example, the growing season at Clear Spring averages twenty days longer than at Hancock. Local factors of geography account for the numerous variations in the length of the growing season.

PRECIPITATION

During the warmer months of the year, generally from April through September, most rainfall results from showery and thunderstorm conditions. During the sunny daylight hours, the ground becomes heated. The air near the ground becomes warmed to the extent that it becomes relatively lighter than the air above it. The lighter air begins to rise, forming convective currents of air. As these currents rise, they cool about 5.5°F. for each 1000 feet, if unsaturated. Soon the temperature has lowered to the extent that the air has become saturated and condensation in the form of clouds begins. The general circulation of the air near the earth's surface is frequently such as to produce converging streams of air over relatively large areas. This convergence, together with the process described above, forces the vertical currents of air to higher and higher, and, consequently colder and colder levels, thus forming the typical thunderstorm clouds. The action within the thunderstorm cloud causes different charges of electricity to build up in different parts of the cloud. The difference in potential between two portions of a cloud, between one cloud and another, or between a cloud and the ground becomes so great that a discharge of electricity takes place. The visible portion of this discharge is the lightning flash and, whether forked or sheet lightning, it is basically the same. The explosive violence of the air, produced by the intense heat of the discharge, generates sound waves which travel out in all directions and are heard as thunder.

The undercutting of warm, humid air by an advancing cold air mass forces the warm air to rise, producing lines of thunderstorms or "squalls" as they are frequently called. Cold front thunderstorms are more likely to produce general showers in Washington County than those which are heat produced.

As temperatures and moisture are usually highest in June, July and August, the highest average and greatest extremes of monthly precipitation occur in those months. Detailed precipitation data are contained in Table 12.

TABLE 10

TEMPERATURES

(Italic figures signify day of month)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
Chewsville, Md.													
Mean, max.	40.1	41.1	51.7	62.5	73.4	81.1	85.7	83.4	77.9	66.6	53.5	41.9	62.2
Mean, min.	21.9	21.7	30.6	38.5	48.7	57.8	62.4	60.5	53.6	42.4	32.9	24.1	41.3
Mean	31.0	31.4	41.2	50.5	61.0	69.5	74.0	71.9	65.8	54.5	43.2	33.0	52.2
Highest and date	1932	1930	1907	1915	1899	1934	1936*	1930	1932	1941	1928*	1916	1930—Aug. 4
	13 77	*25* 76	*23** 88	*26* 94	*29* 96	*29* 100	*10* 103	*4* 104	*1* 99	*5* 95	*18* 78	*5* 70	104
Lowest and date	1912	1899	1900	1923	1947	1904	1943*	1934	1943	1930	1938	1942	1912—Jan. 13
	13 −27	*13* −20	*18* −7	*1* 9	*10* 23	*12* 30	*1* 42	*31* 39	*26* 25	*22* 19	*27* −4	*21* −13	−27
Avg. no. days 90° or higher					1	4	8	6	2				21
Avg. no. days 32° or lower	26	24	19	8	1					5	16	25	124
Clear Spring, Md.													
Mean, max.	40.0	40.3	51.6	62.8	73.8	81.0	86.0	83.5	77.7	66.0	53.0	40.9	63.0
Mean, min.	22.8	21.5	30.8	39.5	49.7	57.8	62.7	61.0	54.9	43.1	33.8	24.3	41.8
Mean	31.4	30.9	41.2	51.1	61.7	69.4	74.4	72.3	66.2	54.6	43.4	32.6	52.4
Highest and date	1932	1948*	1948*	1925	1911	1934	1898	1930	1932	1927	1935	1933	1898—Jul. 3
	14 81	*19* 77	*21* 90	*24* 94	*19* 95	*29* 102	*3* 107	*4* 106	*1* 102	*1* 95	*5* 82	*24* 70	107
Lowest and date	1935*	1899	1934*	1898	1947*	1944	1930	1944*	1935	1930	1938	1917	1935—Jan. 28
	28 −16	*10* −15	*1* 5	*6* 17	*10* 30	*8* 33	*16* 42	*26* 40	*30* 31	*22* 19	*57* −4	*30* −6	−16
Avg. no. days 90° or higher					2	5	9	7	3				26
Avg. no. days 32° or lower	26	24	7	6						4	14	25	106
Green Spring Furnace, Md.													
Mean, max.	39.9	39.3	51.8	64.6	76.3	82.8	87.8	85.1	79.9	66.6	53.4	41.2	64.0
Mean, min.	22.9	21.3	31.0	40.0	50.4	58.3	62.8	61.3	54.6	42.9	33.1	24.5	41.9
Mean	31.4	30.2	41.4	52.3	63.3	70.5	75.3	73.2	67.2	54.8	43.2	32.9	53.0
Highest and date	1906	1909	1907	1915	1911	1911	1900	1911	1897	1904	1895	1916*	1900—Jul. 17
	23 75	*16* 71	*23* 90	*26* 96	*19* 97	*11* 101	*17* 106	*11* 104	*13* 98	*10* 90	*9* 79	*5* 69	106
Lowest and date	1904	1899	1896	1909*	1907	1913	1895	1904	1904	1895	1908	1914	1899—Feb. 11
	5 −13	*11* −14	*14* −1	*11* 17	*5* 29	*10* 39	*31* 46	*28* 42	*23* 32	*30** 20	*16* 2	*27* −9	−14
Avg. no. days 90° or higher					2	6	12	8	4				32
Avg. no. days 32° or lower	26	24	18	6	1					5	15	25	120

Hancock, Md.													
Mean, max.	37.6	40.5	53.8	66.1	77.8	84.8	88.5	86.4	81.3	69.5	55.0	43.7	65.4
Mean, min.	20.6	19.1	29.8	38.4	48.4	57.2	61.1	59.5	52.4	40.8	32.3	23.0	40.2
Mean	30.1	30.1	41.8	52.3	63.1	71.0	74.8	72.9	66.8	55.1	43.6	33.3	52.9
Highest and date	1947	1922	1921	1896	1895	1901	1901	1900	1900	1922	1895	1923	1901—Jul. 1
	30 73	*23* 79	*27* 91	*17* 97	*30* 101	*30* 102	*1* 106	*10** 103	*11* 103	*5* 94	*9* 81	*13* 72	106
Lowest and date	1904	1899	1900	1923	1947	1949	1946	1922	1947	1895	1949*	1895	1899—Feb. 11
	5 −17	*11* −18	*18* −4	*1* 7	*10* 21	*9* 34	*16* 42	*21* 38	*28* 24	*29* 19	*23* 12	*14* −6	−18
Avg. no. days 90° or higher				1	3	9	15	10	5				43
Avg. no. days 32° or lower	27	25	20	9	1				1	7	16	27	133
Keedysville, Md.													
Mean, max.	41.5	43.3	54.5	65.8	76.8	84.2	88.3	86.1	80.3	68.8	55.2	43.1	65.7
Mean, min.	23.4	23.4	31.7	39.7	49.9	58.8	63.1	61.5	54.9	43.5	34.1	25.6	42.5
Mean	32.4	33.4	43.1	52.8	63.4	71.5	75.7	73.8	67.6	56.1	44.7	34.3	54.1
Highest and date	1932	1930	1907	1915	1911	1934	1936	1918	1932	1941	1935	1916	1918—Aug. 6
	13 78	*25* 79	*23* 91	*26* 97	*19* 100	*29* 104	*10* 107	*6* 109	*1* 103	*5* 98	*5* 81	*5* 70	109
Lowest and date	1912	1934	1934	1923	1945	1945*	1943	1934	1947	1942	1938	1942	1912—Jan. 14
	14 −26	*28* −19	*1* 0	*1* 10	*2* 27	*6* 34	*1* 42	*31* 40	*27* 28	*28* 20	*27* −4	*21* −15	−26
Avg. no. days 90° or higher					3	8	13	10	4				38
Avg. no. days 32° or lower	25	23	18	7	1					5	14	23	116
Tonoloway, Md.													
Mean, max.	42.0	44.4	53.8	64.4	75.5	83.5	87.6	85.4	79.4	67.8	55.0	43.4	65.2
Mean, min.	21.9	22.4	29.2	37.1	46.6	55.8	59.9	58.3	51.9	40.2	31.9	24.0	39.9
Mean	31.9	33.4	41.5	50.8	61.1	69.6	73.7	71.9	65.8	53.9	43.4	33.7	52.6
Highest and date	1932	1930	1949*	1925	1942	1934*	1934	1930	1932	1927	1935	1933	1934—Jul. 25
	14 79	*25* 78	*12* 86	*24* 95	*1* 96	*29* 101	*25* 107	*4* 105	*1* 102	*1* 96	*5* 86	*24* 73	107
Lowest and date	1925	1934	1934	1943	1947	1930	1929	1934	1942	1936	1930	1942	1925—Jan. 28
	28 −21	*28* −17	*1* −5	*46* 19	*10* 22	*1* 30	*20* 39	*31* 36	*29* 25	*28* 16	*29* −3	*21* −12	−21
Avg. no. days 90° or higher					2	7	12	9	4				34
Avg. no. days 32° or lower	26	24	20	10	1				1	7	18	25	132

* Also on other dates, months or years.

Most of the precipitation of the colder months of the year, whether rain or snow, results from atmospheric lifting of a different nature. From October through March, most precipitation falls more gently and more continuously. Usually, relatively cold air overlays the area. Warm moist streams of air, having their origin over the Gulf of Mexico or the south Atlantic Ocean, encounter these colder and heavier masses of air to their north and are forced, by their relative lightness, to flow over the colder air. The lifting action ordinarily is gentle but over a large area, producing an extensive area of precipitation. This type of rain or snow is usually associated with an area of low barometric pressure as it moves over or near the region.

From September through November, the lower layers of the atmosphere are heated less and less as the days become shorter and the total amount of sunshine decreases.

TABLE 11

GROWING SEASON

	CHEWSVILLE	CLEAR SPRING	GREEN SPRING FURNACE	HANCOCK	KEEDYSVILLE	TONOLOWAY
Killing frosts:						
Latest date of last in spring	June 1	May 29	May 21	May 30	May 16	June 1
Average date of last in spring	May 4	April 24	April 25	May 4	May 2	May 9
Earliest date of last in spring	April 5	March 20	April 9	April 12	April 11	April 22
Earliest date of first in autumn	Sept. 11	Sept. 19	Sept. 23	Sept. 11	Sept. 11	Sept. 11
Average date of first in autumn	Oct. 9	Oct. 16	Oct. 13	Oct. 7	Oct. 14	Oct. 7
Latest date of first in autumn	Nov. 5	Nov. 7	Oct. 31	Oct. 28	Nov. 13	Nov. 5
Growing season: Length in days						
Longest	202	224	202	180	199	194
Shortest	123	125	137	111	123	119
Average	158	176	171	156	164	151

The movements of areas of low barometric pressure over or near Washington County, which usually produce good amounts of precipitation, are relatively infrequent during this period. It is the period between the showery type of rain in summer and the more or less steady precipitation of winter. With the decreased activity of the two main precipitation producing methods, amounts of precipitation gradually decrease.

However, during the colder months, the wind blows out of the west and northwest a greater amount of time. These west and northwest winds have some of their water content removed as rain or snow on the higher ridges of the Allegheny Mountains. Thus, next to Allegany County, Washington County has the smallest average annual precipitation of any of Maryland's counties. Portions of the county east of Fairview Mountain get about two to three inches more precipitation per year than the portion

TABLE 12

PRECIPITATION

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
Chewsville, Md.													
Greatest precipitation	6.07	4.44	6.99	6.18	7.12	11.57	10.28	8.61	7.51	10.63	5.45	5.83	11.57
Average precipitation	2.74	2.17	2.97	2.96	3.53	3.95	3.79	3.86	3.09	2.98	2.24	2.62	36.90
Least precipitation	0.92	0.34	0.08	0.65	0.63	0.70	0.69	0.64	0.38	0.24	0.28	0.41	0.08
Greatest 24-hr precip	2.59	1.82	3.70	2.55	3.08	5.30	4.14	3.80	3.33	3.05	2.69	2.25	5.30
Avg. no. days 0.01″ or more	9	8	10	10	11	11	10	10	8	8	8	9	112
Avg. snowfall	8.6	7.9	5.2	1.1	T				T	0.1	0.9	4.8	28.6
Greatest 24-hr snow	11.0	14.0	22.0	6.0	T				T	2.8	6.5	9.5	22.0
Avg. no. days 0.1″ or more snowfall	4	3	2	1							1	3	14
Avg. no. days thunderstorms		1	1	2	6	7	8	6	3	1			35
Clear Spring, Md.													
Greatest Precipitation	6.04	5.66	7.27	12.99	7.70	11.01	8.12	9.76	8.86	10.05	6.19	7.03	12.99
Average Precipitation	3.13	2.63	3.51	3.63	3.84	4.13	4.09	4.21	3.08	3.09	2.39	3.14	40.87
Least Precipitation	1.05	0.29	0.71	0.98	1.10	0.98	0.20	1.13	0.61	0.42	0.50	1.00	0.20
Greatest 24-hr Precip	2.25	2.20	3.10	5.84	3.85	4.38	4.03	3.27	3.31	4.48	2.20	2.90	5.84
Avg. No. Days 0.01″ or more	9	9	11	10	11	11	10	10	8	7	8	9	113
Avg. Snowfall	9.6	9.5	7.0	1.5	T					0.2	1.0	6.0	34.8
Clear Spring, Md.													
Greatest 24-hr. Snowfall	15.0	15.0	32.0	8.0	T					6.0	10.0	12.0	32.0
Avg. No. Days 0.1″ or more Snowfall	4	4	3	1	0					0	1	3	16
Avg. No. Days Thunderstorms			1	2	5	6	7	5	2	1			29
Edgemont, Md.													
Greatest Precipitation	5.41	3.62	5.75	5.92	7.35	6.08	11.67	8.46	6.90	6.66	6.22	5.96	11.67
Average Precipitation	2.86	1.93	3.24	3.40	4.66	3.82	4.31	4.05	3.17	3.81	3.32	3.02	41.59
Least Precipitation	1.21	0.30	1.36	0.74	0.90	1.51	2.13	1.08	0.65	0.94	0.70	0.80	0.30
Greatest 24-hr Precip	3.05	1.20	2.75	1.50	3.00	2.66	5.11	2.32	2.40	3.05	1.96	2.80	5.11
Avg. No. Days 0.01″ or more	9	8	11	10	12	9	10	8	6	8	8	8	1.07
Avg. Snowfall	10.7	7.1	9.6	0.1						0.2	0.5	5.0	33.2
Greatest 24-hr Snowfall	12.0	12.0	24.0	0.5						2.0	2.0	5.0	24.0
Avg. No. Days 0.1″ or more snowfall	4	2	2									2	10
Green Spring Furnace, Md.													
Greatest Precipitation	5.25	5.13	5.62	6.29	7.63	8.77	6.83	9.25	5.02	6.00	4.75	5.67	9.25
Average Precipitation	2.83	2.68	3.03	2.74	3.51	4.13	3.69	4.35	2.68	2.47	2.13	2.82	37.06
Least Precipitation	1.46	0.60	0.45	1.18	0.93	0.76	1.27	0.87	0.31	0.77	0.69	0.57	0.31
Greatest 24-hr Precip	2.50	1.42	2.00	2.00	5.00	2.84	1.91	2.52	2.46	2.74	2.75	2.10	5.00
Average No. of Days 0.01″ or more	9	8	10	10	10	11	10	9	6	6	6	8	103
Average Snowfall	6.8	8.3	6.6	0.8	T					T	0.7	5.2	28.4
Greatest 24-hr Snowfall	9.2	11.0	16.0	2.6	T					T	6.0	10.0	16.0
Average No. Days 0.1″ or more Snowfall	4	3	3	0								2	12
Average No. Days Thunderstorms			1	2	3	3	4	3	1				17
Hancock, Maryland													
Greatest Precipitation	5.48	4.70	7.96	8.18	7.28	8.66	6.90	7.83	6.84	9.68	5.70	5.69	9.68
Average Precipitation	2.62	2.12	3.13	3.08	3.46	4.04	3.49	3.20	2.87	3.22	2.28	2.58	36.09
Least Precipitation	0.98	0.27	1.17	0.64	0.77	2.20	0.14	0.48	0.13	0.47	0.34	0.60	0.13
Greatest 24-hr. Precip	2.05	2.35	4.02	4.00	2.00	3.28	3.01	3.40	3.70	3.32	2.17	2.57	4.02
Average No. of Days 0.01″ or more	9	8	10	10	11	10	10	8	8	7	7	8	106
Average Snowfall	7.9	7.4	5.2	0.9	T					0.2	0.7	4.6	26.9
Greatest 24-hr Snowfall	14.0	15.0	18.0	9.0	T					5.0	8.5	10.0	18.0
Average No. of Days 0.1″ or more Snowfall	3	3	2	0								2	10
Average No. of Days Thunderstorms			1	1	2	3	3	2	2				14

TABLE 12—*Continued*

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
Keedysville, Maryland													
Greatest Precipitation	6.07	4.20	5.68	6.78	6.72	7.20	11.66	8.98	6.87	10.26	6.09	6.77	11.66
Average Precipitation	2.85	2.30	2.88	3.19	3.45	3.83	3.93	4.03	3.21	3.26	2.35	2.82	38.10
Least Precipitation	0.91	0.16	0.37	0.69	0.73	1.28	0.18	0.90	0.45	0.32	0.33	0.51	0.16
Greatest 24-hr Precip	2.16	1.88	2.35	3.38	2.65	3.15	4.26	3.40	3.98	4.44	2.82	3.32	4.44
Average No. of Days 0.01″ or more	10	9	10	11	11	11	11	11	8	8	8	10	118
Average Snowfall	7.7	7.7	4.4	0.8	T					0.1	0.6	4.9	26.2
Greatest 24-hr Snowfall	13.0	12.0	14.0	7.0						2.0	10.0	11.0	14.0
Average No. of Days 0.1″ or more Snowfall	3	3	2	0								2	10
Average No. of Days Thunderstorms			1	1	3	4	3	2	1				15
Tonoloway, Md.													
Greatest Precipitation	5.84	4.16	8.59	7.62	7.28	7.68	6.40	6.22	7.24	8.59	4.75	6.22	8.59
Average Precipitation	2.61	2.05	2.95	3.47	3.61	4.04	3.44	3.37	3.03	3.61	2.36	2.40	36.94
Least Precipitation	0.71	0.19	1.06	0.90	0.75	1.98	0.21	1.17	0.13	T	0.53	0.38	T
Greatest 24-hr. Precip	1.89	2.32	4.13	3.77	2.03	3.18	3.44	3.01	2.79	4.55	1.58	2.82	4.55
Average No. of Days 0.01″ or more	9	7	9	10	11	10	10	10	8	8	7	8	107
Average Snowfall	8.3	7.0	5.2	1.1						0.3	0.7	4.7	27.3
Greatest 24-hr Snowfall	11.5	15.0	12.2	9.0						5.0	7.0	8.0	15.0
Average No. of Days 0.1″ or more Snowfall	3	3	2									2	10
Average No. of Days Thunderstorms			1	1	3	4	3	2	1				15
Williamsport, Md.													
Greatest Precipitation	5.27	3.66	5.47	4.98	6.02	7.52	7.48	6.98	7.17	7.81	5.57	4.96	7.81
Average Precipitation	2.89	1.95	3.08	3.18	4.12	4.16	3.53	4.08	2.78	3.56	2.87	3.16	39.36
Least Precipitation	1.31	0.22	0.70	0.81	1.98	1.27	0.60	1.09	0.60	0.73	0.64	0.78	0.22
Greatest 24-hr Precip	2.36	1.45	2.25	1.88	1.66	3.27	3.15	2.66	3.30	2.75	1.50	2.03	3.30
Average No. Days 0.01″ or more	10	8	10	12	13	12	11	10	8	10	9	10	12.3
Average Snowfall	10.1	6.4	6.1							0.2	0.1	3.9	26.8
Greatest 24-hr. Snowfall	16.1	14.0	15.5	0.5						2.0	1.2	5.0	16.1
Average No. Days 0.1″ or more Snowfall	4	3	2									2	11

to the west. However, the small deficiency of the county's precipitation is due to lighter precipitation in the colder months of the year. The rains of the warmer months, the period when adequate rainfall is of greatest importance for growing crops, average about 4 inches per month and are adequate for all agricultural interests.

Average annual snowfall for most sections of the county is between 25 and 30 inches, although the average at Clear Spring is 34.8 inches and at Edgemont 33.2 inches. The Edgemont record is less than twelve years in length and may not be representative over a long period of years. The Clear Spring area is just to the east of Fairview Mountain. Large amounts of snow fall when the winds are blowing from the northeast and the east. The rising elevation from east to west in the vicinity of Clear Spring forces the snow-bearing air streams to rise, producing a lower temperature and increased snowfall. The greatest 24 hour snowfall for the county was on Palm Sunday, March 29, 1942. Edgemont reported a 24 inch snowfall and Chewsville 22 inches on this date.

FOGS

In a broad sense, a fog is a cloud at ground-level. Fogs are formed usually by the temperature of the air lowering to the condensation point, or less frequently, by the addition of water vapor to the air. Most often, it is a combination of the two, with the addition of the water vapor being the minor factor.

Radiation, or ground, fogs form on clear nights when the winds are light or calm. As discussed earlier under the effect of the configuration of the land, the cold air pools in low places and tends to become colder by continued radiation. If the condensation

TABLE 13

STATE OF THE SKY

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
Chewsville, Md.													
Average no. clear days	10	10	11	11	12	12	12	12	14	15	10	9	138
Average no. partly cloudy days	12	11	12	12	14	14	17	15	12	11	13	12	155
Average no. cloudy days	10	7	8	7	5	4	2	4	4	6	7	9	73
Clear Spring, Md.													
Average no. clear days	11	11	12	12	13	15	15	13	15	16	12	11	156
Average no. partly cloudy days	10	10	11	11	12	11	12	13	10	9	10	11	130
Average no. cloudy days	10	7	8	7	6	5	3	4	4	6	8	9	77
Green Spring Furnace													
Average no. clear days	15	15	15	15	18	18	19	19	20	19	17	15	205
Average no. partly cloudy days	6	6	8	7	7	7	8	7	6	6	6	6	80
Average no. cloudy days	10	7	8	7	6	5	4	4	4	6	8	10	79
Keedysville, Md.													
Average no. clear days	12	12	14	14	15	16	17	17	18	17	14	12	178
Average no. partly cloudy days	8	7	8	8	10	9	11	9	7	6	8	8	99
Average no. cloudy days	11	9	9	8	6	5	3	5	5	7	9	11	88
Tonoloway, Md.													
Average no. clear days	12	13	14	15	16	17	19	18	17	17	13	11	182
Average no. partly cloudy days	7	7	8	7	9	8	9	7	7	7	8	7	91
Average no. cloudy days	12	8	9	8	6	5	3	5	6	7	10	13	92

point of the air is reasonably close to the temperature of the air during the evening, the temperature will lower quickly to the condensation point, forming shallow fog layers which slowly build up from the ground as the night progresses.

When warm moist air flows over cold or snow-covered ground, the temperature of the air is quickly reduced to the dew point and condensation occurs. Fog produced in this manner is frequently referred to as advection fog. In both types of fog, the air near the ground is relatively heavier than the air above, and there is no upward dispersion of the fog particles. Fogs in Washington County are fairly infrequent. Averages indicate that dense fogs occur on less than ten days per year. There is a slightly higher incidence of fog in the valleys of the hilly and mountainous areas of the western and extreme eastern portions of the county due to the pocketing of cool air. The greatest frequency is during the colder months when nighttime cooling is longest and the ground is more likely to be cold.

SUNSHINE AND CLOUDINESS

There are no records of the duration of sunshine in Washington County such as at the larger offices of the Weather Bureau. The annual average number of clear, partly cloudy, and cloudy days is shown in Table 13. Comparing these figures with comparable data from other portions of the State, it can be stated that Washington County's sunshine is as great or greater than most areas, except the Cumberland to Westernport section of Allegany County. The percentage of sunshine is greatest from May through October, decreases to a minimum in December, January and February, and then begins to increase again. The nearest mechanical measurements of the duration of sunshine are at Baltimore and Washington, D. C., where the annual averages are 59% and 57%, respectively. Both cities indicate more than 60% of possible amounts from May through October with a peak of about 65% in July. Minimum percentages of possible amounts occur in December and January, being somewhat less than 50%.

WINDS

In the absence of mechanical measurement of the direction and speed of the wind in Washington County, data from Washington, D. C. are used. Except for some effects produced by the mountains, these data are fairly representative of Washington County. The prevailing direction is from the northwest from October through April and from the south during the other months of the year. As is to be expected, the highest average velocities occur during the colder months and the least during the warmer months. Wind speeds are subject to too many deviations caused by geographical effects and exposure of instruments to be reliable in this comparison.

MAGNETIC DECLINATION IN WASHINGTON COUNTY

BY

H. HERBERT HOWE

WHY WE MUST STUDY THE EARTH'S MAGNETISM

We seldom stop to think about the great changes which the compass wrought in the progress of civilization. There have been seafaring nations since the dawn of history, but in olden times a ship was always in peril when out of sight of land. In fair weather, the captain could find direction by the sun and stars; but in foul weather, he had no way of telling one direction from another, unless he could guess from the wind and the waves.

The invention of the compass, a few centuries before the time of Columbus,[1] changed all this. Now, a ship's captain could find his bearings in any weather. General use of the compass was delayed for a time by the superstitious dread that haunted anything new and strange. But the compass was finally accepted, and in the next era daring navigators conquered the seven seas.

Even today, the compass is important in navigation. Small vessels still depend on it. Large ships now use the gyrocompass, which orients itself by the rotation of the earth—but they have magnetic compasses to use in case the gyrocompass gets out of order. Air navigators must rely on the earth's magnetism for finding directions, since the gyrocompass has never been adapted to airplanes. (A directional gyro is reset at short intervals, by reference to the magnetic compass.)

For many years, the compass was an important surveying instrument. It is not very accurate, and its use should be avoided where possible. It is, however, still useful for certain classes of surveying, especially retracing old compass surveys.

Geologists and geophysicists use magnetic instruments, not only to find magnetic iron ore, but also to trace rock formations that may contain oil and other minerals. Changes in the ionosphere are related to radio reception and also to changes in the earth's magnetic field. Earth-currents (natural electric currents in the ground) are related to geomagnetic changes; at times these currents become large enough to affect the operation of telegraph lines and electric power systems. Cosmic rays are also related to the earth's magnetic field.

With so many matters of everyday interest affected directly or indirectly by the earth's magnetism, it is important to find out all we can about it: its cause; how it is distributed over the earth; how and why it changes from hour to hour, and from year to year; and how it is related to earth currents, atmospheric electricity, and solar activity.

[1] A brief history of the compass is given in the Coast and Geodetic Survey's Serial 663. See bibliography at end of this chapter.

GENERAL INFORMATION ABOUT THE EARTH'S MAGNETIC FIELD

THE MAGNETIC ELEMENTS

The earth acts like a great magnet, in that it is surrounded by a magnetic field. To measure the earth's magnetism at any place, we must measure the direction and intensity of this field.

A magnet perfectly free to turn in any direction, and balanced at its center of gravity, would show the direction of the earth's magnetic field. It is almost impossible to suspend a magnet in that way, but we can get the same result by using two different magnets. One of them, a compass needle, is constrained to turn about a vertical axis; it shows the direction of the horizontal component of the field. The other, a dip needle, is constrained to turn about a horizontal axis; when properly oriented, it shows how much the field dips below the horizontal.

The angle between magnetic north and true north (as determined by the north pole of the heavens) is the *magnetic declination* (*D*). *West declination* means that the north end of the needle is west of true north. Magnetic declination is known to some as *variation of the compass.*

The magnetic *dip* or *inclination* (*I*) is the angle that a dip needle makes with the horizontal—i.e., the angle between the plane of the horizon and the lines of force. In Washington County, the dip is about 72°. Over much of the world, the direction of the magnetic field is more nearly vertical than horizontal.

The declination and dip define the direction of the magnetic field. To describe the field completely, we must also measure the intensity or some component of intensity. The total intensity (*F*) is sometimes measured, but it is usually easier and more accurate to measure its horizontal component (*H*), or perhaps its vertical component (*Z*). The declination, dip, and the various components of intensity are called magnetic elements. When we speak of *the* magnetic elements, we usually mean *D*, *I*, and *H*. If we know these three, we can compute any other magnetic element.

DISTRIBUTION OF THE EARTH'S MAGNETIC FIELD

The earth's magnetic field is different in different places. It is so irregular that it must be measured in many places to get a satisfactory picture of its distribution. There are, however, certain regular features.

At the *magnetic poles*, a dip needle stands vertical, the horizontal intensity is zero, and a compass does not show direction. At the north magnetic pole, the "north" end of the dip needle is down; at the south magnetic pole, the "north" end is up.

The north magnetic polar region is probably centered at about latitude 73° N., longitude 100° W. Within this region, there are no doubt many magnetic poles, none of them stationary; and throughout the region, the compass is useless for practical purposes. The position of the south magnetic polar region is rather uncertain; it is perhaps near latitude 68° S., longitude 144° E.

As one goes away from the magnetic polar regions, the dip decreases and the horizontal intensity increases. At the *magnetic equator*, dip is zero. The magnetic equator is south of the geographic equator in South America, and north of it in Africa and the Orient.

SOME MISCONCEPTIONS ABOUT MAGNETIC POLES

Many people believe that the compass points true north. If it did, there would be no need to measure the magnetic declination. The compass does, in fact, point in a general northerly direction in most places—but usually not exactly north. For example, in northeastern Maine, it points 22° west of true north; in northwestern Washington, 24° east of true north.

Many other people believe that the compass points toward the magnetic pole. If it did, we would have only to measure the declination at two places to locate the magnetic pole, and could then compute the declination for other places. The compass does, in fact, point in the general direction of the magnetic pole over nearly all of the earth—but usually not exactly toward it. For example, along the 100th meridian in the United States, the north magnetic pole bears due north but the compass points 10° or more to the east of true north.

The compass as a whole is not drawn toward the magnetic pole, nor in any other direction. The effect of the earth's magnetism is to turn a compass, not to pull it. Nor does it turn it toward any particular point in the earth or in the heavens. It merely turns it so that it points in the direction of the horizontal projection of the magnetic field at the point of observation.

The action of the compass is in no way controlled by the magnetic poles. The earth's magnetic field results from some cause distributed throughout a large volume of the earth; a magnetic pole is one of its manifestations, and the magnetic declination in Washington County is another. Now, it is true that an airplane which traveled always toward the magnetic north as shown by its compass would finally reach the vicinity of the north magnetic pole, in the Canadian Arctic, but by a curved route. This shows that the earth's magnetism has a measure of world-wide coordination. If the airplane flew in the direction shown by the *south* end of the compass, it would reach the south magnetic pole, in Antarctica.

The term "magnetic pole," when used with respect to the earth, has a meaning quite different from its meaning with respect to a bar magnet or a horseshoe magnet. A magnetic pole of the earth is a point at which a dip needle will stand vertical; the poles of a bar magnet are imaginary points within it, so chosen that the external field of the magnet is the same as if the magnetism were concentrated at the poles. (Such points do not actually exist, but points can be found fulfilling these conditions to a fairly good approximation.) The basic difference between these two types of "poles" may be seen from the following considerations: (*a*) The field of a bar magnet is much more intense near the poles than near the middle; the field of the earth is only about twice as strong at the magnetic poles as at the magnetic equator. (*b*) If we imagine a powerful bar magnet, placed within the earth so as to give an external field as nearly like the earth's actual field as possible, this bar magnet would have to be quite short and near the center of the earth; its poles would thus be thousands of miles from the actual magnetic poles of the earth, which by definition are on the surface.

The magnetic poles are thus not centers of attraction—they are merely regions in which the magnetic field happens to be vertical. Very likely there would be much less popular interest in magnetic poles if it were thoroughly understood that their positions do not determine the direction taken by a compass needle. The principal real concern about magnetic poles is that a compass is useless near them.

It is also widely supposed that secular change results from motion of the magnetic poles. Secular change is too complex to explain in this way, and too great to explain by the known motion of the magnetic poles. Secular change is a regional phenomenon, rather than a world-wide one. Secular change in Washington County is closely related to that in the rest of Maryland, but it bears no relation to the change in Madagascar; and the secular change in Alaska is not related to either one.

TABLE 14

AVERAGE DAILY VARIATION OF MAGNETIC DECLINATION IN MARYLAND

A plus sign means that west declination is greater than the mean for the day. For individual quiet days, the range may be more or less, and the extremes may come at different hours.

LOCAL MEAN TIME	JAN., FEB., NOV., DEC.	MAR., APR., SEPT., OCT.	MAY, JUNE, JULY, AUG.	LOCAL MEAN TIME	JAN., FEB., NOV., DEC.	MAR., APR., SEPT., OCT.	MAY, JUNE, JULY, AUG.
	′	′	′		′	′	′
1 a.m.	+0.1	−0.4	−0.2	1 p.m.	+3.0	+4.6	+5.5
2 a.m.	+0.2	−0.5	−0.3	2 p.m.	+3.2	+4.8	+5.5
3 a.m.	+0.2	−0.6	−0.4	3 p.m.	+2.7	+4.0	+4.4
4 a.m.	−0.1	−0.9	−0.9	4 p.m.	+1.6	+2.4	+2.7
5 a.m.	−0.4	−1.3	−1.9	5 p.m.	+0.8	+1.2	+1.2
6 a.m.	−0.8	−2.2	−3.9	6 p.m.	+0.2	+0.7	+0.3
7 a.m.	−1.1	−3.4	−5.5	7 p.m.	−0.2	+0.4	+0.1
8 a.m.	−2.3	−4.7	−6.0	8 p.m.	−0.4	0.0	+0.4
9 a.m.	−3.1	−4.1	−4.9	9 p.m.	−0.6	−0.2	+0.2
10 a.m.	−2.7	−2.6	−1.8	10 p.m.	−0.6	−0.4	0.0
11 a.m.	−0.7	+0.6	+1.8	11 p.m.	−0.4	−0.2	−0.2
Noon	+1.6	+3.3	+4.5	Midnight	−0.2	−0.4	−0.2

This table is based on records of the Cheltenham Magnetic Observatory, averaged over 10 quiet days of each month, 1918–1928. In Washington County, 7 a.m. local mean time is 7:12 a.m. Eastern Standard Time.

Further comments on magnetic poles are given in Serial 726. It is there pointed out that the magnetic pole is not even a definite, determinable point.

CHANGES OF THE EARTH'S MAGNETISM

The earth's magnetic field is always changing. The changes of magnetic declination discussed here are the daily variation, lunar variation, irregular disturbance, magnetic storms, secular (or annual) change, and annual variation.

DAILY VARIATION

There is usually a fairly systematic departure of the magnetic field from its daily mean value. This repeats itself with fair regularity day after day. The amount of departure depends upon the time of day, the season, the magnetic latitude, and other factors not wholly understood. This systematic change is called *daily variation.*

The amplitude of the daily variation is not predictable for any one day. Table 14 shows the average daily variation of the magnetic declination at Cheltenham, Md. For individual undisturbed days, departures from the mean may be more or less than shown, and the extremes may come earlier or later. On disturbed days, the changes are quite different.

In northern latitudes the north end of the needle moves eastward in the morning, with an easterly extreme about 8 or 9 A.M., local time. The westerly extreme comes about 1 or 2 P.M., followed by easterly motion. From dusk to the early morning, there is little change. The daily range is greater in summer than in winter, and greater near the magnetic pole than near the Equator.

In the Southern Hemisphere, the westerly extreme is in the morning and the easterly one is in the afternoon; the greatest amplitude is in December. Part of the Tropics lies in a transition belt, in which the northern type of variation predominates in June and the southern type in December.

In the United States in summer, the north end of the compass needle points on the average 12′ more to the west at 1 P.M. than at 8 A.M. A line run 1000 feet by compass at 8 A.M. would end 3 feet to the right of the place where it would end if run at 1 P.M. Thus, daily variation is one factor limiting the accuracy of compass surveys.

The chief features of the most widely held theory of the daily variation are as follows: ultra-violet light from the Sun produces the ionosphere, a region of ionized air beginning perhaps 60 miles high. This ionized air partakes of various kinds of motion, including those produced by two forces which recur every 24 hours, namely (*a*) the Sun's gravitational attraction, and (*b*) the expansion caused by heat received from the Sun. The resulting overhead motion of conducting gases through the earth's magnetic field generates electric currents which cause the variations in the magnetic field that are observed on the ground.

LUNAR VARIATION

Of no practical importance, but of great theoretical interest, is the *lunar variation.* Motion of the ionosphere is also caused by the moon's gravitational attraction, which causes a periodic change twice in each lunar day, like the tides. The effect on declination is only one or two tenths of a minute in this latitude.

The lunar variation was discovered in the 1840's. Since that was long before ionization was known, its cause long remained a mystery.

IRREGULAR DISTURBANCES AND MAGNETIC STORMS

Irregular changes are generally superimposed on the regular daily variation. When these changes become large, we say that there is a *magnetic storm.* These "storms" are quite different from ordinary storms. Their only manifestations that are visible without instruments are the Northern Lights (and Southern Lights). Magnetic storms are associated with sunspots, and are characterized by pronounced disturbance to radio transmission and wire telegraphy—occasionally even to power transmission lines. A magnetic storm may last many hours or even several days, and the larger ones occur all over the earth at the same time.

SECULAR AND ANNUAL CHANGE

As a rule, the average value of a magnetic element for one year differs from that for the next year. This change, known as the *secular change*, usually continues in one direction for many years. The amount of secular change in one year is called the *annual change*.

Secular change does not continue indefinitely in one direction; eventually a turning point is reached. At some stations, two turning points have been recorded. Thus, at London, the declination reached extremes of 11° East and 24° West in 1580 and 1810, respectively.

TABLE 15

ANNUAL MEANS OF MAGNETIC DECLINATION AT CHELTENHAM MAGNETIC OBSERVATORY

Cheltenham is in Prince Georges County, Maryland. Latitude, 38° 44′; longitude, 76° 51′. A table of this sort, showing annual values, can be prepared only for a magnetic observatory.

The table shows that the declination does not change at a constant rate. In addition to minor irregularities, there was a major change in rate in 1933.

YEAR	DECLINATION	YEAR	DECLINATION	YEAR	DECLINATION	YEAR	DECLINATION*
	° ′		° ′		° ′		° ′
1902	5 06.8W	1914	5 59.8W	1926	6 42.8W	1938	7 05.1W
1903	10.0	1915	6 04.0	1927	45.7	1939	05.0
1904	13.3	1916	07.7	1928	49.0	1940	05.0
1905	17.8	1917	10.4	1929	52.0	1941	05.4
1906	21.5	1918	12.4	1930	6 55.9	1942	05.9
1907	26.0	1919	15.0	1931	7 00.0	1943	06.3
1908	31.1	1920	18.5	1932	03.7	1944	06.0
1909	36.4	1921	22.4	1933	06.2	1945	05.8
1910	41.4	1922	27.7	1934	06.8	1946	05.2
1911	45.6	1923	32.0	1935	06.5	1947	04.6
1912	50.0	1924	35.8	1936	06.2	1948	04.0
1913	5 54.6W	1925	39.4W	1937	7 05.4W	1949	7 04.4W

* The values in the last column are provisional; but the final values will differ from them by only a few tenths of a minute.

Table 15 illustrates the fact that the change from year to year is not uniform, and that the declination ultimately reaches a turning point. It also shows why we cannot derive the secular change for 100 years by multiplying 100 into the annual change—the annual change is too irregular.

At one time, it was thought that declination could be represented by formulas of sine terms. Some people used them as aids to interpolation—others proposed to extrapolate into the future. It now seems preferable to avoid such formulas. They are useless for extrapolation, and any interpolation formula that contained enough terms to be reliable would be very cumbersome. It is much better to use a secular-change table, such as Table 17.

There is no tangible basis for predicting secular change. When one must forecast it, the best that can be done is to assume that the rate will be the same in the near future as in the recent past. Actually, the rate sometimes undergoes abrupt changes, as exemplified in Table 15, for the year 1933. (Prediction is further discussed in Serial 726.)

ANNUAL VARIATION

When the average monthly values are corrected for secular change, there remains a small systematic seasonal effect. This is called *annual variation.* Its magnitude and direction differ in different places. In Maryland, west declination is about a minute larger in winter than in summer.

LOCAL MAGNETIC DISTURBANCE

The declination differs from place to place. In most regions, the change is gradual enough so that a surveyor can use the same declination throughout a small area. In some regions, however, there are large differences within a small area—sometimes several degrees within a hundred feet or less. Sometimes, it makes considerable difference how high the compass is above the ground.

These effects are due to *local disturbances* or *local anomaly.* If caused by the works of man, a disturbance is called *artificial disturbance*; otherwise, it is *natural disturbance.* Local disturbance is often called *local attraction*, but this is misleading, since the needle is not necessarily attracted toward anything. The term *local irregularity* would be better.

Local disturbance can usually be detected by observing the compass bearing of a line at two or more points on the line.

NATURAL DISTURBANCE

Natural anomalies of several degrees are usually due to the admixture of an iron ore known as magnetite somewhere in the underlying formations (although not necessarily in commercial deposits). Other ores and geological formations cause smaller anomalies.

Even in undisturbed regions, minor irregularities are the rule. Almost anywhere, the declination at two points 100 feet apart differs by a few minutes. Natural anomaly is responsible for many of the shortcomings of the compass as a surveying instrument.

The effect of magnetic material diminishes rapidly with increasing distance. Large natural disturbances are uncommon at sea, since the nearest disturbing matter is at or below the bottom of the sea. Likewise, an airplane in flight is far removed from any source of natural disturbance. (For both sea and air navigation, the principal uncertainties of the compass arise from the effect of iron in the craft itself, and the dynamic effects of the craft's motion.)

Local disturbance is not always an inconvenience. Oil and valuable ores are often associated with geological formations that can be traced by their magnetic effects.

ARTIFICIAL DISTURBANCE

Whenever compass surveys are being made, artificial magnetic disturbance should be avoided. Iron, steel, or direct electric currents near the instrument will have an effect. The magnitude of this effect diminishes rapidly with increasing distance.

Unless precautions are taken, the observer's clothing is likely to contain iron in hat brim, spectacles, belt buckles, zippers, etc. Some brass is nonmagnetic; but much commercial brass contains iron as an impurity, and is therefore magnetic.

There may be iron in buildings, fences, or buried pipes. Power lines are often supported by steel towers large enough to have considerable magnetic effect, although an alternating electric current has no effect on a compass, because the magnetic field of the current reverses direction so fast that the compass cannot respond to it.

Far-reaching artificial disturbances are caused by direct-current electric railways with grounded rails. Leakage from the rails may affect sensitive magnetic instruments 10 miles away, although it may not affect appreciably an ordinary compass at a quarter mile.

At sea, the iron of a ship causes magnetic disturbance. It is possible to *compensate* for most of the disturbance, by placing permanent magnets, soft iron spheres, and soft iron bars in the proper places near the compass.

MAGNETIC SURVEYS

The earth's magnetic field cannot be computed from knowledge about magnetic poles. Moreover it changes from year to year. It must therefore be measured at regular intervals.

To get information about daily variation and irregular changes, and to get the best information about secular change, magnetic observatories are established. At an observatory, continuous photographic records are made of the changes in direction and intensity of the magnetic field. The buildings are well insulated, to free the instruments from the effects of rapid temperature changes. The Coast and Geodetic Survey has operated magnetic observatories at intervals since 1860, and continuously since 1900. It now has 7 of them: one in Maryland, one in Arizona, one in Puerto Rico, one in the Hawaiian Islands, and three in Alaska. The one in Maryland is near Cheltenham, in Prince Georges County.

The Coast and Geodetic Survey has recently devised the *declination recording station*. This produces a photographic record of changes of declination only, and requires attention only at intervals of several months, whereas a standard observatory requires daily attention. Two declination recording stations have been established, one near Gatlinburg, Tennessee, and one at Logan, Utah.

Magnetic observations have been made at nearly 9000 other places in the United States. Each of these is called a *magnetic station*. At about 100 of these, called *repeat stations*, observations are repeated at intervals of about 5 years, to measure changes in the earth's magnetism.

A magnetic station is often marked by a sunken stone or concrete post. There is usually a bronze disk in the center of the top. Many stations were established near county seats, so that they could be used by local surveyors for testing compasses. The observers tried to choose sites free from artificial or natural disturbance, but many stations have nevertheless been made useless by industrial developments.

In a magnetic survey, declination and horizontal intensity are usually measured with a magnetometer, in which a magnet is suspended by a fine gold ribbon, to eliminate the friction of a pivot. Since declination is the angle between the true and magnetic meridians, both meridians must be found. The magnetic meridian is found with the magnetometer, and the true meridian by observing the sun with a theodolite. Dip is measured with an earth inductor or with a dip circle. Complete details on these measurements are given in Serial 166, and brief summaries are given in Serials 718 and 663. Serials 166 and 663 give pictures of the instruments.

A description of each station is prepared, telling where it is and how it is marked. The description often gives the true azimuths or true bearings of several prominent objects, so that magnetic observations can be made in the future without having to redetermine azimuth. In the magnetic and geodetic work of the Coast and Geodetic Survey, azimuths are counted from 0° to 360° as follows: 0° = south; 90° = west; 180° = north; 270° = east; 360° = south.

MAGNETIC SURVEY OF MARYLAND

The original magnetic survey of Maryland was made between 1896 and 1900. In 1896, the Maryland Geological Survey employed the late Dr. L. A. Bauer. He borrowed a magnetometer and a dip circle from the United States Coast and Geodetic Survey, and by prodigious effort made a fairly complete survey of the State in three months. The Geological Survey continued to employ him, and he occupied many additional stations in 1897 and 1898. In May 1899, Bauer entered the Coast and Geodetic Survey, becoming chief of its new division of Terrestrial Magnetism (now known as the Division of Geomagnetism and Seismology). The survey of Maryland was continued by the Coast and Geodetic Survey in 1899 and 1900. The results of this survey were published in two reports, described in the bibliography at the end of this chapter.

Most of the magnetic observations made in Maryland by the Coast and Geodetic Survey between 1901 and 1938 were at repeat stations. In 1939, a number of stations were occupied by an observer attached to a triangulation party.

Magnetic Observations in Washington County

Table 16 shows data for all the magnetic stations in Washington County. In the following brief descriptions of these stations, "MGS" means Maryland Geological Survey; "C&GS" means United States Coast and Geodetic Survey; and "USGS" means United States Geological Survey.

Hagerstown (1896).—Established by MGS on the east side of the Hagerstown Academy. Marked by an ash stave.

Hagerstown (1900).—C&GS made observations at the north stone of the meridian line of the USGS, at the almshouse, about 1.8 miles north of town. In 1925, the county surveyor reported that the station had been destroyed.

Hancock.—In 1897, MGS made magnetic observations in a large open field belonging to Mr. Brosius, north of the railroad depot.

Maryland Heights (1870).—C&GS made magnetic observations at a point near the triangulation station MARYLAND HEIGHTS. This station is on top of the mountain overlooking Harpers Ferry, just south of the massive ruins of the old stone fort. The magnetic station was not permanently marked.

Maryland Heights (*1897A*).—MGS occupied another point near the triangulation station. Not permanently marked.

Maryland Heights (*1897B*).—MGS also observed in a little apple orchard back of Mr. Hughes' house. Not permanently marked.

Maryland Heights (*1939*).—C&GS made magnetic observations at five nearby points, only one of which was marked. The marked station, described as Auxiliary D, is the azimuth mark of triangulation station MARYLAND HEIGHTS.

To reach this station, follow U. S. Highway 340 to a point that is 1.3 miles west of the highway junction in Weverton, and 0.25 mile northeast of the northeast end of the new bridge connecting Maryland and Virginia. At this point, turn north onto a narrow hard-surfaced road; follow this road 0.45 mile. The azimuth mark is 1 foot west of the line of posts marking west edge of right-of-way, at a point that is 125 feet north of the lane entering a farmyard; this farmyard may be identified by a small

TABLE 16

VALUES OF THE MAGNETIC DECLINATION IN WASHINGTON COUNTY

STATION	LATITUDE		LONGITUDE		DATE OF OBSERVATION	MAGNETIC DECLINATION (WEST)			
						Observed		Reduced to January 1, 1945	
	°	′	°	′		°	′	°	′
Hagerstown (1896)	39	38	77	43	10/ 9/96	4	34.2	6	46
Hagerstown (1900)	39	38	77	45	6/ 9/00	4	36.7	6	35
Hancock	39	42	78	10	7/28/97	4	24.9	6	29
Maryland Heights (1870)	39	20	77	43	10/12/70 to 11/16/70	2	56.0	6	47
Maryland Heights (1897A)	39	20	77	43	7/27/97	4	24.0	6	33
Maryland Heights (1897B)	39	20	77	43	7/28/97	4	14.4	6	23
Maryland Heights (1939)	39	20	77	42	9/14/39	6	39.4	6	40
Do., Aux. A	Do.		Do.		Do.	6	02.3	6	03
Do., Aux. B	Do.		Do.		Do.	5	57.6	5	58
Do., Aux. C	Do.		Do.		Do.	6	36.0	6	36
Do., Aux. D	Do.		Do.		Do.	6	28.5	6	29

stone building near the public road. The azimuth mark is a concrete post with a bronze disk in the top, which is stamped "MARYLAND HEIGHTS 1939" and has an arrow pointing toward the triangulation station (on the mountain).

The primary magnetic station, and auxiliaries A, B, and C, were to the eastward, some distance from the fences.

MAGNETIC CHARTS

Results of magnetic surveys are often shown by magnetic charts. The most common magnetic chart is the *isogonic chart*, which has a number of lines called *isogonic lines*; each isogonic line is drawn through places having *approximately* the specified value of the declination. An *isoclinic chart* shows dip or inclination; an *isodynamic chart* shows some component of intensity.

Since the earth's magnetic field changes from year to year, a chart must be made for some specified year or *epoch*.

ISOGONIC CHART OF WASHINGTON COUNTY

Figure 45 shows an isogonic chart of Washington County, for the epoch 1950. It was prepared by the "anomaly method" described in Serials 664 and 667, using observations in Washington County and in neighboring areas. Since the secular change has been small in recent years, this chart could be used for any year from 1930 to 1950, with but a few minutes' error.

INTERPRETING A MAGNETIC CHART

Making magnetic charts is a special art. One might suppose that we should draw an isogonic line so that all greater values of declination fell on one side, and all smaller values on the other. This is always possible, but is not usually desirable. If we did this, the chart would not fulfill its main purpose, which is to show the most likely value of declination at a point at which observations have not been made.

This may be made clear by analogy to the elevations of the earth's surface above sea level. There are general trends in elevation across Maryland; there are also many local irregularities where the elevation changes 50 feet or more within a quarter mile. Since we can see these changes, it is feasible to make maps of equal elevation (topographic maps) with a reasonable amount of work, and this has been done for all of the State.

There are similar variations in the earth's magnetic field. The real lines of equal declination (at a given moment) are a very complex system of bends, loops, and closed curves. But the irregularities cannot be seen; an observation at a point tells only the value at that point. Hence, the real lines cannot be drawn without an exceedingly large number of observations.

Suppose, now, that it were impossible to tell anything about elevation except by setting up an instrument and making observations; and suppose only a few hundred such observations had been made in Maryland. No one could draw a good topographic map from such data; an observation would tell little about the elevation a quarter mile away, since the point of observation might be on a mountain or in a valley. The best that one could do would be to draw lines showing the general trend across the State. In a region in which all observations agreed well, we would surmise that it was a region of gentle slopes, in which we could interpolate with fair accuracy for points at which no observations had been made; in a region in which the observations did not agree well, we would know that the topography was rugged, and that any estimate for a point at which no observations had been made would be more or less of a guess.

Similarly, we have observed the declination at only a few hundred points in Maryland, and cannot use these observations to give accurate values for other points. The best we can do is to draw lines indicating general trends, which is what we do when we make an isogonic chart.

For these reasons, a *chart value* of declination (i.e., a value read from a chart, and corrected for secular change) is usually not the actual declination at the point. It is, however, the best value for a surveyor to use unless he has other information. It is roughly equal to the average declination over a circle of 10-mile radius, centered at the point. There is perhaps an even chance that a chart value agrees with the actual value within half a degree. Occasionally, they differ by many degrees.

There is still much difference of opinion as to the best way of drawing isogonic lines from given data. This may be seen by comparing charts drawn in different countries (or, for that matter, charts drawn by different persons in the same country): some have much straighter lines than do others. Even within the Coast and Geodetic Survey, the principles used in drawing charts change from time to time. For example, the isogonic chart shown as Figure 31 of "The Physical Features of Carroll County and Frederick County" has straighter lines than does Figure 45, because a different method was used in drawing them.

The chart value of declination varies but little in Washington County. Although the general trend is for declination to increase to the northeastward across Maryland, the lines for Washington County have been modified in this respect on the basis of observations near the northeast corner of the county.

FINDING A CHART VALUE FOR A DIFFERENT DATE

A value scaled from Figure 45 is intended to be a mean value for January 1950, eliminating daily variation and irregular variation. To get the declination for other years, a correction for secular change is to be applied, as shown in example (g) below.

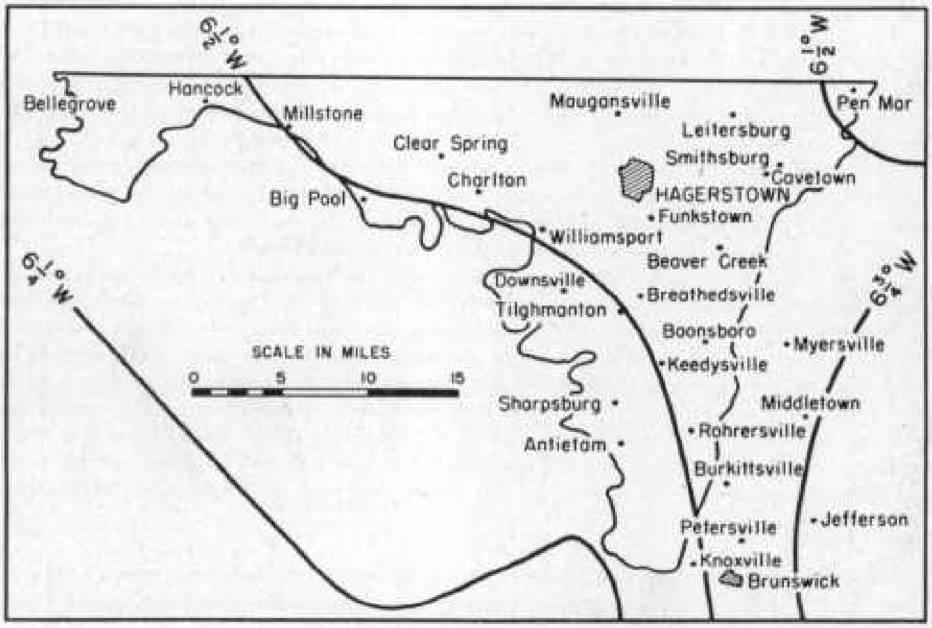

FIGURE 45. Isogonic Chart of Washington County for 1950

RETRACING OLD COMPASS SURVEYS

It is not easy to retrace an old compass survey. The Coast and Geodetic Survey gets many letters each year from surveyors who want help. In most cases, the surveyor has found one or more corners of a piece of land, and wants to know what declination to use to find the lines. Sometimes, instead, he asks the present magnetic bearings of old lines.

To help answer these questions the Coast and Geodetic Survey has made extensive studies of old information, some of it not very accurate. Since 1855, the Survey, has made magnetic observations which are useful for determining secular change, and since 1900 it has made systematic repeat observations for that purpose. From these have been prepared "secular-change tables," which are published in Serials 664 and 667. Table 17 is derived from these published tables. Annual-change rates or mathematical formulas should not be used to compute secular changes for extended periods.

When a surveyor asks us for help in retracing an old survey, we answer his question as best we can. The answer is not very reliable. There is no assurance that the sur-

TABLE 17

SECULAR CHANGE OF THE MAGNETIC DECLINATION

YEAR	MARYLAND HEIGHTS (1939)	HAGERSTOWN (1900)	HANCOCK	YEAR	MARYLAND HEIGHTS (1939)	HAGERSTOWN (1900)	HANCOCK
	° ′	° ′	° ′		° ′	° ′	° ′
1750	2 22W	2 18W	2 22W	1880	3 27W	3 21W	3 17W
1760	1 42	1 37	1 41	1890	4 04	3 57	3 54
1770	1 05	1 00	1 03	1900	4 41	4 35	4 32
1780	0 35	0 29	0 32	1905	5 00	4 54	4 51
1790	0 14	0 08W	0 09W	1910	5 20	5 14	5 10
1800	0 03	0 03E	0 03E	1915	5 40	5 35	5 31
1810	0 02	0 05E	0 05E	1920	5 56	5 50	5 46
1820	0 11	0 04W	0 03W	1925	6 15	6 10	6 06
1830	0 29	0 22	0 20	1930	6 30	6 26	6 21
1840	0 57	0 50	0 48	1935	6 43	6 38	6 33
1850	1 31	1 24	1 21	1940	6 40	6 35	6 29
1860	2 07	2 00	1 57	1945	6 40	6 35	6 29
1870	2 47W	2 40W	2 37W	1950	6 35W	6 30W	6 24W

This table, which was derived from Table 2 of Serial 664, shows the approximate magnetic declination at the sites of the specified magnetic stations, for the beginnings of the specified years. The earlier part of the table is uncertain by 15′ or perhaps 30′.

Declinations are given to minutes, in both the table and the examples. In no case is the value actually known within 1′; that precision is used only to avoid accumulation of rounding-off errors.

Before using this table, a surveyor should read the entire section "Retracing Old Compass Surveys."

veyor will be able to retrace the old line if he uses it. Let us see why this is so, and what a surveyor can do about it.

Some problems

First, secular-change tables are not perfect. In making them, we had to reconcile all sorts of inadequate data. The difference between two observed declinations is not all secular change: part of it may be daily variation, error in the instruments, or local disturbance.

Second, every compass may have an appreciable *index error*; that is, its readings may be consistently wrong, to a greater or lesser extent. For modern compasses, the error is usually small; for old ones, it may have been a quarter or half degree. This error might affect either the original survey of the line, or the modern surveyor's rerunning of it.

Third, the surveyor may not know when the original survey was made. He has a deed giving compass courses. Although the deed is dated, the courses may not have been run at that time. Compass bearings in one deed are often copied into other deeds, perhaps 50 years later, when magnetic bearings are really a degree or more different. Also, when land is subdivided, sometimes old bearings are copied for the old lines, while the bearings of new lines are observed at the time of subdivision.

Fourth, compass surveys are inherently lacking in accuracy. There is uncertainty in reading the needle, and the needle is affected by daily variation, irregular disturbance, and local disturbance. The effect of local disturbance upon a resurvey depends upon the method used in the original survey. Modern practice calls for fore-and-back sights at each station, as described below under "New Compass Surveys." But it was once rather common to make only one pointing at each station, namely a sight to the next station; the various bearings and angles then reflect any local disturbance of declination.

How to meet these problems

First, the surveyor may know of a nearby and well-defined line that was run about the same time as the lost line, the two lines having been run by different compasses. He can measure the change in compass bearings of this line, and use this to get the compass bearing of the line he is trying to find. This eliminates the uncertainty in the secular change, and he does not need the table at all. The method does not eliminate the index-errors of the old compasses.

Second, if both lines were run with the same compass, this process also eliminates the errors of the old and new compasses.

Third, a careful study of all of the deeds will often tell when the survey was really made. If the same compass course is given in two deeds, it was probably copied into the second without resurvey. If it is known (or assumed) that all lines of the tract were surveyed at the same time, the uncertainty of the date can be eliminated by the method described in "first," provided the "well-defined line" is a line of the tract itself.

Fourth, the compass is normally used for surveying only when the accuracy required is so low that the daily variation and the uncertainty of reading the compass are unimportant. If a magnetic storm is in progress, the needle may be noticeably unsteady; in that case, the surveyor should wait until another day. Retracing a compass survey in an area of local disturbance may be quite difficult, if only one sight was made at each station, unless the record is explicit enough to permit reoccupation of the original stations in the original order.

SECULAR-CHANGE TABLE (TABLE 17)

Table 17 gives the approximate mean magnetic declination at three magnetic stations in Washington County, at intervals of 5 or 10 years. The changes shown for these three stations may be used for other points in their respective vicinities, even where the declination itself is different.

Values for intermediate years can be found by interpolation. The change is not really uniform from year to year (e.g., see Table 15), but the error which results from using a uniform change is not significant for surveying. Furthermore, for most of the period covered, we have no information about more detailed changes.

The rate of change from 1945 to 1950 is shown as 1′ per year. This rate may be continued for prediction a few years beyond 1950; but, since secular change follows no known law, prediction for more than a few years should be avoided. Sudden changes in rate sometimes occur, as illustrated by Table 15.

Examples of use of Table 17

(*a*) *What was the magnetic declination in September 1843 at the point later occupied by magnetic station Hancock?* The table shows 0° 48′ West for January 1840, and 1° 21′ West for January 1850. Interpolating, we get 1° 00′ West for September 1843.

(*b*) *How much did the declination in western Washington County change between September 1843 and January 1950?* The table gives 6° 24′ West for Hancock for 1950, while example (*a*) gave 1° 00′ West for 1843. The net change was 5° 24′. This same change may be used with adequate accuracy for other points in that area.

(*c*) *In September 1843, the following magnetic bearings were observed near Millstone: N. 45° W.; N. 30° E.; S. 60° E.; S. 27° W.; S. 2° E. What were the magnetic bearings of these same lines in January 1950?* (This is one of the most common problems involving secular change.) In example (*b*), we found a secular change of 5° 24′ during this interval. West declination increased, and magnetic north moved westward. Bearings in the northeast and southwest quadrants increased, while those in the northwest and southeast quadrants decreased. The computed magnetic bearings for January 1950 are: N. 39° 36′ W.; N. 35° 24′ E.; S. 54° 36′ E.; S. 32° 24′ W.; S. 3° 24′ W. (The original bearings are stated only to degrees; these bearings are thus not known to minutes. In practice, they would be rounded off to quarter-degrees.)

(*d*) *What was the declination at Sharpsburg in January 1950?* The isogonic chart shows 6° 25′ West. This is the best value to use in any compass survey near Sharpsburg, unless the declination has been observed in the near vicinity of the survey. The declination at any one point may be considerably different from this value; but, in the absence of better information, this chart value is the best value to use.

(*e*) *What will be the declination at Sharpsburg in 1955?* Table 17 shows a rate of —1′ per year from 1945 to 1950. If this rate continues, the chart value will be 6° 20′ West in 1955. However, the rate might change abruptly, as it did in 1933 (see Table 15); in that case, the chart value for 1955 would be different.

(*f*) *What will be the declination at Sharpsburg in 1960?* This is so far in the future that no attempt should be made to predict it on the basis of information now available.

(*g*) *What was the declination at Millstone in 1843?* By example (*b*), it was 5° 24′ less than in 1950. By the chart, it was 6° 30′ West in 1950; hence, in September 1843, it was 1° 06′ West. This value is subject to the uncertainty inherent in a value scaled from an isogonic chart as well as the uncertainty inherent in a secular-change table.

NEW COMPASS SURVEYS

Nowadays, the compass is not widely used in new surveys. A land survey is of little value unless it can be retraced later, and we have seen some of the troubles which arise in retracing compass surveys. Nevertheless, there are circumstances which make it desirable to use a compass. In such cases, all reasonable care should be taken to eliminate errors.

Daily variation may be partly eliminated by applying the corrections given in Table 14. The actual daily variation, however, is different on different days. Daily variation, and irregular changes as well, can be more nearly eliminated by writing to the Coast and Geodetic Survey, Washington 25, D. C., to obtain a correction applicable to the particular date and time. However, it hardly pays to use the compass if the required accuracy is such that daily variation and ordinary irregular changes are important. If the change is very irregular, the needle may be noticeably affected, and observations should be deferred until another day.

Local magnetic disturbance is an ever-present problem. For the best results, fore and back sights should be taken at each station, and all angles read with the vernier; the closure of the survey is then not influenced by the compass, which is needed only to orient the survey as a whole. If the instrument has no vernier, the fore and back sights may be read with the needle itself; in this case, the closure is affected by uncertainties in reading the compass, but need not be affected by local disturbance, since each angle can be found as the difference of the compass bearings of two lines as sighted from the same point. In any case, the record of the survey should show clearly what points were actually occupied, and how the angles were actually measured.

If a value of magnetic declination is used in a new survey, its source should be stated (whether actually observed or scaled from a chart).

INSTRUMENTAL PROBLEMS

A compass survey should be made with the compass in good condition. The peep sights should be vertical; the line of sight should be centered over the vertical axis of the instrument; the needle should be straight and horizontal; and the pivot should be centered accurately in the graduated circle. Above all, the bearing surfaces must be clean and undamaged. A blunted pivot or a cracked jewel (the result of moving the compass with the weight of the needle resting on the pivot) will cause the needle to be sluggish. Loss of magnetism will have the same effect.

In dry weather, a compass sometimes becomes erratic because static electricity accumulates on the glass cover. This may be removed by moistening a finger and rubbing it over the glass.

Even though it is in good operating condition, a compass may have an appreciable index correction. At any rate, it is desirable to check at regular intervals, as described below.

Determining the compass correction

The *compass correction* or *index correction* is the angle between the real magnetic north and the direction shown by a given compass. It is found by observing the declination with the compass at a point at which the actual declination is known.

There is no magnetic station in Washington County that is suitable for testing magnetic compasses. Surveyors from that county may test their compasses at the

Cheltenham Magnetic Observatory, which is on the grounds of Cheltenham Boys' Village, about a mile west of the Cheltenham post office, in Prince Georges County. The surveyor should write to the Observer in Charge, Cheltenham Magnetic Observatory, for an appointment. He will observe declination with his compass, and the observatory can tell him what the declination was at the time he observed—the difference is the correction to the surveyor's compass.

If a surveyor cannot come to Cheltenham, he should write to the Coast and Geodetic Survey, Washington 25, D. C., for data on some nearer magnetic station. A test using such a station is not so accurate as one at a magnetic observatory, but is better than no test at all.

Referring compass surveys to the true meridian

Instead of measuring the compass correction, a surveyor may determine the combined effect of the compass correction and the magnetic declination. He may, for example, have a meridian line, consisting of two stones, one due north of the other. To test his compass, he sets up at the south stone, and reads the magnetic bearing of the north stone: this figure combines the declination and the compass correction. This value is to be recorded in the record of the survey, along with the magnetic bearings of the lines.

In later years, if another surveyor wants to retrace the survey, he can measure the magnetic declination at the same station with his compass. This difference, applied to the old compass bearings, will give the desired bearings for use with the new compass. This method will be vitiated if any artificial magnetic disturbance has been introduced, either at the meridian line or at the site of the survey.

The importance of this method of testing compasses is recognized in Maryland by the following sections of article 25 of the 1939 Code:

137. It shall be lawful for the county commissioners of each county in the State, if they shall deem it expedient, to cause to be erected at some public spot adjacent to the courthouse of each county, two good and substantial stone pillars, one hundred feet distant apart . . . upon the same true meridian line, . . . the said pillars . . . to be free to the access of any surveyor of lands or civil engineer residing in said county, or engaged in surveying therein, for the purpose of testing the variation of the compass for the time being, and to cause the said meridian line to be verified at any time when required so to do by order of the circuit court for the said county . . .

139. It shall be the duty of each and every surveyor surveying land in any county of this State that shall adopt the provisions of the two preceding sections to test and note the actual variation of his compass from the aforesaid true meridian line at least once in every year, and to deposit a copy of the same, with the date and time of such test, accompanying the same with affidavit verifying its correctness, with the clerk of the county in which he may reside, to be by him recorded in a book kept for that purpose, and every surveyor neglecting or refusing to comply with the provisions of this section, shall be liable to a penalty of fift dollars . . .

141. Any person or persons who shall wilful erase, deface, displace, or otherwise injure said pillars . . . shall, upon conviction thereof, be punished by a fine of not less than fifty nor more than five hundred dollars.

True north may be found by observations on the Sun or on Polaris, as described in Serial 664. It may also be found by transferring azimuth from a triangulation station. Instead of setting two stones as a meridian line, it is sometimes better to set just one stone. One then determines the true bearings of various "marks," such as tanks, steeples, or the corners of buildings. Whenever a surveyor tests a compass at such a station, he finds the true meridian by turning off the true bearing of a mark on the horizontal circle. Just as with a meridian line, the station should be in a place free from natural or artificial disturbance.

A station used in this way can be a magnetic station, or any other marker from which an accurate true bearing has been determined, provided it is free from artificial magnetic disturbance. Triangulation stations are sometimes used in this way. A surveyor wishing to use one, for this or any other purpose, can get the necessary data by writing to the Director, U. S. Coast and Geodetic Survey, Washington 25, D. C. It is to be noted that sites for triangulation stations are selected without reference to magnetic disturbance, and sometimes the markers are magnetic.

PUBLICATIONS ON GEOMAGNETISM

MARYLAND GEOLOGICAL SURVEY

The original magnetic survey of the State was described in two reports:

First Report upon magnetic work in Maryland, including the history and objects of magnetic surveys, by L. A. Bauer, Maryland Geological Survey, volume I, part V, 1897, pp. 405–529. This report gave data on declination only. Much of the history and description of objects and methods of magnetic surveys is still of interest, although parts of it are obsolete.

Second Report on magnetic work in Maryland by L. A. Bauer, Maryland Geological Survey, volume V, part I, 1905, pp. 23–98. This gives data for declination, dip, and horizontal intensity. It is more nearly an actual report on the survey than was the First Report.

The following has been largely if not entirely superseded by the Coast and Geodetic Survey's Serials 457, 602, and 667:

Report on the lines of equal magnetic declination in Maryland for 1910, by L. A. Bauer, Maryland Geological Survey, volume IX, part IV, pp. 331–338.

The Maryland Geological Survey and the Department of Geology, Mines, and Water Resources have issued several publications similar to the present one. Each of these contained a chapter dealing with the magnetic declination. The latest one of the series is:

The Physical Features of Charles County. Published at Baltimore, 1948. The chapter entitled "Magnetic Declination in Charles County," by H. Herbert Howe, covers pages 228–245.

UNITED STATES COAST AND GEODETIC SURVEY

The Coast and Geodetic Survey will send on request a leaflet entitled "Publications on Geomagnetism," which describes the current publications on this subject. The following list shows the prices of the publications which have been mentioned in this chapter:

Serial No.	*Name*	*Pages*	*Price*
166	Directions for Magnetic Measurements	129	$1.00
457	Magnetic Declination in Delaware, Maryland, Virginia, West Virginia, Kentucky, and Tennessee, 1925	112	Out of print

Serial No.	Name	Pages	Price
663	Magnetism of the Earth	79	0.35
664	Magnetic Declination in the United States in 1945	65	0.50
667	United States Magnetic Tables and Magnetic Charts for 1945	135	1.00
718	Magnetic Surveys	21	Free
726	Magnetic Poles and the Compass	7	Free

Requests for the free publications, as well as for the leaflet mentioned above, should be addressed to the Director, U. S. Coast and Geodetic Survey, Washington 25, D.C. The other publications may be bought from the Superintendent of Documents, Washington 25, D. C.

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DESCRIPTION OF PLATES

Plate 1. Cambrian and Ordovician Fossils

Figures 1, 2. Conococheague formation.

1. Cryptozoon undulatum Bassler. Reduced view of a specimen (about ⅓ natural size) from the Conococheague limestone 2½ miles southeast of Funkstown, Md.

2. Prosaukia stosei (Walcott). Pygidium (×3); near Scotland, Franklin County, Penna.

Figures 3–7. Beekmantown limestone.

3. ?Lecanospira compacta Salter. Casts of two specimens (×1); Paradise Church, Md.

4–7. Finkelnburgia virginica Ulrich and Cooper. Figures 4, 5, brachial and pedicle exteriors; figures 6 and 7, brachial and pedicle interiors; (×2). These are etched specimens which were collected and prepared by R. B. Neuman. Beekmantown limestone southwest of Pinesburg, Md. (See section under Stratigraphy).

Figures 8–13. Stones River limestone (St. Paul).

8. Maclurites magnus Leseur. Ventral exterior (×½). Row Park member, old abandoned quarry about 500 feet southwest of railroad crossing at Pinesburg Station, Md. Collected by R. B. Neuman.

9, 10. Tetradium syringoporoides Ulrich. Figure 9 is a transverse thin section of a specimen (×9) collected and prepared by R. B. Neuman; from the New Market limestone, 1.2 miles S. 65° W. of Marion, and 1.6 miles N. 70° W. of Kaufman, Franklin County, Penna. Figure 10 is a naturally weathered transverse section (×6) from the New Market limestone, near St. Pauls Church, Md. Collected by R. B. Neuman.

11–13. Mimella cf. *M. vulgaris* (Raymond). Pedicle and brachial interiors and brachial exterior (×2); Row Park limestone, 1.3 miles east of railroad station at Marion, Penna.

Figures 1–3 on this Plate are from the Cambrian and Ordovician volume of the Maryland Geological Survey; figures 8–9, 11–13 were made by R. B. Neuman; figures 4–7, 10 original.

Plate 2. Ordovician Fossils

Figures 1–5. Martinsburg shale.

1, 2, 4, 5. Cryptolithus cf. *C. bellulus* (Ulrich). Figure 1 is a natural cast of a nearly complete individual (×2); this appears to be a cast of the lower side, causing the pits along the brim to appear as elevations; Blue Mountain, near Harrisburg, Penna. Figure 2 is a rubber cast made from a natural mold of an incomplete cephalon (×2); Swatara Gap, Penna. Figures 4 and 5 are fragments of the brim of *Cryptolithus* from the Martinsburg shale, about 2 miles north of Clear Spring, Maryland; figure 4 is a rubber cast (×2) and figure 5 is an actual specimen (×1).

3. Flexicalymene sp. Dorsal view of an incomplete cranidium (×2); same locality as figures 4 and 5 above (this is a rubber cast).

Figures 6-16. Chambersburg limestone.

6. Lonchodomas ? sp. Nearly complete pygidium (×2). Wilson, Md.

7. Isotelus gigas Dekay. Dorsal view of a small specimen (×1) from the Trenton limestone, Trenton Falls, New York.

8. Isotelus sp. View of the pygidium and part of the thorax of a large individual (×1) from the Chambersburg, near Marion, Penna. Fragments of *Isotelus* are common in the Chambersburg but complete specimens are rare.

9-11. Echinosphaerites aurantium (Gyllenhal). Figure 11 is a reduced view (×½) of a nearly complete specimen showing the plates; Chambersburg limestone near Greencastle, Penna. Figure 10 is an enlarged view (×1½) of calyx plates showing arrangement of pores, same locality as fig. 11. Figure 9 is an enlarged view of the calyx plates (×3) to show the appearance of the pore rhombs after the surface is abraded; Chambersburg near Wilson, Md.

12. "Sowerbyella" pisum (Ruedemann). Brachial exterior (×2); Chambersburg limestone, Wilson, Md.

13. Strophomena sp. Brachial exterior (×1); Chambersburg limestone near Wilson, Md.

14. Dinorthis cf. *D. transversa* Willard. Pedicle exterior (×1); Chambersburg limestone near Wilson, Md.

15, 16. Nidulites pyriformis Bassler. Figure 15 shows a nearly complete specimen partially embedded in limestone (×1); figure 16 is a view of a piece of limestone showing sections of several specimens (slightly reduced). Both of the specimens shown are from Strasburg, Virginia; also common in the Chambersburg limestone of Maryland.

Figures 7, 10, 11, 15, 16 are from the Cambrian and Ordovician Volume of the Maryland Geological Survey; all others original.

Plate 3. Silurian Fossils

Figure 1. Tuscarora sandstone.

1. Arthrophycus alleghaniensis (Harlan). Reduced view of a specimen (about ⅙) from the gorge below Niagara Falls; similar ones occur in the Tuscarora of Maryland.

Figures 2–3, 6–8. Clinton shale.

2, 3. Coelospira hemispherica (Sowerby). Brachial valve and internal cast of a pedicle valve; Cresaptown, Md.

6. Mastigobolbina typus Ulrich and Bassler. Left valve (×8); Lakemont, Penna.

7. Chonetes novascoticus Hall. Pedicle valve with hinge spines preserved (×2); Flintstone, Md.

8. Calymene macrocephala Prouty. Cranidium (×1); north of Cresaptown, Md.

Figures 4–5, 9–20. McKenzie formation.

4, 5. Howellella crispa (Hisinger). Pedicle exterior and internal cast of pedicle valve (×1); Rochester member of McKenzie formation, Cumberland, Md.

9, 10. Dalmanites limulurus (Green). Figure 10 is a small, complete individual from the Rochester member at Six-Mile House, Md.; figure 9 is a view of a large pygidium from the Rochester, Rose Hill, Md. This species also occurs in the Clinton formation.

11, 12, 13. Whitfieldella marylandica Prouty. Pedicle, brachial and lateral views of the type specimen (×1). Rochester member at Rose Hill, Md.

14, 15. Parmorthis elegantula (Dalman). Brachial interior and internal cast of pedicle valve (×1); figure 14 is from the Rochester at St. Johns Run, Md. Figure 15 is from the same member at Six-Mile House, Md. This species is also recorded from the Clinton formation.

16, 17. Schuchertella elegans Prouty. Pedicle and brachial views (×1); Rochester member, Six-Mile House, Md.

18. Beyrichia moodeyi Ulrich and Bassler. View of a left valve (×20). Lower part of McKenzie formation, 1½ miles east of Great Cacapon, W. Va.

19. Drepanellina clarki Ulrich and Bassler. Left valve (×9, approx.); Rochester member, Cumberland, Md.

20. Dizygopleura swartzi Ulrich and Bassler. Left valve (×20); McKenzie formation at Cumberland, Md.

Figures 21–24. Wills Creek shale.

21, 22. Calymene camerata Conrad. Incomplete cephalon (×1) and pygidium (×2); Wills Creek formation at Flinstone, Md. This species also occurs in the Tonoloway limestone.

23. Leperditia elongata willsensis Ulrich and Bassler. Slab showing several specimens (×2); Wills Creek formation, Pinto, Md.

24. Fardenia? interstriata (Hall). Brachial view (×2 ; Wills Creek shale, Flintstone Creek, Md. This species is also present in the Tonoloway limestone.

Figures 25–28. Tonoloway limestone.

25, 26. Hindella (?) *congregata* Swartz. Lateral and pedicle views (×1); Tonoloway limestone at Pinto, Md. This species is also present in the Wills Creek shale.

27. Hormatoma rowei Swartz. Specimen showing external ornamentation (×2); Tonoloway limestone, Pinto, Md. This species is also present in the Wills Creek shale.

28. Leperditia mathewsi Ulrich and Bassler. View of a left valve (×6); Tonoloway limestone, Grasshopper Run, near Hancock, Md.

All of the illustrations on this Plate are from the Silurian Volume of the Maryland Geological Survey.

PLATE 4. SILURIAN AND DEVONIAN FOSSILS

Figures 1–10. Keyser formation.

1. Chonetes jerseyensis Weller. Pedicle view (×1); the spines of the posterior margin are not preserved on this specimen. Flintstone, Md.

2, 3. Meristina praenuntia (Schuchert). Pedicle and brachial views of two different specimens (×1); Keyser, W. Va.

4–6. Rhynchospirina globosa (Hall). Brachial, pedicle and lateral views of the same specimen (×1); Cumberland, Md. This species is also recorded from the New Scotland member of the Helderberg limestone.

7. Favosites helderbergiae var. *praecedens* Schuchert. Side view of a small corallum (×1). The corallum of this species is variable in shape and in some individuals may reach a diameter of 3 or 4 inches. Keyser, W. Va.

8. Tentaculites gyracanthus (Eaton). Enlarged view of a specimen (×5); Keyser, W. Va. This species is also recorded from the Tonoloway limestone.

9. Pseudocrinites gordoni Schuchert. Side view showing elevated food grooves (×1); Keyser, W. Va.

10. Sphaerocystites multifasciatus Hall. Oral view of a large specimen (enlargement approximately ×1⅓); Keyser, W. Va.

Figure 11. Helderberg limestone, Coeymans member.

11. Gypidula coeymanensis Schuchert. Brachial view (×1); New York.

Figures 12–21. Hedelberg limestone, New Scotland member.

12, 13. Isorthis perelegans (Hall). Pedicle and brachial views of a specimen (×1). This specimen is from the New Scotland of New York; the specimens from Maryland are similar although somewhat smaller. This species is also recorded from the Coeymans member.

14. *Favosites conicus* Hall. The corallum illustrated (×⅔) is from the Becraft member, North Mountain, W. Va. Also present in the Becraft member of the Helderberg limestone and in the Oriskany sandstone.

15, 16. *Delthyris perlamellosa* (Hall). Pedicle and brachial views of an individual (×1); Cumberland, Md.

17. *Edriocrinus pocilliformis* Hall. Side view of a calyx without the arms. This specimen from the New Scotland of New York; specimens of this species are common in the New Scotland of Maryland

18. *Pleurodictyum lenticulare* (Hall). View of the upper side of a somewhat abraded corallum (×1); Cumberland, Md. Also recorded from the Coeymans member.

19. *Eospirifer macropleurus* (Conrad). Dorsal view (×1); Corriganville, Md.

20, 21. *Rhipidomella oblata* (Hall). Brachial and ventral views of a specimen (×1). This specimen is from the New Scotland of New York; common in the New Scotland of Maryland and also reported from the Coeymans.

All of the illustrations on this Plate are from the Devonian Volume of the Maryland Geological Survey.

PLATE 5. DEVONIAN FOSSILS

Figures 1–3. Helderberg limestone, Becraft member.

1. *Rhipidomella assimilis* (Hall). Pedicle view (×1); North Mountain, W. Va.

2, 3. *Nanothyris subglobosa* (Weller). Pedicle views of two different individuals (×1); Cherry Run, W. Va.

Figures 4–13. Oriskany sandstone, Ridgely member.

4. *Orthonychia tortuosa* (Hall). (×1); Cumberland, Md.

5. *Acrospirifer murchisoni* (Castelnau). Brachial view of an average specimen (×1); Cumberland Md.

6. *Technocrinus ? lepidus* Ohern. Reduced view of a calyx with arms (×½); near Hancock, Md.

7, 13. *Rhipidomella musculosa* (Hall). Brachial exterior and pedicle interior, the latter showing the large flabellate muscle field (×1); Cumberland, Md.

8, 9, 10. *Costellirostra pecularis* (Conrad). Figs. 8 and 10 are pedicle and brachial views of the same individual; figure 9 is a view showing the brachial interior of another specimen (×1); Cumberland, Md. This species is also reported from the Becraft and New Scotland members of the Helderberg formation.

11. *Edriocrinus sacculus* Hall. Calyx with arms (×1); Cumberland, Md.

12. *Costispirifer arenosus* (Conrad). Brachial view (×1); Cumberland, Md.

Figure 14. Romney shale, Onondaga member.

14. *Coelospira acutiplicata* (Conrad). Pedicle view (×1¼). Williams Road, 3½ miles southeast of Cumberland, Md. This species is also recorded from the Hamilton member.

Figures 15–16. Romney shale, Marcellus member.

15, 16. *Leiorhynchus limitare* (Vanuxem). Brachial views of two incomplete specimens (×1½); 21st bridge, Baltimore and Ohio Railroad, 1 mile east of Keyser, W. Va.

All of the illustrations on this Plate are from the Devonian Volume of the Maryland Geological Survey.

PLATE 6. DEVONIAN FOSSILS

Figures 1–10. Romney shale, Hamilton member.

1. *Greenops boothi* (Green). Slightly enlarged view of a pygidium (×1½). Evitts Creek below Wolfe Mill on road about halfway between Romney and Hanging Rock, W. Va.

2. *Phacops rana* (Green). Small individual (×1).

3. *Loxonema hamiltoniae* Hall. View showing strong longitudinal striae (×1¼). Four and a half miles northeast of Oldtown, Md. This species is also recorded from the Onondaga member of the Romney shale and from the Parkhead member of the Jennings formation.

4. *Modiomorpha concentrica* (Conrad). (×1); Evitts Creek below Wolf Mill, W. Va.

5, 6. *Tropidoleptus carinatus* (Conrad). Brachial and pedicle views of the same specimen (×1); 21st bridge, Baltimore and Ohio Railroad, 1 mile east of Keyser, W. Va. This species is also recorded from the Jennings formation (Chemung and Parkhead members).

7. *Orthonota undulata* Conrad. (×1) Baltimore and Ohio Railroad cut at Hancock Station, W. Va.

8. *Mucrospirifer mucronatus* (Conrad). Pedicle exterior (×1); near Hancock, Md.

9, 10. *Spinocyrtia granulosa* (Conrad). Fig. 9 is an enlarged view (×8) of the surface showing granules; fig. 10 is a ventral view of a nearly complete specimen (×1); 21st bridge, Baltimore and Ohio Railroad, 1 mile east of Keyser, W. Va.

Figures 11–22. Jennings formation.

11. *Pterochaenia fragilis* (Hall). Enlarged view (×3). This specimen is from the Woodmont member, Town Creek, Gilpin. This species is also recorded from the Genessee member.

12. *Buchiola retrostriata* (v. Buch.). Enlarged view of a somewhat flattened valve (×3). This specimen is from the Geneseee member, Barrelville Road one-half mile west of Corriganville Md. This species is also recorded from the Woodmont member and the Romney shale

13. Lingula ligea Hall? Enlarged external view (×3). Woodmont member, U. S. Route 40, east of Hancock.

14, 15. Nucula corbuliformis Hall. Figure 14 is a right valve (×1) from the Parkhead member 2 miles north of mouth of Town Creek; figure 15 is an enlarged view of a cast showing the internal hinge structure, Parkhead member, Williams Road, Polish Mountain. This species is also recorded from the Chemung member and the Woodmont member.

16. Camarotoechia congregata var. *parkheadensis* Clarke and Swartz. Pedicle view (×1); Parkhead member, U. S. Route 40, east of Hancock, Md.

Figures 17–22. Jennings formation, Chemung member.

17, 20. Cyrtospirifer disjunctus (Sowerby). Figure 17 is a view of an internal cast of a pedicle valve. U. S. Route 40, Polish Mountain; figure 20 is an external view of a pedicle valve, U. S. Route 40, near top of Polish Mountain, Md. Both natural size.

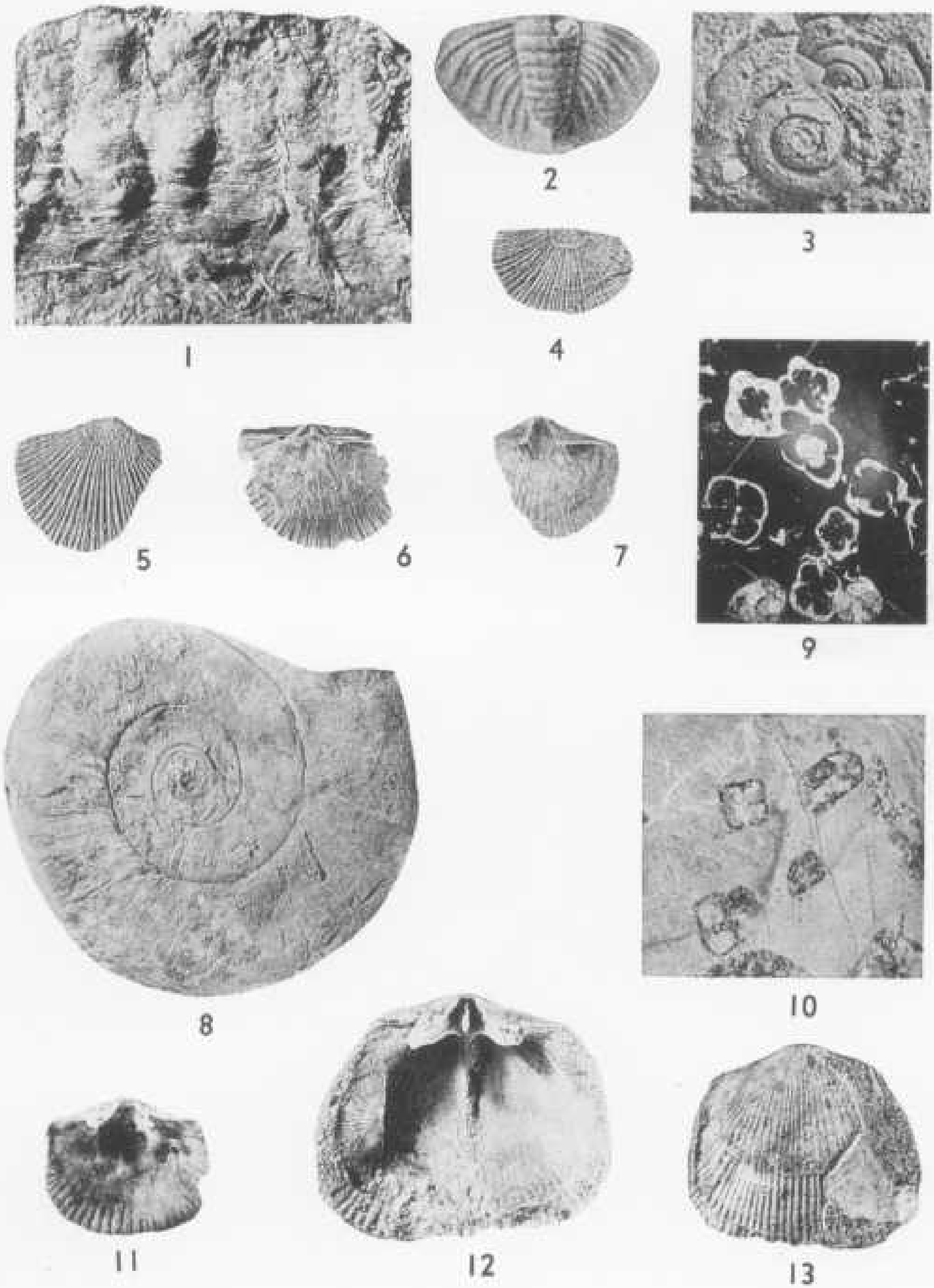
18. Leptodesma medon Hall. Small left valve (×1); U. S. Route 40, 7 miles west of Frostburg, Md.

19. Douvillina cayuta (Hall). Pedicle view (×1); Deer Park, Md.

21, 22. Cariniferella tioga (Williams). Figure 21 is a pedicle view of a small specimen; figure 22 shows an internal cast of a brachial valve (×1). Ellerslie, Penna.

All of the illustrations on this Plate are from the Devonian Volume of the Maryland Geological Survey.

PLATES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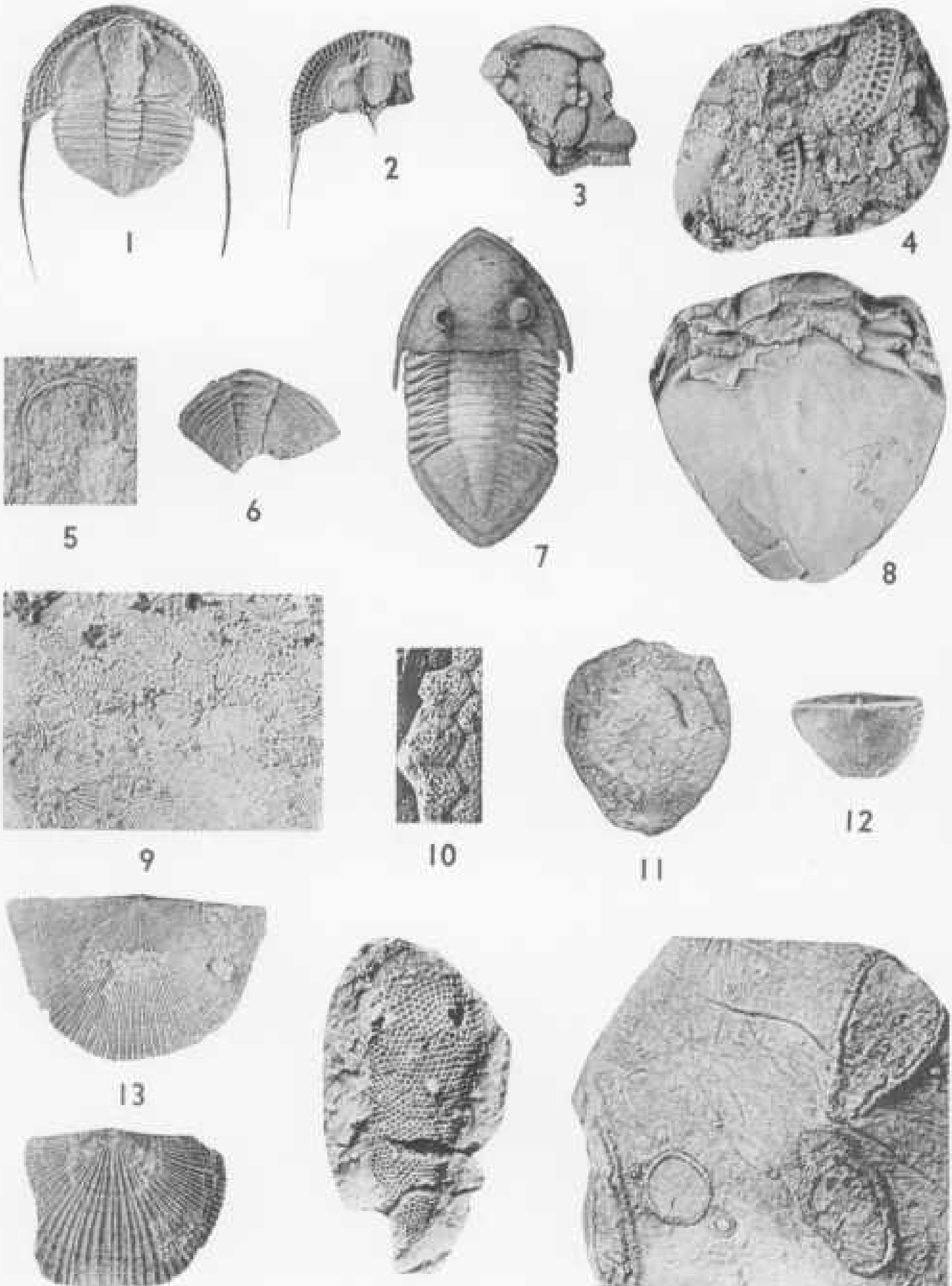
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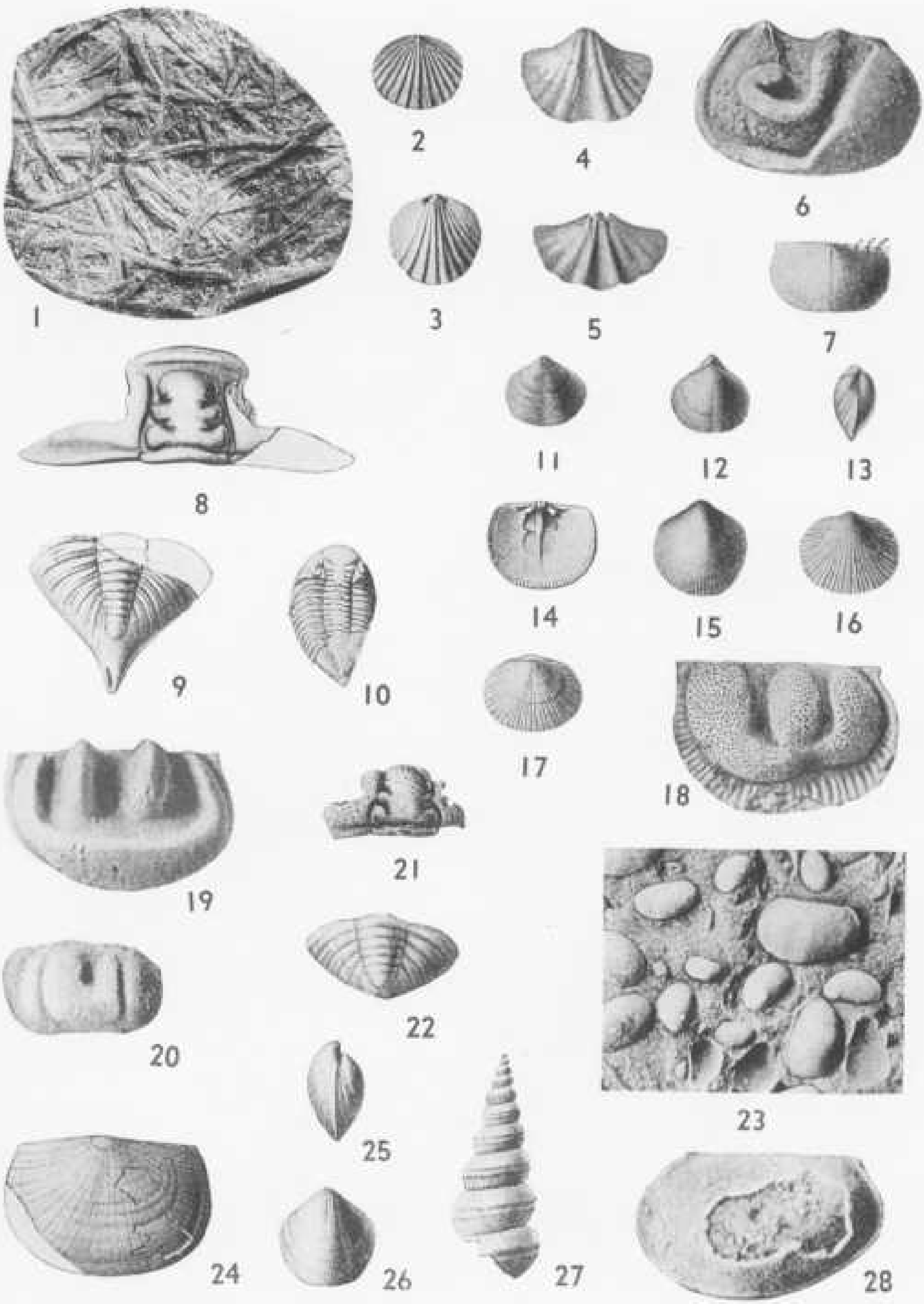
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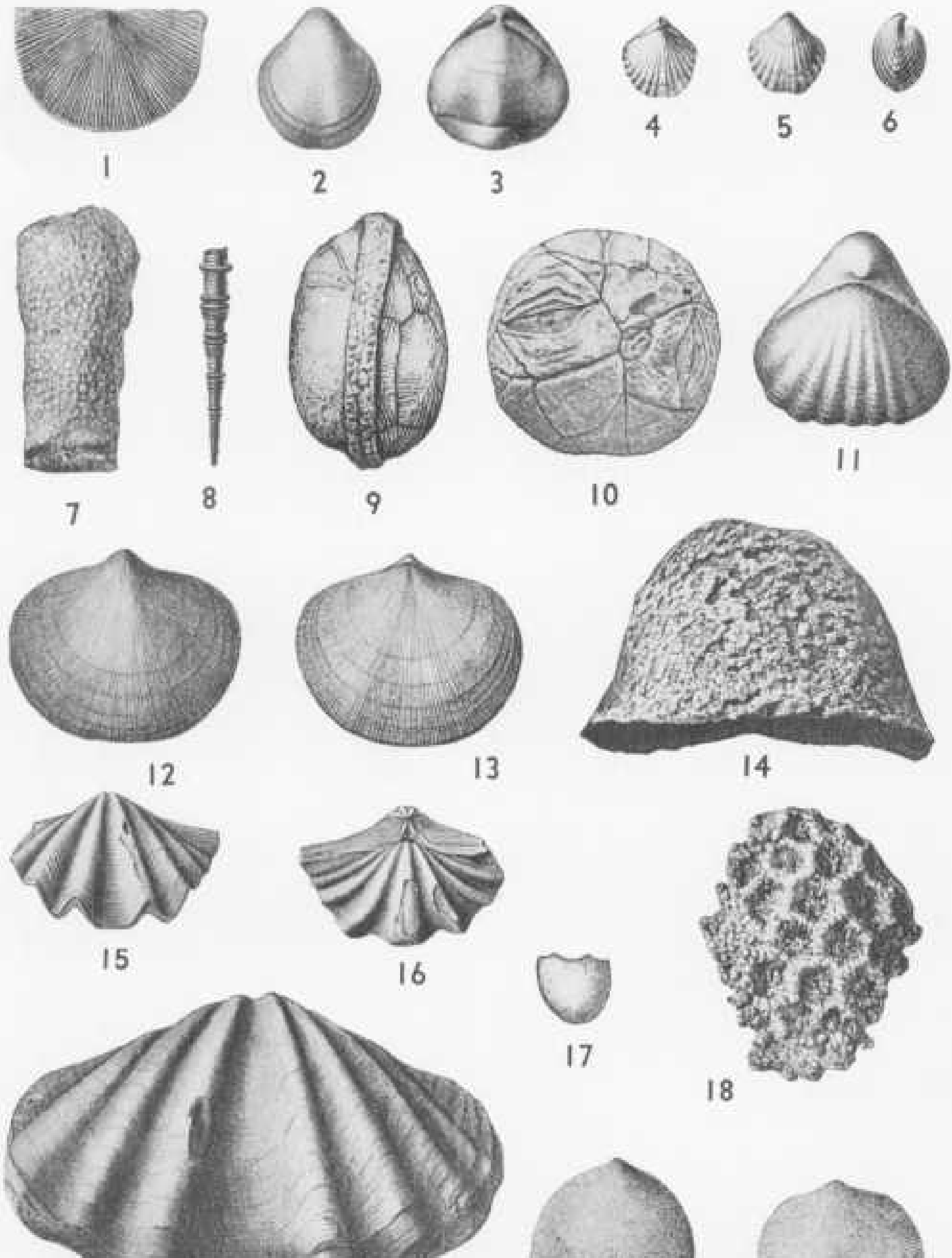
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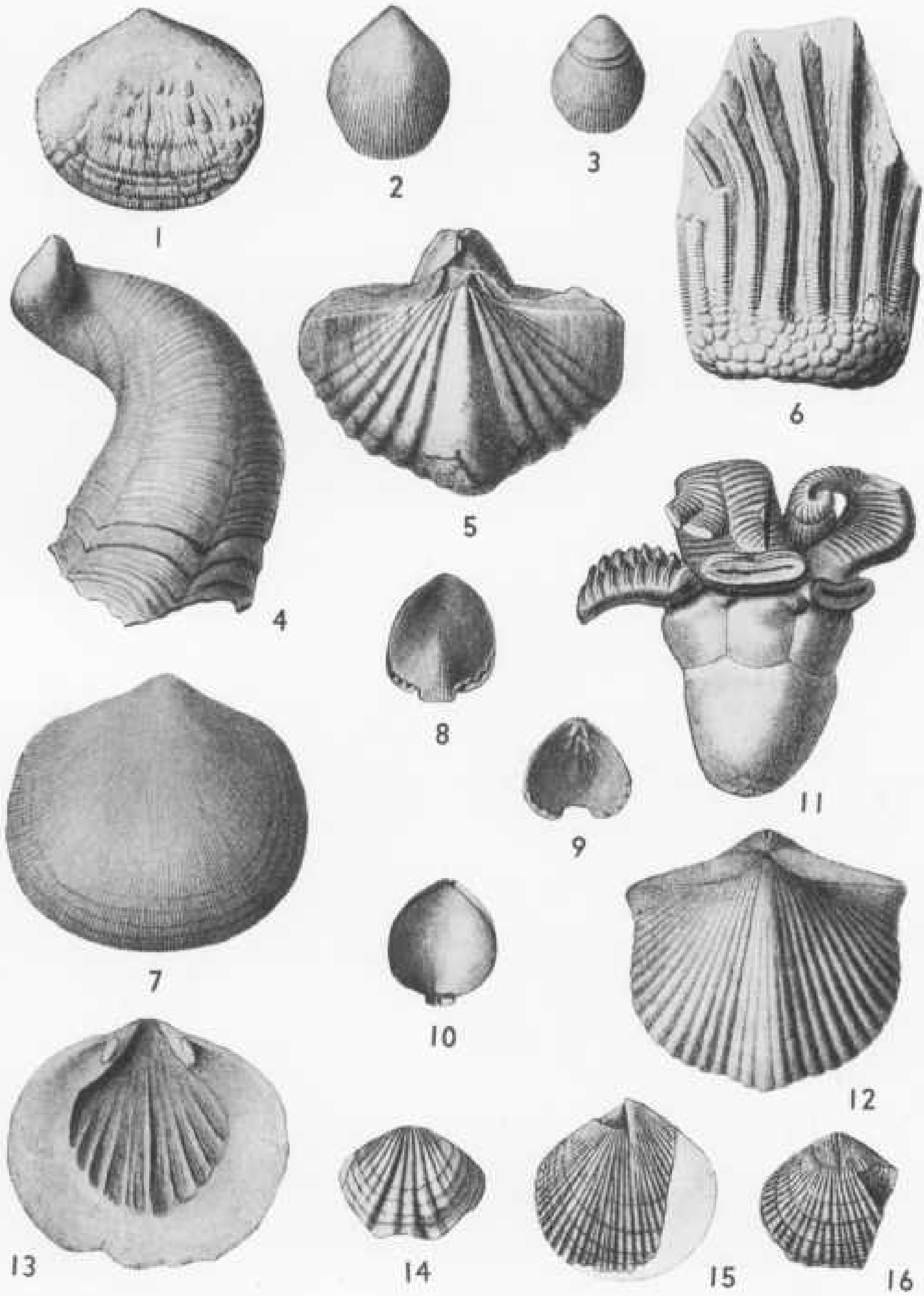

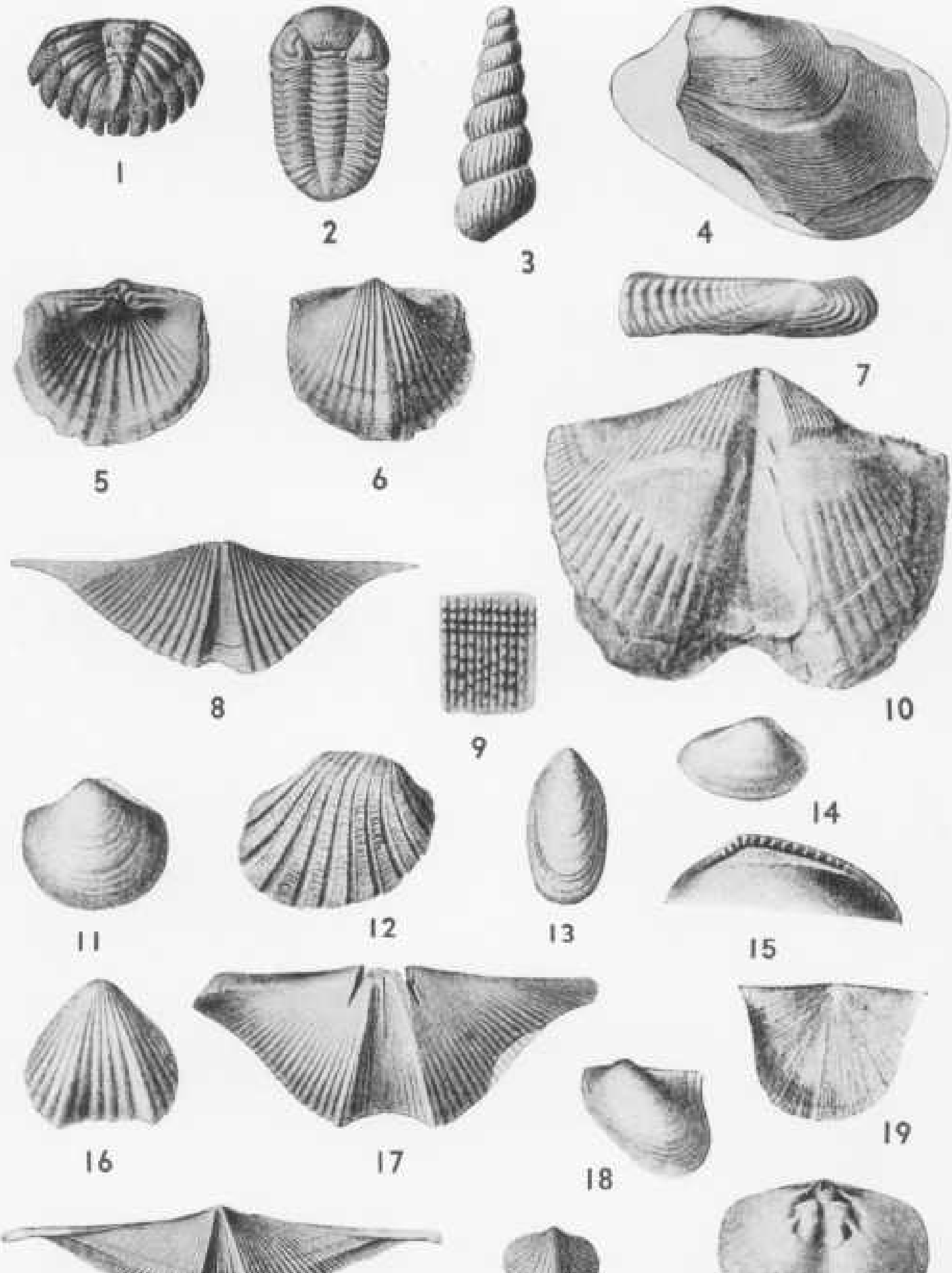
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PLATE 7, *Figure 1.* Potomac River Gap below Harpers Ferry. White islands in foreground: grano diorite gneiss. Islands with vegetation: greenstone. Rapids beyond greenstone: Weverton. Harpers Ferry in center of gap. View from highway bridge to the west.

Figure 2. Eastern Slope of South Mountain at Black Rock Looking South. Weverton quartzite in foreground dips gently left (east).

PLATE 8, *Figure 1.* Banded Harpers Phyllite. Bedding dips left, cleavage gently right.

Figure 2. Banded Harpers Phyllite. About 400 feet below contact with overlying Antietam sandstone. Waynesboro section.

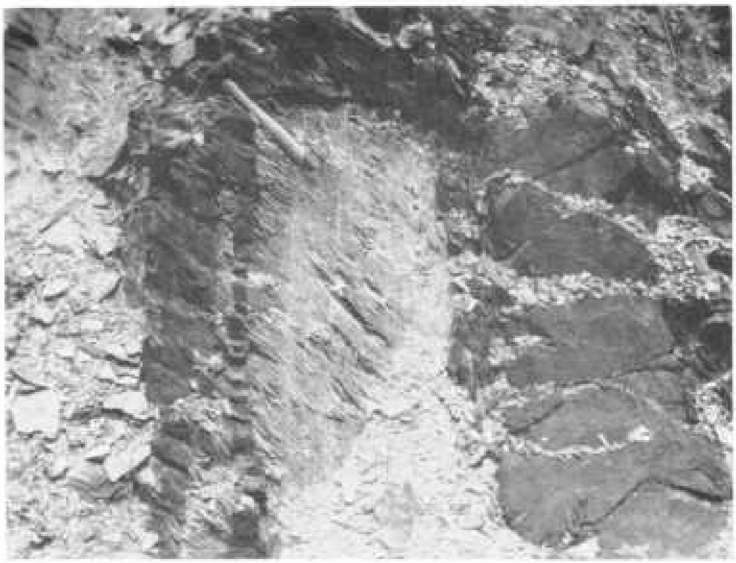

PLATE 9, *Figure 1*. Bedding and Cleavage in Lower Harpers Formation. Laminated shale and sandstone interbedded dip vertical. Cleavage dips about 45 degrees to the right (east). Waynesboro section.

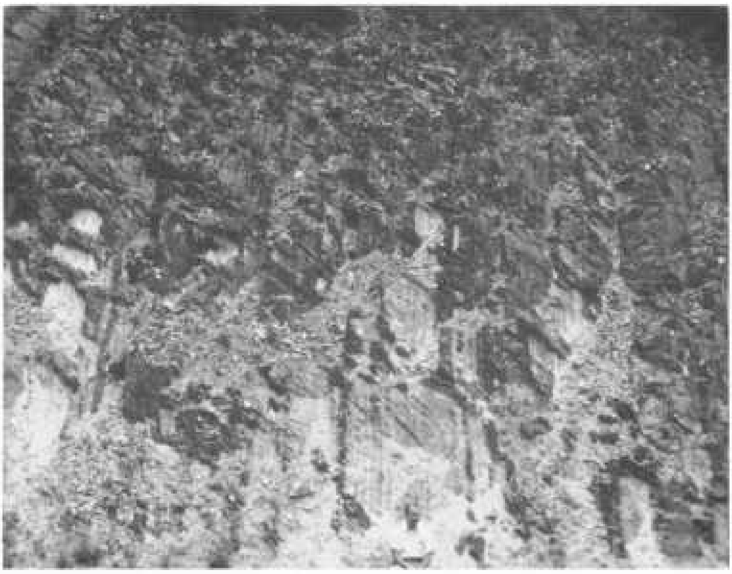

Figure 2. Laminated Lower Harpers Formation. Bedding vertical, cleavage dips to the right (east). Waynesboro section about 500 feet above Weverton contact.

PLATE 10. Gentle Anticline in Wills Creek Formation. About 2 miles due west of Hancock on parallel road north of U. S. 40. West left, east right.

PLATE 11, *Figure 1.* Greenstone East of Contact with Weverton Quartzite in Potomac River Gorge below Harpers Ferry. Cleavage dips east (right).

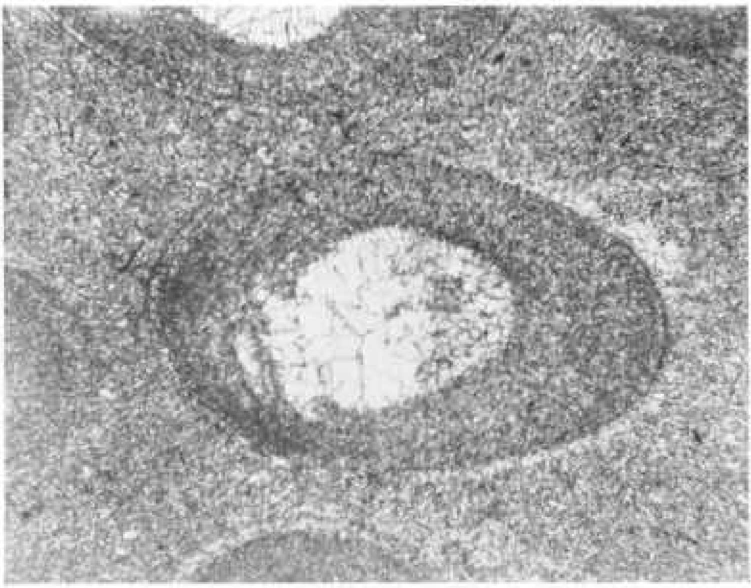

Figure 2. Deformed Oölite.

PLATE 12, *Figure 1.* Flexure Folds in Tonoloway Limestone. Cacapon section. Limestone layers are bent and retain even thicknesses. No obvious cleavage.

Figure 2. Shear Folds in Shale. Wills Creek formation, Cacapon section. An intense axial plane cleavage transects all beds which are wrinkled.

PLATE 13, *Figure 1.* Thrust in Sandstone Layer of Bloomsburg Shale Formation. Cacapon section. The bed has thickened due to the pushing together of the wedges. (Compare with figure 35).

Figure 2. Cleavage Perpendicular to Bedding, Wills Creek Shale at Round Top.

PLATE 14, *Figure 1*. Anticline Overriding Syncline on Thrust Plane. Round Top section. (Compare fig. 34).

Figure 2. Low Angle Thrust Sideling Hill Gap. The upper beds are disconformable to the lower ones and have been pushed outward from the center of the syncline. (Compare Fig. 37.)

PLATE 15, *Figure 1.* Boudinage in Stones River Limestone, Forsyth Quarry, Williamsport. The rolls are the boudins or sausages due to pulling apart of the competent bed in a direction normal to the welts.

Figure 2. Close-up of *Figure 1.*

PLATE 16, *Figure 1.* Crenulations on Bedding Plane Parallel to the Fold Axes and Slickensides Normal to Crenulation, Down Dip of Bedding Plane. Wills Creek shale just above Bloomsburg shale, Cacapon section.

Figure 2. Coarse Crenulation, Cleavage-bedding Intersection, and Distorted Plane in Wills Creek Shale, Round Top Section.

PLATE 17, *Figure 1*. Stripped Stones River Limestone at Wilson. Beds dip steeply.

Figure 2. Forsyth Quarry, Williamsport. Vertical beds of Beekmantown limestone.

PLATE 18, *Figure 1*. Old Road Bridge at Wilson, Conococheague Creek. Masonry largely Stones River and Beekmantown limestone.

Figure 2. St. Pauls Church on U. S. 40 between Conococheague Creek and Clear Spring. Mostly Stones River and Beekmantown limestones.

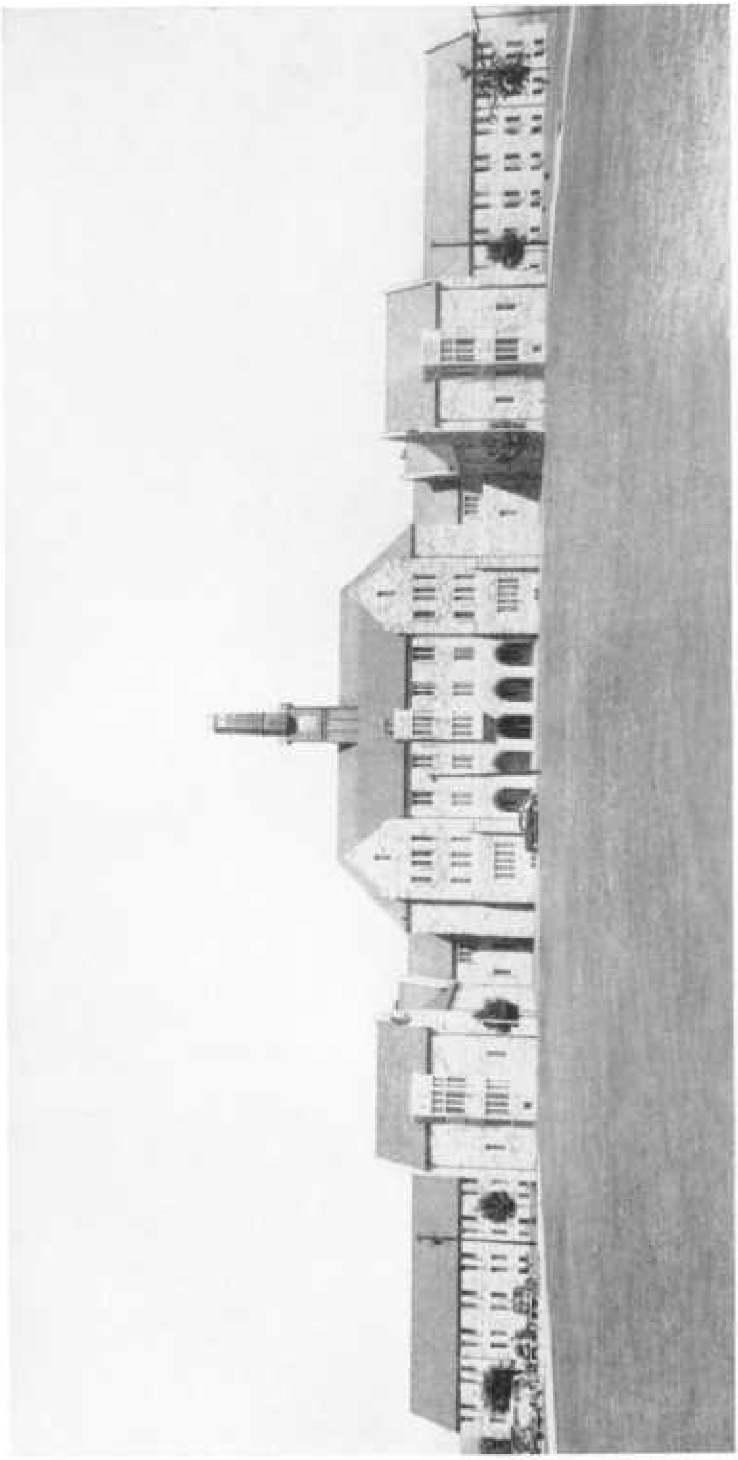

PLATE 10. Maryland Reformatory at Breathedsville. Built of Ellbrook limestone

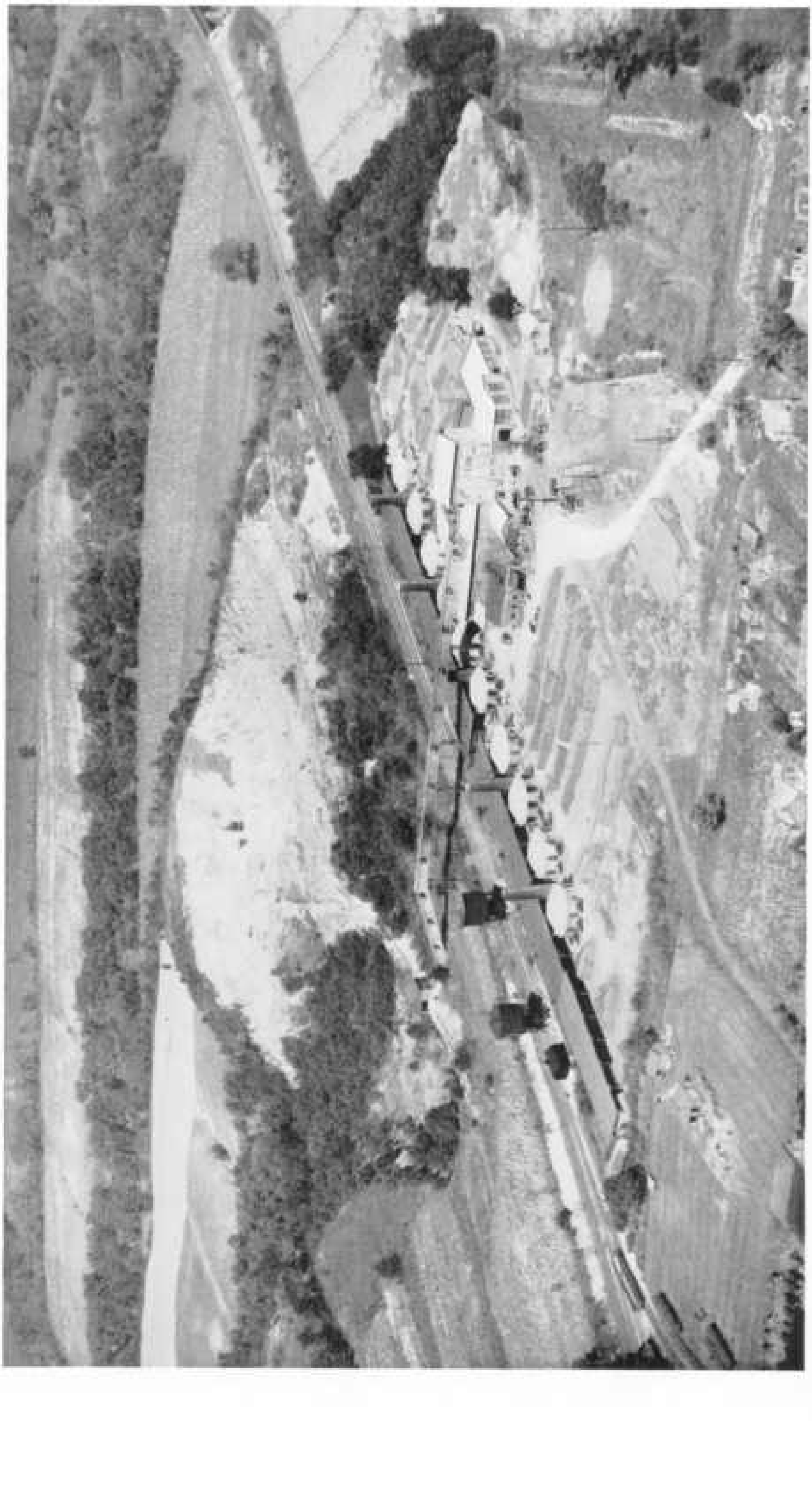

PLATE 20. Brick Plant of Victor Cushwa and Son, Williamsport. (Photograph by Frank Turgeon Jr.).

PLATE 21, *Figure 1.* Facing Upstream at Gage House on Potomac River at Hancock

Figure 2. Engineer Making Inspection of Automatic Water-Stage Recorder

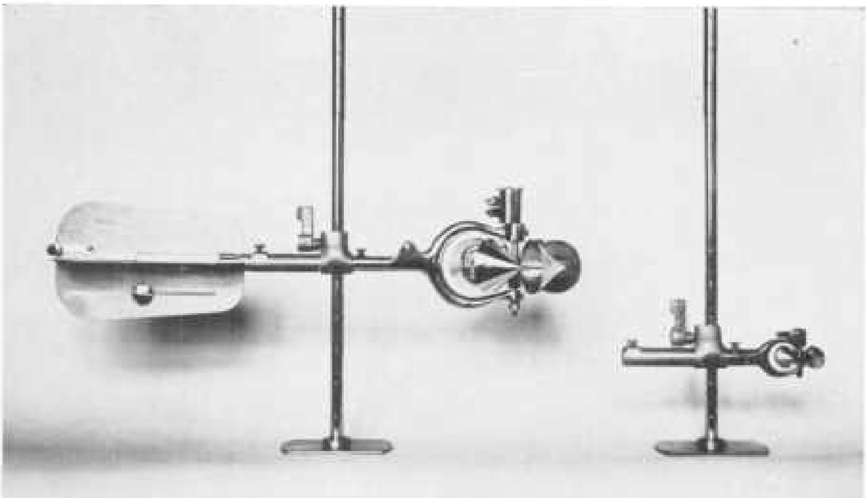

PLATE 22, *Figure 1.* Standard Price Current Meter and Pygmy Meter on Wading Rods, Used to Measure Discharge.

Figure 2. Equipment Used in Making Discharge Measurements from Bridge

PLATE 23. Farm Planning Conservation Survey Map in the South Mountain Area. Shows pattern of slopes and associated soil, erosion and land use conditions. Soil, slope, and erosion boundaries are shown by solid lines and land use by dashed lines. First number in compound symbol is soil type.

Deep, well-drained, acid soils: 28, Highfield gravelly loam; 74, Allen gravelly loam.

Moderately deep to shallow, imperfectly drained soil, having hardpan in subsoil: 70, Trego gravelly silt loam.

Moderately deep to shallow, well-drained acid soils: 96, Chandler silt loam; 93, Edgemont-Chandler channery loam; 152, Edgemont channery loam.

Shallow, well-drained, acid soil: 148, Chandler shale loam—shallow phase.

Moderately deep to shallow, well-drained, acid, stony soil: 13, Dekalb stony loam.

Letter in compound symbol denotes slope. The following slope classifications apply to these soils:

Trego and Allen: A, 0–3%; B, 3–8%; C, 8–15%; D, 15–25%; E, 25–45%; F, 45% or more.

Highfield, Edgemont-Chandler, Edgemont: A, 0–5%; B, 5–10%; C, 10–20%; D, 20–35%; E, 35–45%; F, 45% or more.

Chandler: A, 0–3%; B, 3–10%; C, 10–20%; D, 20–30%; E, 30–45%; F, 45% or more.

Dekalb: A, 0–5%; B, 5–12%; C, 12–25%; D, 25–45%; E, 45% or more.

Final number represents erosion: 0, no apparent erosion; 1, 0–25% of surface soil lost; 2, 25–75% of surface soil lost.

Land use is shown by letter symbols standing alone: L, cropland; X, idle land; F, woodland.

PLATE 24. Farm Planning Conservation Survey Map in the Pleasant Valley Area. Shows pattern of slopes and associated soil, erosion, and land use conditions. Soil, slope, and erosion boundaries are shown by solid lines and land use boundaries by dashed lines. First number in compound symbol is soil type.

Deep, well-drained, acid soils: 21, Fauquier channery loam; 23, Fauquier silt loam; 27, Myersville channery loam; 29, Myersville silt loam.

Shallow, well-drained, acid soils: 18, Enders gravelly loam.

Deep, imperfectly drained, acid, flood plain soil: 58, Codorus silt loam.

Deep to moderately deep, well-drained, acid, stony soil: 26, Highfield stony loam.

Letter in compound symbol denotes slope: A, 0–3%; B, 3–10%; BB, 10–20%; C, 20–30%; D, 30% or more.

Final number represents erosion: 1, no apparent erosion; 2, 0–25% of surface soil lost; 27, 0–25% of surface soil lost, occasional shallow gullies; 2⑦, 0–25% of surface soil lost, occasional deep gullies; 3, 25–75% of surface soil lost; 37, 25–75% of surface soil lost, occasional shallow gullies; 3⑦, 25–75% of surface soil lost, occasional deep gullies; 4, over 75% of surface soil lost.

Land use is shown by letter symbols standing alone: L, cropland; F, woodland; H, residential uses.

PLATE 25. Farm Planning Conservation Survey Map in the Limestone Area of the Great Valley. Shows land use pattern, slopes, and associated soil and erosion conditions. Soil, slope, and erosion boundaries are shown by solid lines and land use boundaries by dashed lines. First number in compound symbol is soil type.

Deep, well-drained, upland soils: 1, Hagerstown silt loam; 2, Hagerstown silty clay loam; 107, Duffield silt loam.

Deep, well-drained soils deposited at base of steeper slopes and along drainage ways, may be subject to occasional flooding: 88, Emory silt loam.

Moderately deep, well-drained soils: 104, Frankstown cherty silt loam.

Well-drained stony soils: 6, Hagerstown stony clay loam; 104, Frankstown stony loam; 137, Hagerstown stony silty clay loam.

Well-drained very stony soils: 04, Hagerstown very stony silt loam; 06, Hagerstown very stony clay loam; 0104, Frankstown very stony loam; 0108, Duffield very stony silt loam.

Letter in compound symbol denotes slope: A, 0–3%; B, 3–8%; and C, 8–15%.

Final number represents erosion: 1, 0–25% of surface soil lost; 2, 25–75% of surface soil lost; 3, 75% of surface soil to 25% of subsoil lost.

Land use is shown by letter symbols standing alone: L, cropland, P, pasture

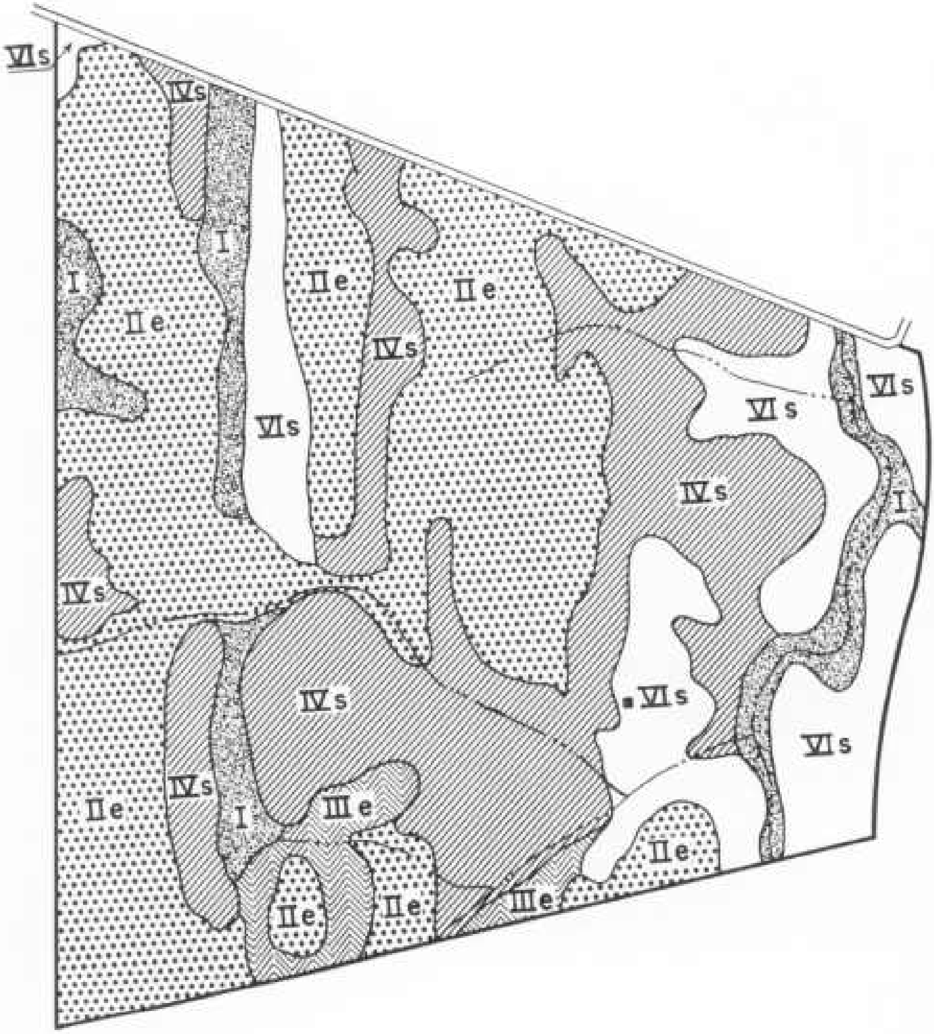

PLATE 26. Land Use Capability Map of the Area Shown on PLATE 25.

Class I—Land is subject to no more than very slight limitations in use. It is very good land that can be cultivated safely with ordinary good methods of farming.

Class IIe—Land subject to moderate limitations in use for crop production. Dominant limitation is susceptibility to erosion.

Class IIIe—Land is subject to severe limitations in use for crop production. Dominant limitation is susceptibility to serious erosion.

Class IVs—Land subject to very severe limitations in use for crop production. Dominant limitation is the stony condition.

Class VIs—Land of this class is not for cultivation. It is subject to moderate limitations. The dominant limitation is the very stony condition.

PLATE 27. Farm Planning Conservation Survey Map in the Martinsburg Shale Area of the Great Valley. Shows pattern of slopes and associated soil, erosion, and land use conditions. Soil, slope, and erosion boundaries are shown by solid black lines and land use boundaries by dashed lines. First number in compound symbol is soil type.

Deep, well-drained, acid soils: 68, Holston gravelly loam; 74, Allen gravelly loam.

Deep, imperfectly drained, acid flood plain soil: 56, Philo silt loam.

Moderately deep to shallow, imperfectly drained, acid soil having a very compact subsoil: 83, Monongahela silt loam.

Moderately deep to shallow, well-drained, acid shale soil: 111, Berks shaly silt loam.

Letter in compound symbol denotes slope: A, 0–3%; B, 3–8%; C, 8–15%; D, 15–25%; E, 25–45%.

Final number represents erosion: 0, no apparent erosion; 1, 0–25% of surface soil lost; 2, 25–75% of surface soil lost; 27, 27–75% surface soil lost, occasional shallow gullies; 3, 75% of surface soil to 25% of subsoil lost; 37, 75% of surface soil to 25% of subsoil lost, occasional gullies; 38, 75% of surface soil to 25% of subsoil lost, frequent gullies.

Land use is shown by letter symbols standing alone: L, cropland; P, pasture, F, woodland.

PLATE 28. Farm Planning Conservation Survey Map in the Ridge and Valley Area. Shows pattern of slopes and associated soil, erosion, and land use conditions. Soil, slope and, erosion boundaries are shown by solid lines and land use boundaries by dashed lines. First number in compound symbol is soil type.

Deep, well-drained, light-textured acid soils: 110, Ungers channery fine sandy loam; 141, Laidig gravelly sandy loam.

Shallow, well-drained, medium-textured acid soil: 149 Calvin channery loam.

Shallow to very shallow, well-drained, medium-textured acid soil: 115, Ashby channery loam.

Deep, well-drained, stony acid soil: 81, Laidig stony loam.

Moderately deep to shallow, well-drained, very stony, acid soils: 10, Dekalb-material rough stony land; 13, Dekalb stony loam.

Letter in compound symbol denotes slope. The following slope classifications apply to these soils: Ashby, Calvin and Ungers: A, 0–3%; B, 3–10%; C, 10–20%; D, 20–30%; E, 30–45%; F, 45% or more. Laidig: A, 0–3%; B, 3–8%; C, 8–15%; D, 15–25%; E, 25–45%; F, 45% or more. Dekalb: A, 0–5%; B, 5–12%; C, 12–25%; D, 25–45%; E, 45% or more.

Final number represents erosion: 0, no apparent erosion; 1, 0–25% of surface soil lost; 2, 25–75% of surface soil lost; 27, 25–75% of surface soil lost, occasional shallow gullies; 3, 75% of surface soil to 25% of subsoil lost; 37, 75% of surface soil to 25% of subsoil lost, frequent gullies.

Land use is shown by letter symbols standing alone: L, cropland; X, idle land; F, woodland.

INDEX*

* *Italics* indicate detailed descriptions. Fossils are indexed by generic name only.

WASHINGTON COUNTY

1951