GEOLOGY OF THE BUTT MOUNTAIN AREA
GILES COUNTY, VIRGINIA

by

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ILLUSTRATIONS

INTRODUCTION

Location of the Area

The Butt Mountain area comprises a pentagonal area of approximately 55 square miles in the northeast portion of Giles County, Virginia, and is included in the United States Geological Survey's 15 - minute Pearisburg quadrangle edition of 1937. The area is bounded on the northwest by the Virginia-West Virginia line which follows the crestal portion of Peters Mountain. The area is bounded on the west by 80° 40' west longitude and on the south by 37° 20' north latitude (Pl.1).

Four secondary roads traverse the area. The old Salt-Sulphur Turnpike which many years ago was a principal route of stagecoach travel crosses the southern portion of the area from the base of Johns Creek Mountain to Mountain Lake. State Road 613 enters from the south and follows Doe Creek to Mountain Lake. State Road 623 enters from the southeast and traverses the central portion of the area along Little Stony Creek and crosses the northwest portion of the area. All of these roads join U. S. Route 460 south of the area.

In addition to the four secondary roads are many logging and farm roads. The logging roads are located primarily in the vicinity of the only two settlements in the area, which are Olean and Interior, both along Stony Creek. The central portion of the area is circuited by serviceable dirt roads along which are located several hunting lodges.

Geography

The Butt Mountain area lies within the Valley and Ridge physiographic province. The maximum relief in the area is about 2000 feet. The lowest elevation, 1750 feet, is on Stony Creek just west of Olean, Virginia. The highest point, 4363 feet, is Bald Knob one half mile south of Mountain Lake. Butt, Big, Salt Pond, and Doe mountains all have altitudes above 4000 feet and together define a high tableland which constitutes nearly two thirds of the area.

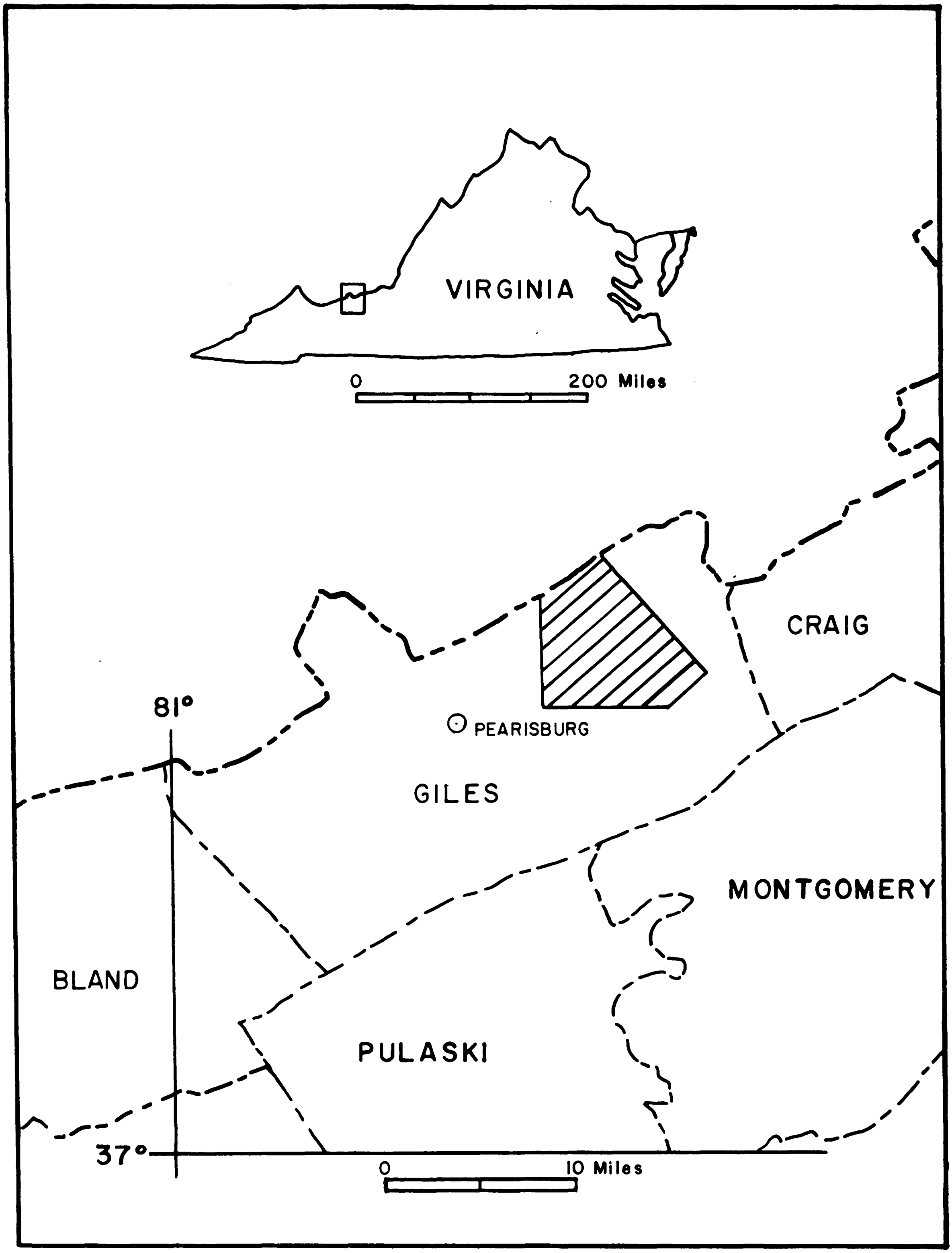
The area is drained principally by Doe, Little Stony and Stony creeks which are tributaries of New River to the south. Little Stony Creek drains the central portion of the tableland formed by Butt, Big, and Doe mountains. The creek descends the southeastern rim of the tableland by means of two cataracts and flows through a gorge to the low-lying area to the southeast. Stony Creek flows sinuously through a relatively steep-sided valley which lies between Peters Mountain on the northwest and Fork Ridge-White Rock Mountain on the southeast. A small segment of the southeast portion of the area at the confluence of Johns Creek Mountain and Salt Pond Mountain is drained by Johns Creek. Johns Creek flows northeast into Craig Creek, a tributary of the James River, near New Castle, Virginia.

Mountain Lake, situated at the intersection of State Roads 623 and 700 and the Salt-Sulphur Turnpike, is one of the excellent scenic features in the area. The lake is 3879 feet above sea level and about 2000 feet above New River. The lake, 0.65 mile long and nearly 0.25 mile wide, is drained to the north by Pond Drain, a tributary of Little Stony Creek.

Purpose of the Investigation

The purpose of the investigation was to prepare a geologic map,

Plate I



Index map showing location of Butt Mountain area, Giles County, Virginia.

structure sections, and a report on the geology of the Butt mountain area. The investigation was carried out during the summer and fall of 1961.

Acknowledgments

The writer wishes to express his sincere appreciation to his friend and fellow worker, James W. Bryan who offered his companionship and opinions during the investigation. Dr. Byron N. Cooper guided the writer during the investigation and preparation of the geologic map and report and it is to him that the writer submits his sincere appreciation. Many helpful suggestions were received from Dr. Wallace D. Lowry, Dr. Chauncy G. Tillman and Mr. Mark Fara who visited the writer in the field. Appreciation is extended to the Virginia Polytechnic Institute's Engineering Experiment Station for financial assistance. Thanks are also extended to Mr. Thomas Gathwright for taking photographs. The writer also thanks Mr. James Laing of Pearisburg, Virginia for permission to map his land.

Previous Work

After the geologic reconnaissance work of the Virginias by William Barton Rogers little was done to study the general geology of the northeast portion of Giles County, Virginia until the work of Hubbard and Croneis (1924) who published a report on the general geology of Giles County. However, this work was still of a general reconnaissance nature. Butts (1940) in his geologic report of the Valley of Virginia, includes many details of the geology in the Butt Mountain area, but his studies, although more detailed than those before him, were still of a reconnaissance nature and some of his interpretations of the geology along the Narrows fault in the area are necessarily modified in the present report.

Many workers have discussed one geologic aspect or another of the Butt Mountain area and the literature is abundant with published works and articles relating directly or indirectly to the geology of the area. The structural geology of Giles County was discussed by Mathews (1932, 1934, 1935, and 1938). The economic geology of parts of the area is discussed by Watson (1907), Stose (1922), Mathews (1934), and Cooper (1960). Mountain Lake in the Butt Mountain area was discussed by Sharp (1936), Holden (1938), and in a brief note in the Minerals Industry Journal (Anon., 1957).

STRATIGRAPHY

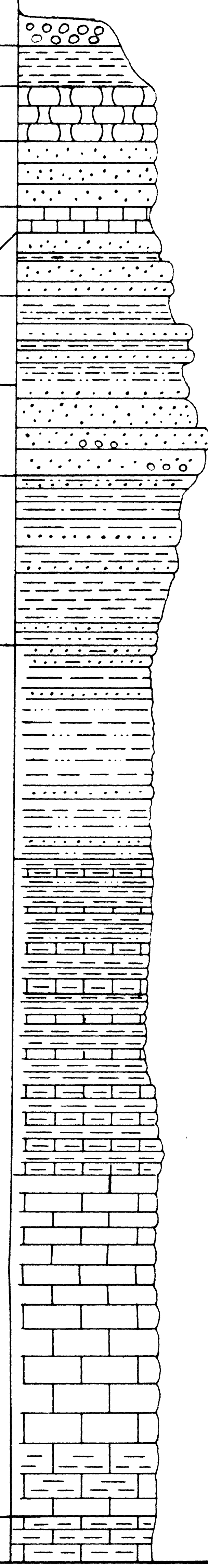
General Statement

The Butt Mountain area is underlain by Paleozoic sedimentary rocks largely of marine origin. The exposed Paleozoic rocks range in age from Middle Ordovician through Middle Devonian. The rock succession is divided into eleven mappable rock units, each with characteristic lithology. The thickness of the exposed strata is approximately 3500 feet (Pl. 2). Distribution of the rock units is shown on the geologic map (Pl. 3) and the geologic structure is depicted on six cross sections (Pls. 4 and 6).

The Moccasin Formation is the oldest mapped rock unit although older Middle Ordovician rocks occur in the southwest part of the area. These older units are shown in part on the geologic map (Pl. 3) and were taken from Shanholtz (1955, Pl. 1). Other older units crop out to the west and southwest. Rocks younger than the Devonian Millboro black shale crop out to the north and east outside of the area and range in

	FORMATION	CHARACTER	THICKNESS IN FEET
QUAT.	Alluvium and Colluvium	Boulder gravel with blocks of quartzite and sandstone	
DEVONIAN	Millboro shale	Black fissile shale, limy concretions, weathers brown	200
DEVONIAN	Huntersville chert	Blocky white chert	80 to 100
DEVONIAN	Rocky Gap sandstone	Dark-gray, coarse, calcareous sandstone, weathers brown and friable	80 to 100
SILURIAN	Tonoloway ls	Gray, fossiliferous limestone, weathers reddish-gray and shaly	75
SILURIAN	"Keefer" ss	Massive white quartzite	150
SILURIAN	Rose Hill	Hematite-cemented sandstone with red and green shales	150 to 200
SILURIAN	Tuscarora sandstone	White conglomeratic quartzite	50 to 140
ORDOVICIAN	Juniata	Variegated maroon and greenish-gray sandstone, siltstone, and shale	190 to 350
ORDOVICIAN	Martinsburg-Eggleston	Limestone, shale, and at top siltstone with Orthorhynchula faunulé	1500 to 1700
ORDOVICIAN	Moccasin	Red mudstone and limestone	

SECTION



Generalized columnar section of the formations in the Butt Mountain area, Giles County, Virginia.

age from Devonian to Pennsylvanian. Throughout the area, Quaternary (?) unconsolidated deposits lie unconformably on all Paleozoic units.

ORDOVICIAN SYSTEM

Middle and Upper Ordovician Series

Moccasin Formation

Name and Lithology. - The name Moccasin Formation was proposed by Campbell (1894, p.2) for a sequence of red mudrock and argillaceous limestones which crop out along Moccasin Creek near Moccasin Gap, Scott County, Virginia. In the Butt Mountain area only the upper part of the formation was mapped as part of the field study. The upper part consists of a succession of interbedded red and light-gray, fine-grained, argillaceous limestone; red and olive-drab variegated silty and argillaceous mudrock; olive-drab, thick-bedded siltstone; and red and olive argillaceous shale. Cooper (1961, pp. 41-42, 95) gives the variation in thickness and lithology of the Moccasin in the Butt Mountain area and states that the upper brown-weathering calcareous sandstones with intercalated sandy shales are thicker in the trough of the Johns Creek syncline.

Distribution. - The Moccasin Formation underlies the low slopes near the base of Butt, Doe, and Johns Creek mountains. Good exposures of the upper part of the formation can be found along County Road 613, along Doe Creek, and County Road 623, along little Stony Creek. A nearly complete section crops out along Road 626, 1.5 miles north of Pembroke, Virginia. Cooper (1956, Chart 1) assigns the Moccasin to the Wilderness Stage.

Eggleston Formation

Name and lithology. - The name Eggleston Formation was proposed by Mathews (1934, footnote, p. 11) for exposures of light-brown, argillaceous limestone part of which is characterized by cuneiform jointing and interbedded bentonite along a road, one mile north of Narrows, Virginia. The formation to the south of the Butt Mountain area has been described by Cooper (1961, p. 42) as a succession of drab-gray to brown calcareous siltstones, silty limestones and thin bentonite beds which are underlain by silicified cuneiform-jointed beds. The Eggleston Formation was mapped together with the Martinsburg Formation because the contact between the two formations is gradational and because it is poorly exposed throughout the area.

Distribution. - The lower units of the Eggleston Formation are exposed in only a few localities. An incomplete exposure is along Doe Creek on the north side of Road 613 near the Moccasin contact (Pl. 3). The Eggleston, like the Moccasin forms a continuous belt around the low slopes of Butt, Doe, and Johns Creek mountains. Cooper (1956, chart 1) assigns the Eggleston Formation to the Upper Wilderness Stage.

Martinsburg Formation

Name and lithology. - The name Martinsburg Formation was proposed by Geiger and Keith (1891 , footnote, p. 161) for exposures of black and gray calcareous shales near Martinsburg, West Virginia. The Martinsburg in the Butt Mountain area is divisible into three units. The lower unit consists of light-gray, thin- to thick-bedded limestones. The middle unit consists of gray, calcareous shales and olive, thin-bedded limestones.

The upper unit consists of brown-weathering thin- to medium-bedded sandstones and siltstones. The upper beds of the unit are abundantly fossiliferous and contain the brachiopod Orthorhynchula. The Orthorhynchula beds are found along a trail 0.2 mile west of Mountain Lake and along the Salt-Sulphur Turnpike at the southwest edge of the lake.

The Martinsburg brown sandstones are succeeded by the red and green sandstones and siltstones of the Juniata Formation. The Martinsburg-Juniata contact was not found exposed anywhere in the area; however, the contact is placed at the first occurrence of red sandstones and shales above the Orthorhynchula beds of the Martinsburg Formation.

Distribution and thickness. - The formation marks a continuous belt along the middle gentle slopes of Johns Creek, Doe, Butt, and Big mountains (Pl. 3). Partial exposures of the Martinsburg Formation crop out along Roads 611, 623, and 700. The thickness of the Martinsburg can not be determined with any degree of accuracy because of tight drag folds; however, the thickness is of the order of 1500 to 1700 feet. These measurements were made on the geologic map and the thickest development of the formation was measured along the west slope of Butt Mountain.

Insofar as known all of the Martinsburg at the type locality is Trenton in age; however, it is also the youngest formation. (Twenhofel, et al, 1954, p. 276). Butts (1940, p. 210-213) assigns the Martinsburg exposed in the Narrows section to the Trenton, Eden, and Maysville ages on the basis of characteristic fossils.

Soils developed on the upper part of the formation characteristically have yellow weathered shale chips. A sharp topographic break marks the approximate location of the contact between the Martinsburg and the overlying Juniata Formation. On outcrop slopes the contact between the formations is delineated by an abrupt change in the slope angle. The Juniata produces steeper slopes whereas the upper Martinsburg produces more gentle slopes.

Juniata Formation

Name and lithology. - The origin of the name "Juniata" as a formation name is obscure; many authors (Clark, 1897, p. 180; C. K. Swartz, 1923; and Butts, 1940, p. 221) cite Darton (1896) as naming the formation; but apparently Darton (1896, p. 2) is simply the first to use the name "Juniata" for a formation and he refers to a section along the Juniata River far removed from the area he described. He stated that the red shales and sandstones in the Piedmont Folio area, West Virginia, are like the typical "Juniata Formation" of Pennsylvania, which had not been previously recognized.

The Juniata Formation in the Butt Mountain area is a succession of laminated and cross-laminated maroon siltstones and fine-grained, micaceous sandstones and interbedded silty, micaceous shales and gray and green sandstones. The lithologic character of the upper part of the formation is given in Geologic Section 1. The upper maroon shales of the Juniata underlie thick bedded, light-gray Tuscarora quartzite in comformable sequence.

Distribution and thickness. - The Juniata Formation occupies a continuous belt just below the crests of Johns Creek, Doe, Butt, and Big mountains (Pl. 3). The upper part of the formation is well exposed near the crest of Salt Pond Mountain and crops out as massive cliffs along the northeast slope of Doe Mountain 0.5 mile below The Cascades. Partial exposures of the Juniata crop out in Stony Creek north of Olean, Virginia, where it forms the hanging wall of the White Rock Mountain fault. The Juniata Formation ranges greatly in thickness in the area. The maximum thickness of the formation is approximately 400 feet on the west slope of Butt Mountain and the least thickness is 190 feet near the crest of the Mountain Lake anticline near Mountain Lake.

The Juniata Formation has been assigned to both the Upper Ordovician (Twenhofel, 1954, p. 272) and Lower Silurian (Clark, 1897, p. 180). The writer prefers to follow the former because of evidence cited by Butts (1940, p. 229). Few fossils are reported from the Juniata Formation; however, specimens of Lingula and cephalopods and gastropods were collected from maroon and greenish-gray siltstones above the first prominent, cross-laminated sandstone of typical Juniata lithology on the southwest slope of Salt Pond Mountain about 0.5 mile south of Bald Knob (Pl. 3).

SILURIAN SYSTEM

Medinan Series

Tuscarora Sandstone

Name and lithology. - The origin of the name "Tuscarora" as a formation name is obscure. Many authors (Clark, 1897, p. 181; C. K. Swartz, 1923, p. 26; and Butts, 1940, p. 229) cite Darton (1896) as naming the Tuscarora; but apparently Darton (1896, p. 2) is simply the first worker to refer to a section in the Tuscarora Mountains far removed from the area he described. He states that the white sandstones above the Juniata Formation in the Piedmont folio area of Maryland and West Virginia are like the white sandstones and shales along the Tuscarora Mountains in Pennsylvania.

The Tuscarora Sandstone in the Butt Mountain area consists of thick-bedded quartzite, coarse-grained and conglomeratic quartzitic sandstone, and quartz-pebble conglomerate. The quartz sand grains are well cemented by quartz. The quartz pebbles range up to 2 inches and are round- and egg-shaped. The pebble beds are nearly always exposed along the underside of the lower beds of the formation where they form overhanging ledges. On Fork Ridge, two miles east of Olean, Virginia, Tuscarora beds are inverted and the weathered pebble beds are beautifully exposed. The sandstones in the Tuscarora are cross-bedded, particularly the lower units. The detailed lithologic character of the Tuscarora Sandstone is given in Geologic Sections 1, 2, and 3. The Tuscarora Sandstones grade upward into light-gray, mottled maroon siltstones and green shales of the Rose Hill Formation.

Distribution and thickness. - The resistant character of the Tuscarora quartzites is well attested to by the massive cliffs near the crest of Butt, Big, and Doe mountains where the quartzite is nearly continuously exposed. The Tuscarora quartzite is the ridge-former on Peters, Salt Pond and Johns Creek mountains (Pl. 3). A complete section of the Tuscarora crops out along Stony Creek northeast of Olean, Virginia and below the Cascades along Little Stony Creek. Bold cliffs occur well down the northwest slope of Butt Mountain where the Tuscarora is repeated by faulting (Pls. 3, and 7A). The Tuscarora Sandstone is the principal rock forming the extensive upland colluvial deposits in the high valleys around Big, Butt, and Doe mountains.

The thickness of the Tuscarora Sandstone ranges from about 50 feet near the Cascades to 140 feet near the west end of Butt Mountain. The thickness along Stony Creek is approximately 120 feet. Arthrophycus and "Scolithus" are found throughout much of the formation.

Niagaran Series

Rose Hill Formation

Name and lithology. - C. K. Swartz (1923, p. 28) named the Rose Hill Formation for Rose Hill, Cumberland, Maryland for all beds between the Tuscarora and Keefer sandstones of Maryland. The Rose Hill Formation in the Butt Mountain area is roughly divisible into three units. The lower unit is distinguished by green and red finely laminated shales and gray sandstones. The middle unit consists of maroon, thick-bedded, medium-grained, hematite-cemented sandstones. The upper unit consists of green and buff shales and locally also interbedded maroon, thin-bedded fine-grained, hematite-cemented sandstone. The lithologic character is given in Geologic Sections 2 and 3. The Rose Hill is succeeded by thick-bedded, white and reddish-white quartzites, possibly of "Keefer" age.

Distribution and thickness. - The Rose Hill Formation forms a continuous belt along the crest of Peters Mountain and crops out in an extensive belt along the crest of Butt Mountain (Pl. 3). Excellent exposures of the formation occur 0.75 mile northeast of Olean, Virginia, along

Stony Creek where the formation is nearly completely exposed. Nearly vertical cliffs of Rose Hill occur at The Cascades. The thick-bedded, hematite-cemented sandstones are secondary ridge-formers and crop out as prominent ledges around the crest of Big, Butt, and Doe mountains.

The Rose Hill Formation ranges in thickness in the area. The thickness on Johns Creek Mountain is about 160 feet; at the Cascades the Rose Hill is 144 feet. Along the northwest slope of White Rock Mountain the thickness is 206 feet. Swartz (1942, chart 3) assigns the Rose Hill Formation to the Niagaran Series. The _Mastigobolbina_ _lata_ Hall zone (Middle Clinton) is present in the Rose Hill sandstones exposed along Peters Mountain. Specimens of _Mastigobolbina_ _modesta_ Ulrich and Bassler, identified by Dr. C. G. Tillman, were collected from the crest of Peters Mountain, approximately 3 miles due north of Interior, Virginia.

"Keefer" Sandstone

Name and lithology. - The name Keefer Sandstone was proposed for a sequence of white sandstones on Keefer Mountain, a few miles northeast of Hancock, Maryland (Swartz, 1923, p. 28). Butts (1940, p. 119) includes the Keefer in the Clinton Formation. Cooper (1944, p. 119), on the basis of fossil correlation with the Maryland Silurian section, believes that the "Keefer" of southwestern Virginia is older than the true Keefer. The name "Keefer" in the Butt Mountain area is used loosely to refer to a sequence of white and reddish-white quartzites, conglomerates, and sandstones and thin intercalated shales which overlie the Rose Hill formation. The detailed lithologic character of the "Keefer" is given in Geologic Section 3. Although the "Keefer" quartzite in most outcrops throughout the area is difficult to distinguish from the Tuscarora quartzite of similar lithology, the red and yellow weathering, punky, sandy shale bed and light-red quartzites in the upper part of the formation are readily distinguishable. The Tuscarora quartzites can be distinguished from the "Keefer" by the distinctive pebble conglomerates at the base and in the middle of the Tuscarora. Where outcrops show only the white quartzites, the two units can not be separated readily and the identity of the unit is determined by the identity of the overlying or underlying red unit, the Rose Hill or Juniata formations. The red beds are distinguished using criteria resulting from a study made by Cooper (1944, p. 110).

The "Keefer" quartzites are overlain by a succession of gray, shaly weathering fossiliferous limestones of the Tonoloway.

On most dip slopes the contact between the "Keefer" and Tonoloway is indicated by a sharp break in slope and is marked by a zone consisting of fragments and blocks of "Keefer" Sandstone, Rocky Gap Sandstone, and in places Huntersville Chert, all of which are cemented with oxides of iron and manganese. The resulting rock is a collapse or founder breccia (Norton, p. 191) (Pl. 7 B). The collapse breccia is formed after the strata have been deformed and tilted and is a product of extensive dissolution. The origin of the breccia is probably related to processes described by Norton (1917, pp. 191-192) and Farnham (1960, p. 41, Pl. 1) for the dissolution of the Tonoloway Limestone in the Tumbling Creek area, Washington, Smyth, and Tazewell Counties, Virginia. The Tonoloway Limestone is readily soluble by percolating ground water whereas the underlying "Keefer" quartzite forms an essentially impermeable seal. Cavities develop in the limestones well below the surface and pieces of overlying Rocky Gap Sandstone break off and fall into the cavities. Subsequent erosion of the dip slope and migration of the Rocky Gap-Huntersville bluff down slope produces surficial float blocks of chert and additional sandstone which creep down slope into the cavity in the Tonoloway Limestone. Cementation of the loose blocks occurs as manganese- and iron-rich groundwater percolate through the breccia. Hydrous ferric and manganic oxides are precipitated around the loose fragments and finally cement the material.

Distribution and thickness. - Excellent exposures occur along Stony Creek, 0.75 mile northeast of Olean, Virginia. The formation marks a continuous belt along the upper slopes of Peters Mountain (Pl. 3). The "Keefer" is a secondary ridge-former and forms broad flatirons along the southeast slope of Big Mountain and the northwest slope of Butt Mountain.

Determinations of the exact thickness of the "Keefer" Sandstone are difficult because the contact with the overlying Tonoloway Limestone is not well exposed in the area; however, the average thickness is of the order of 150 feet. Swartz (1942, chart 3) assigns the true Keefer to the Niagaran Series. All of the Rose Hill in the area is probably Middle Clinton in age. If the "Keefer" of the Butt Mountain area is older than the Keefer of Maryland as Cooper (1944, p. 119) believes, then there is an unconformity of considerable magnitude between the "Keefer" and Tonoloway Limestones. Because the Tonoloway rests directly upon the "Keefer" without any apparent structural unconformity the unconformity is indicated by the absence of true Keefer, Rochester, McKenzie, an

Bloomsburg, and Wills Creek beds. These units are present in the northern part of the Appalachian Valley (Butts, 1940, pp. 243-257). On the other hand the "Keefer" Sandstone of the area, being much thicker (150 + feet) than the type Keefer of Maryland (20-40 feet) may represent a sandy facies of the Upper Clinton and higher units.

Cayugan Series

Tonoloway Limestone

Name and lithology. - The name Tonoloway Limestone was proposed for a succession of fossiliferous gray platy limestones on the lower slopes of Tonoloway Ridge, Washington County, Maryland (Swartz, 1923, p. 33). The Tonoloway Limestone in the Butt Mountain area is a succession of gray and yellowish-brown, coarse- to fine-grained, fossiliferous limestones. The detailed lithologic description of the formation is given in Geologic Section 4. The upper sandy and silty limestones and interbedded quartzite of the Tonoloway give way to overlying calcitic quartz sandstones of the Rocky Gap Sandstone.

Distribution and thickness. - A nearly complete section of the Tonoloway Limestone is exposed along Stony Creek, 0.1 mile north of Interior, Virginia (Pl. 8 A). No other exposure of the formation is known to occur in the area; however, the limestones upon weathering yield a typical yellow to red clayey soil. This distinctive soil stands in marked contrast to the sandy brown soils developed on the underlying "Keefer" and overlying Rocky Gap Sandstone. The breccia which occurs above 2500 feet altitude also marks the areas underlain by the Tonoloway. The Tonoloway Limestone is mapped together with the "Keefer" Sandstone as one map unit because exposure of the Tonoloway is poor.

The following is a list of fossils identified by the writer from the Tonoloway Limestone exposed 0.1 mile north of Interior, Virginia:

Fossils of the Tonoloway Limestone

Ostracodes

Beyrichia cf. *B. tonolowayensis* Ulrich and Bassler

Dibolbina producta Ulrich and Bassler

Dizygopleura halli Ulrich and Bassler

Leperditia sp.

Welleria obliqua Ulrich and Bassler

Zygobeyrichia sp.

Pteropods

Tentaculites gyracanthus Eaton

Beyrichia cf. *B. tonolowayensis* differs in several respects from the type specimen of *B. tonolowayensis* (Ulrich and Bassler, 1923, Pl. 23, Fig. 26). First the anterior lobe is narrower and sharper crested. Secondly, the median and anterior sulci are broader. Thirdly, the furrows on the frill are broader and fewer. However, the specimen is unlike any other illustrated or described. *Beyrichia tonolowayensis*, *Dibolbina producta*, *Dizygopleura halli* and *Welleria obliqua* are all restricted to the Tonoloway Limestone of Maryland and West Virginia (Ulrich and Bassler, 1923, pp. 183-232).

The Tonoloway along Stony Creek is 75 feet thick and is structurally located in the trough of a northeast plunging syncline. The thickness elsewhere in the area is estimated on the basis of residual clayey soils to be about 50 feet.

DEVONIAN SYSTEM

Lower Devonian Series

Rocky Gap Sandstone

Name and lithology. - The Rocky Gap Sandstone is probably the ferruginous sandstone unit in Campbell's (1896, p. 2) Giles Formation. The Giles Formation included everything between the "Keefer" (of this report) and Romney Shale (Millboro of this report). Swartz (1929, p. 80) applied the name Rocky Gap to a sequence of sandy and cherty beds in Rocky Gap, Bland County, Virginia, below the Saltville Chert which he correlated with the Shriver Chert.

In the Butt Mountain area the Rocky Gap Sandstone consists of dark-gray to dark-brown calcite-cemented sandstones. Numerous ferruginous granule conglomerates occur throughout the formation. The lithologic character of the Rocky Gap is given in Geologic Section 5. The upper sandstones of the formation near the trough of the Butt Mountain syncline contain an interbedded breccia which consists of angular fragments of white sandstone. The lithology of the sandstone fragments is similar to the Tuscarora and Keefer sandstones. The Rocky Gap sandstones weather to brown and orange sands and the quartz grains are mostly angular to subangular. In bold outcrops, the bedding features are lost owing to leaching of the calcite cement. Locally, fractures in the sandstone are filled with manganese and iron oxides. The Rocky Gap conglomeratic sandstones are succeeded by the yellow and brown chert beds of the Huntersville.

Distribution and thickness. - The Rocky Gap Sandstone is poorly exposed throughout the area. The distribution is shown on the geologic map (Pl. 3). Exact thickness measurements of the Rocky Gap are difficult to make because of poor exposures; however, the thickness is probably 60 to 80 feet, north of Interior, Virginia, on the south flank of Peters Mountain (on the northwest limb of theFork Ridge syncline) and more than 100 feet north of Little Meadows (along the northwest flank of the Butt Mountain syncline) (Pl. 3). Cooper (1942, chart 4) assigns the Rocky Gap to the Helderberg Stage of the Devonian. Spiriferoid brachiopods occur in float blocks on the south slope of Peters Mountain.

Huntersville Chert

Name and lithology. - The Huntersville Chert is probably the chert unit of Campbell's (1896, p. 2) Giles formation. Price (1929) named the Huntersville Chert from Huntersville, Pocahontas County, West Virginia. In the Butt Mountain area, the Huntersville is a sequence of light-gray to white chert with intercalated glauconite beds. The weathered chert in some exposures is stained dark-brown. The chert occurs on dip slopes in clayey soils as fractured, manganese- and iron-stained, blocky fragments. The Huntersville is succeeded by the black and chocolate-brown shales of the Millboro.

Distribution and thickness. - The Huntersville is poorly exposed throughout the area. The distribution is shown on the geologic map (Pl. 3). The average thickness of the formation is estimated to be 70 feet along Peters Mountain north of Interior and more than 100 feet in the Butt Mountain syncline north of Little Meadows. Cooper (1942, chart 4) assigns the formation to the Onesquethaw Stage of the Devonian.

Millboro Shale

<u>Name and lithology</u>. - Butts (1940, pp. 308-309) named the Millboro Shale for exposures of black fissile shale at Millboro Springs, Bath County, Virginia. In the Butt Mountain area the Millboro is the youngest preserved formation. It consists of black fissile shales which weather to chocolate-brown. Soils developed over the Millboro contain weathered chips and flakes of the shale. Locally calcareous concretions occur in the formation.

<u>Distribution and thickness</u>. - The Millboro Shale is confined to the trough of the Butt Mountain syncline (Pl. 3 and 4 section C-C'). The thickness near Little Meadows is approximately 200 feet.

Colluvium and Alluvium

Colluvium is a general term which refers to loose unconsolidated and incoherent deposits which accumulate by the action of gravity. Alluvium, also a general term, refers to stream deposits of comparatively recent time. In the Butt Mountain area, both the alluvium and colluvium are mapped as one unit. The differentiation of the two deposits can only be made along the major streams. The deposits are mapped where the distribution of the bedrock formations is obscured by the covering material. The deposits consist of fragments and blocks of sandstone derived chiefly from weathering of Tuscarora and "Keefer" sandstones and quartzites which crop out near the crests of Peters, Big, Butt, Doe Salt Pond and Johns Creek mountains.

The alluvium and colluvium consists of several types of deposits which are called talus, sliderock, terrace deposits and "let-down" erratics (Landes, 1959 and Farnham, 1960, pp. 43-44). Excellent examples of talus and sliderock occur on the northwest slope of Doe Mountain and along the high slopes and steep valleys fronting Big and Butt mountains. In the upper reaches of resequent stream valleys on the south slope of Peters Mountain, colluvial material clogs or in places fills the apparently once steep and deep valleys. Blocks of Tuscarora and "Keefer" sandstone clog the upper reaches of Johns, Doe, and Little Stony creeks and Pond Drain. The thickness of accumulation of the loose blocks of Tuscarora in high valleys is indicated in the north end of Mountain Lake and Pond Drain. There the lake reaches a maximum depth of approximately 75 feet. The depth of the lake is probably an indication of the depth of a former valley which has subsequently been filled with large blocks of Tuscarora sandstones (Pl. 11). Some of the rectangular-shaped blocks measure 20 by 12 by 8 feet and weigh an estimated 150 tons. Similar-sized isolated blocks of predominantly Tuscarora lithology are found on low slopes underlain by Martinsburg shales on the south slope of Doe Mountain and west slope of Butt Mountain. These are appropriately called "let-down" erratics and they point to the highly resistant character of the Tuscarora quartzites.

Alluvial deposits occur along Stony Creek and the low reaches of Laurel Branch, Little Stony Creek and Doe Creek. Imbricate boulders lying in the stream channel occur throughout the bed of Stony Creek. Locally a terrace gravel deposit is exposed along the southwest side of Stony Creek, approximately 10-15 feet above the stream level. Plate 8B shows a typical exposure of the rounded stream pebbles and boulders of the deposit, 2.5 miles northeast of Clean, Virginia. The distribution of the colluvium and alluvium is shown on the geologic map (Pl. 3).

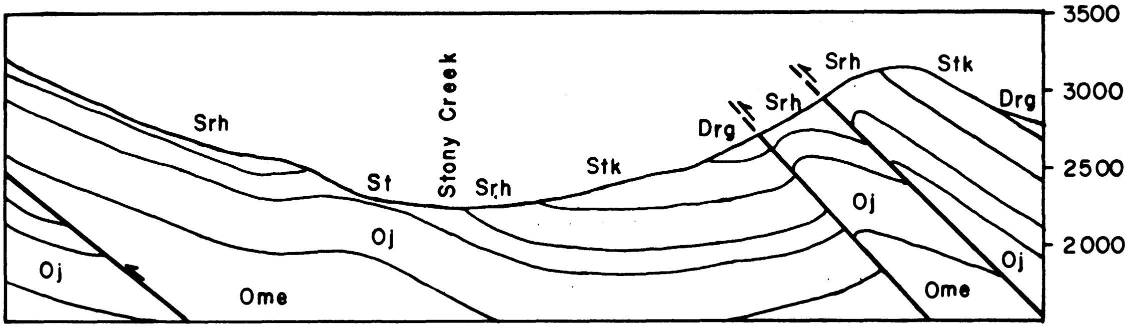
STRUCTURAL GEOLOGY

General Features

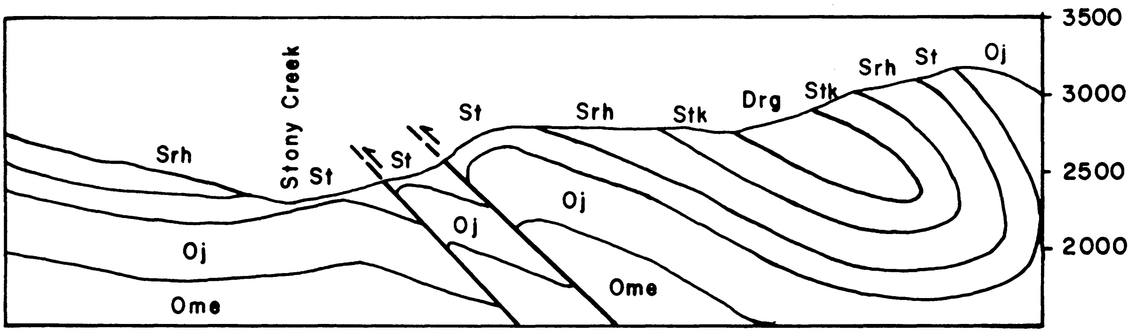
The Butt Mountain area lies within an area of complexly folded and thrust-faulted strata in the Valley and Ridge province of southwest Virginia. Parts of two Appalachian thrust blocks are present; part of the Narrows block occupies the south and central portions of the area and part of the St. Clair block occupies the north portion. The major structures in the area are synclines. The Narrows fault, which extends for approximately 50 miles northeast from Tazewell, Virginia, dies out in the northeast part of the area. The relations of the structures in the Butt Mountain area to adjoining areas is given by Plate 5 which shows the axial traces of folds and traces of major faults. Five synclines, three anticlines, and five faults trend across the area in a northeast direction (Pl. 3). Local names have been applied to some structures and are taken from related physiographic features. The interpretation of structure is depicted on six cross sections (Pls. 4 and 6). Three sections (Pl. 4) show the structure across the entire area from northwest to southeast; three other sections (Pl. 6) supplement the sections of Plate 4 and show complications in the local structure along the valley of Stony Creek.

Intense deformation appears to have been concentrated in the northwest part of the area where geologic structures are tight, overturned, and faulted (Pls. 3 and 4, especially A-A'). Within the area, the trough portion of the Butt Mountain synclinorium contains the thickest sections of Devonian, Silurian, and probably Ordovician rocks

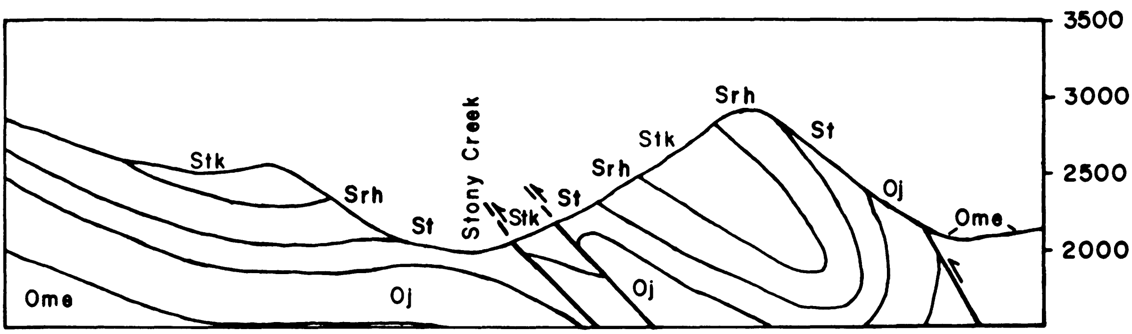
Plate 6



SECTION ALONG LINE F-F'



SECTION ALONG LINE E-E'



SECTION ALONG LINE D-D'

0 1000 2000 Feet

Horizontal and Vertical scale

Interpretation of the geologic structure along Stony Creek Valley. [See the geologic map (Pl. 3) for line of sections and explanation.]

(Cooper, 1962, p. 94). The following description and interpretation of the geologic structure supplements the structural features shown on the geologic map (Pl. 3) and Plates 4, 5, and 6. These will be discussed in turn from the southeast to the northwest.

Johns Creek Syncline

The major structure of the Valley of Johns Creek is the Johns Creek syncline. This doubly plunging fold has a length of more than 25 miles and its axis trends N. 55° E. (Pl. 5). The southwest nose is at the juncture of Johns Creek Mountain and Salt Pond Mountain (Pl. 3). The ridge crests are held up by the resistant Tuscarora sandstones whereas the "Keefer" sandstones mark the trough portion along Johns Creek. The northwest flank of the Johns Creek syncline becomes the southeast flank of the Mountain Lake anticline.

Mountain Lake Anticline

The structure along Doe Creek and Mountain Lake is the Mountain Lake anticline (Pl. 3). The fold trends N. 60° E. and plunges gently to the northeast. The anticline is symmetrical and both limbs have dips ranging from 10° to 20° (Pl. 4, C-C'). Gentle northwest dipping Tuscarora and Rose Hill beds along Doe Mountain mark the northwest limb. The crest of the anticline is located where the contact between flat-lying Moccasin and Martinsburg-Eggleston beds cross Doe Creek (Pl. 3). Martinsburg beds along both flanks of the anticline are tightly folded into miniature anticlines and synclines whose axes plunge in the direction of the axis of the Mountain Lake anticline. The northwest limb of the anticline becomes the southeast limb of the Butt Mountain synclinorium.

Butt Mountain Synclinorium

The Butt Mountain synclinorium is named for Butt Mountain, a high but broad flat-lying region held up by flat-lying Silurian sandstones of the southwest nose and trough portion of the synclinorium. The major culmination of the fold occurs between New River and Pearisburg, Virginia, (Pl. 5). The synclinorium is a major system of east-northeast trending folds with a length of more than 200 miles.

The northeast plunging portion of the synclinorium, northwest of New River, trends N. 65° E. across the central portion of the Butt Mountain area. Near the crest of Butt Mountain the fold plunges 10° to 20° to the northeast. The youngest formation is Devonian in age and is preserved in a minor depression of the axial portion near Little Meadows (Pl. 3).

The synclinorium is composed of one major depression and several minor folds (Pl. 5). The southeast flank is formed by a syncline and an anticline both of which trend N. 40° E. and plunge approximately 20° north-northeast. The trough portion of the synclinorium trends N. 65° E. along the northwest part of the crest of Butt Mountain and along Laurel Creek where an axial depression is shown by reversal of plunge in the Millboro Shale (Pl. 3).

It is this depression of the Butt Mountain synclinorium that contains the thickest development of Devonian rocks within the area. The Rocky Gap Sandstone is 100 feet thick whereas on the northwest limb of the Fork Ridge syncline to the northwest the Rocky Gap is approximately 60 feet thick. The Huntersville Chert is approximately 100 feet thick (map measurement) on the northwest limb of the Butt

Mountain syncline whereas on the northwest limb of the Fork Ridge syncline it is approximately 60 feet thick.

The structure is asymmetric along little Meadows with the northwest limb dipping 35° southeast and the same rock units on the southeast limb dipping 15° northwest. Most other folds in the area are asymmetric with the southeast limb having the steeper dip. The steeper dips on the northwest limb of the syncline are probably related to the high-angle Big Mountain fault (Pl. 3). The Millboro Shale in the depression is tightly folded. The contorted nature of the shale, like the Martinsburg of the Mountain Lake anticline, appears incongruent in view of the relative openness of the syncline.

Two high-angle faults repeat parts of the Juniata, Tuscarora, Rose Hill, and "Keefer" beds within the Butt Mountain synclinorium (Pl. 3). The Lookoff Rock fault lies northwest of Lookoff Rock and trends N. 60° E. into the trough portion of the major depression of the Butt Mountain synclinorium. The identity of the fault as either reverse or normal is largely interpretation because critical areas are covered by colluvium. The trace of the fault as near as can be traced in the field from Lookoff Rock on Butt Mountain southwest into the southwest end of the mountain indicates a steep dip for the fault. The fault is interpreted to be nearly vertical or to dip steeply to the southeast (Pl. 4, A-A'). The fault probably passes into an anticline to the southwest in Middle Ordovician limestones (Pls. 3 and 5).

The other high-angle fault, the Big Mountain fault, trends N. 65° E. and lies northwest of the Lookoff Rock fault and southeast of the Narrows fault-Epling Draft anticline (Pls. 3 and 5). The greatest stratigraphic displacement occurs immediately north and below the high point on the crest of Big Mountain where Juniata beds abut against "Keefer" beds. At its southwest termination the fault probably dips nearly 90° whereas towards the northeast the fault dips steeply to the southeast. The fault was traced for approximately 5.5 miles in the area and continues to the northeast for an unknown distance.

A minor asymmetric syncline is between the Lookoff Rock fault and Big Mountain fault along the west crest of Butt Mountain (Pls. 3 and 4, A-A'). Beds on the northwest limb dip gently to the southeast whereas beds on the southeast limb dip steeply to the northwest. Here again these steep dips were probably produced by drag along the hanging wall of the Lookoff Rock fault.

The Tuscarora sandstone in the trough portion of this minor syncline is 140 feet thick whereas the Tuscarora along Big Mountain, 4.5 miles southeast of Olean is 100 feet thick. At The Cascades, 1.5 miles south of the Lookoff Rock fault, the Tuscarora is 50 feet thick (Pl. 7). The relationship between the thicker Tuscarora Sandstone in the Minor syncline and the Lookoff Rock fault may be significant. Because the fault is not discernible to the northeast where Devonian beds crop out the Tuscarora may be thicker because of movement along the fault at the time of formation of the Tuscarora.

The geologic structures northwest of the Butt Mountain synclinorium contrast markedly with those just described in the south and central parts of the area. Asymmetric folds cut by several minor faults characterize the north portion of the area from the Narrows fault on the southeast to the North Fork syncline on the northwest.

Narrows Fault and Epling Draft Anticline

The Narrows fault, one of the major structural breaks in the southern Appalachians of Virginia, was named for The Narrows of New River at the upper end of which the fault crosses the river. Southwest of The Narrows, the fault trends generally S. 80° W. and dies out near Tazewell, Virginia. Northeast of The Narrows, the fault loses displacement rapidly and finally dies out in the crestal portion of the Epling Draft anticline in the northeast portion of the area (Pls. 3 and 5). The Narrows fault southwest of New River in the Burkes Garden quadrangle is called an overthrust and dips approximately 45° to the southeast (Cooper, 1944, p. 198). The dip of the Narrows fault northeast of The Narrows is unknown and can not be accurately determined in the Butt Mountain area, however, it is estimated to dip approximately 50° to 60° to the southeast. Here the fault is better termed a high-angle thrust. Two of the three border faults on the northwest side of the Narrows fault are well displayed in a road cut at Olean, Virginia, (Pl. 9).

Butts (1933) shows the Narrows fault extending along the northwest slope of Butt and Big mountains and dying out in the northeastern Giles County, near the Virginia-West Virginia boundary. He showed Martinsburg beds faulted against Silurian beds throughout its extent across the Butt Mountain area. However, that Martinsburg belt terminates along and immediately northeast of the saddle between Big Mountain and Fork Ridge. Whether or not the fault passes through the saddle and beyond to the northeast is open to question. The Martinsburg beds in the saddle are interpreted to represent the crestal portion of the Epling Draft anticline which is overturned to the northwest. The writer believes it more likely that the Narrows fault dies out just south of or in the saddle (Pl. 3). The trace of the Narrows fault along Laurel Branch is obscured by a cover of colluvium and alluvium which occurs not only along the stream but well up on the northwest slope of Butt Mountain (Pl. 3).

Northwest of the saddle between Big Mountain and Ford Ridge the southeast dipping Juniata beds of the overturned northwest limb of the Epling Draft anticline become vertical and finally dip steeply to the northwest along strike to the northeast near the eastern edge of the area.

Fork Ridge Syncline

The Fork Ridge syncline is named for Fork Ridge which is held up by the overturned Silurian sandstones of the southeast limb of the fold. The syncline is the northeast extension of the Hemlock Ridge syncline (Hale, 1960, Pl. 1). The area between Fork Ridge and White Rock Mountain marks the axial portion of the fold (Pl. 3). The faulted trough portion is well displayed along County Road 635 at Olean, Virginia. Also near Olean part of the Rose Hill Formation on the northwest limb is probably faulted out. The belt of outcrop is so narrow that scarcely all the formation (200+ feet) could be present between the mapped boundaries (Pl. 3).

White Rock Mountain Fault

The northwest limb of the Fork Ridge syncline on the northwest slope of White Rock Mountain probably is cut by two reverse faults.

Plate 6 illustrates the structural interpretation and relations along the faulted limb. The faults constitute a zone of faulting and tight folding and in places nearly isoclinal folding involving mostly Silurian units. The associated folds along the zone were probably produced as a result of drag along the fault planes during faulting. The principal fault of the zone is designated the White Rock Mountain fault (Pls. 3 and 5) and is a continuous break from southwest of Olean, Virginia, (Hale, 1961, Pl. 1) northeast to Interior, Virginia, and beyond the area. The dip of the fault is estimated to be between 35° and 45° to the southeast along the western part of the area, and where the faults play out into one fault in the northeast part of the area the dip is estimated to be less than 35° (Pl. 10A).

Ronk Anticline and Stony Creek Syncline

Northwest of the White Rock Mountain fault, two prominent minor folds are developed on the northwest limb of the Fork Ridge syncline. The axes of the folds trend N. 35° E. along the southeast slope of Peters Mountain and along Stony Creek. The folds plunge 12° to 15° to the northeast. To the northeast these folds become part of a major syncline which plunges to the northeast. (Pls. 3 and 5).

Peters Mountain Homocline

All the beds southeast from the St. Clair fault to the crestal portion of Peters Mountain dip to the southeast. The crest of Peters Mountain marks the N. 60° E. trend of the homocline (Pls. 3 and 5). The average dip of the beds near the crest of Peters Mountain is 20° southeast. Halfway across the north part of the area along the crest of Peters Mountain, the homoclinal structure is abruptly terminated by the Huckleberry Ridge thrust and the nose of the North Fork syncline (Pl. 3). The Huckleberry Ridge fault is estimated to dip 30° to the southeast (Pl. 4, C-C').

The North Fork syncline is a doubly plunging slightly asymmetric fold (Pl. 3 and 4, C-C'). The southwest nose forms a broad flat lying area underlain by "Keefer" and Rose Hill beds at the juncture of Fork Mountain and Peters Mountain.

SUMMARY OF STRUCTURAL FEATURES

The purpose of the summary is to point out and emphasize certain structural features which have been uncovered during the field study and to discuss their possible significance or implications.

The writer disagrees with some of the structural interpretations made by Mathews (1934, pp. 15-17). Mathews states that the general trend of the primary structure in Giles County is about N. 60° E. and that crossing this primary structure are four distinct anticlinal folds and two "overlap fault zones", the axes of which cut the primary axes at angles of about 68° to form a grid pattern of all structures. Mathews' map (1934, Pl. 2) shows the axis of one of his "cross" anticlines (Butt Mountain anticline) extending from the Goodwins Ferry area through the crest of Butt Mountain. The writer does not agree with this interpretation. The axis of Mathews' postulated Butt Mountain anticline is not continuous across the area in a north-south direction and it appears that Mathews may have lined up culminations of some of the major northeast-southwest trending folds.

The relationship of the faults in the northern part of the area to the Big Mountain and Lookoff Rock faults is not apparent. The high-angle faults and tight folding along the northwest limb of the Fork Ridge syncline die out to the northeast in an area underlain by broad, gently plunging folds which are cut by a low-angle southeast dipping thrust fault. The Narrows fault also dies out to the northeast in the northern part of the area. The asymmetry of these folds and the direction of dip of the faults in the northern part of the area indicate that a deforming force acting laterally from the southeast produced the folds. However, the very high angle, nearly vertical faults on Butt and Big mountains (Pls. 3 and 4, A-A' and B-B'), downthrown on the northwest sides, are not easily explained by lateral compression from the southeast. Available evidence indicates that the displacement and high angle of dip of the Big Mountain fault as known from exposures of Silurian sandstone extends downward at least to Middle Ordovician limestones.

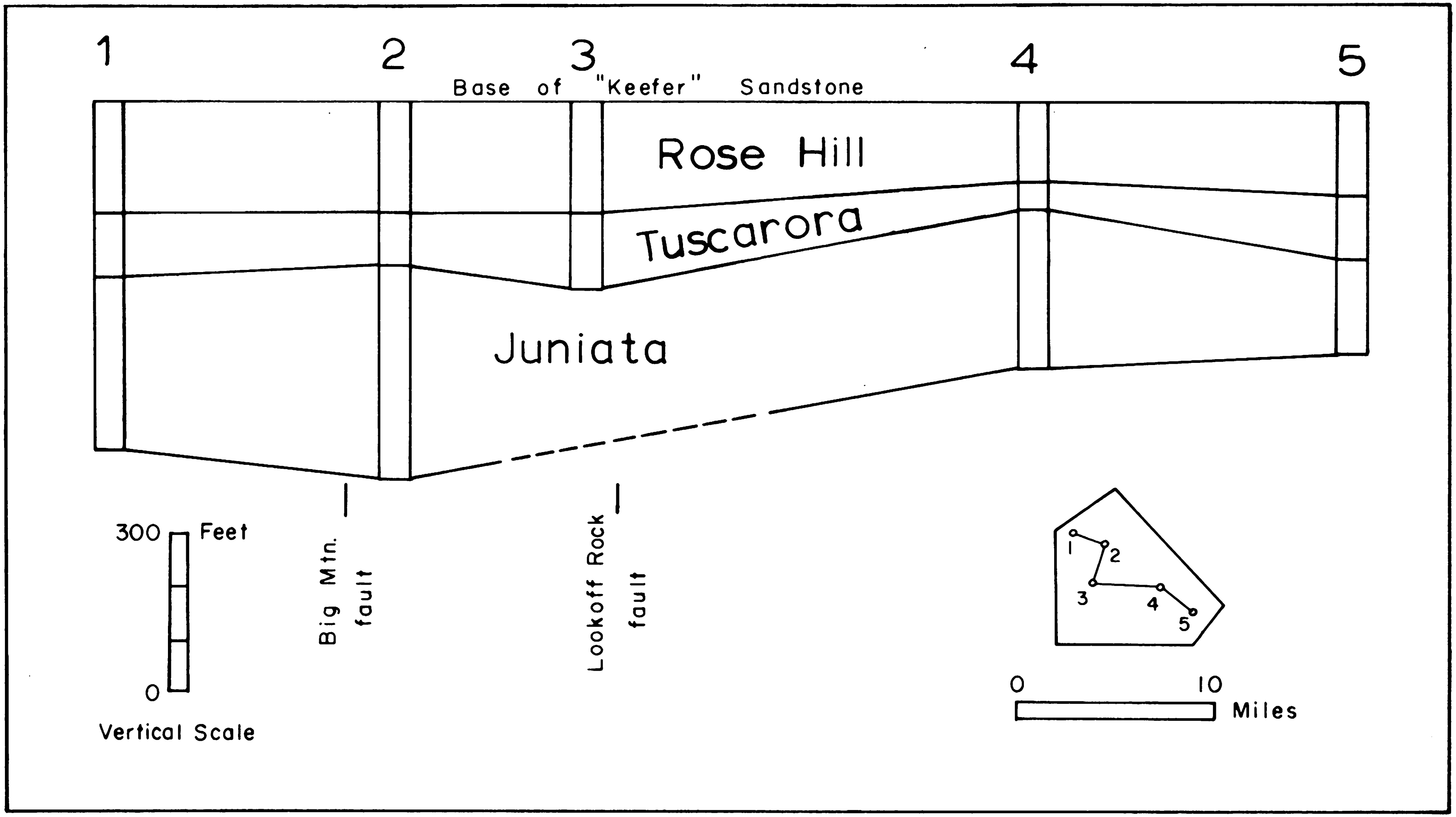
Cooper (1961, pp. 114-116) points out that if synclinal subsidence caused thrusts to develop, the possibility is strong that further subsidence produces a kind of underthrust action along the sheared limb. Downwarping in the area northwest of the Narrows fault possibly explains the relation between the faults and tight overturned folds in the northwest part of the area and the high-angle faults along Butt and Big mountains. If the Butt Mountain synclinorium remained as a stable passive block to lateral deforming forces produced by downwarping in the area of the present Fork Ridge syncline, the assumed movement of the underthrust block could have produced the tightly overturned

Fork Ridge syncline and could have faulted and tightly folded the northwest limb. The Big Mountain and Lookoff Rock faults would form in response to vertical downward movement of the Fork Ridge syncline to the northwest.

Local thickening of Silurian sandstones and possibly Juniata formation in the vicinity of the high-angle faults may indicate local subsidence during the time of deposition (Pl. 7). The Tuscarora in the trough of the minor syncline northwest of the Lookoff Rock fault is 140 feet thick whereas the Tuscarora on the northwest limb of the Butt Mountain syncline, 4.5 miles southeast of Olean, is approximately 100 feet. Near the crest of the minor strongly north-northeast plunging anticline at The Cascades the Tuscarora is 50 feet thick. The rate of change in thickness between these areas is not known. The thickened Tuscarora Sandstone as well as the thickened Devonian units in the major depression of the Butt Mountain synclinorium in the area where the Lookoff Rock fault dies out may indicate an area of local downwarping with perhaps some attendant normal faulting during the deposition of Silurian sands. Normal faults in most cases are thought to be the result of vertical and/or tensional forces. The fact that the Lookoff Rock fault occurs near the trough portion of the synclinorium strongly indicates that tensional forces could not have been acting to produce the differential movement. Instead the writer believes that the fault is probably the result of vertical forces, possibly in the basement, acting either at the time of deposition or after sedimentation ceased in the area.

The nature of the deforming process which produced the tight folds

Plate 7



THICKNESS VARIATIONS OF THE ROSE HILL, TUSCARORA, AND JUNIATA FORMATIONS.

in Silurian sandstones along the faults in the northwest part of the area might be determined by a detailed petrographic study of the Silurian sandstones. Cursory study of three thin sections, made from a sample of the "Keefer" on the overturned limb of the Fork Ridge syncline near Olean, Virginia, shows overgrowths and surtured contacts between the quartz grains. This may indicate possible flow phenomena (de Sitter, 1956, p. 74). Detailed study of the Silurian sandstones of the Fork Ridge syncline may prove or disprove flowage during deformation.

PHYSIOGRAPHIC FEATURES

The Butt Mountain area is within the Valley and Ridge province of Virginia. Most of the ridges of the province are narrow crested and held up by resistant Silurian or Mississippian sandstones. Where the ridges are high, broad flat-lying areas, the geologic structure of the underlying resistant sandstones is either a large open anticline or syncline. The broad and high crest of Butt Mountain is caused by a gently northeastward plunging synclinal fold in resistant Silurian sandstones. The northeastern part of Doe Mountain and Salt Pond Mountain are also broad flat areas underlain by gently dipping Silurian sandstones of the relatively open and gently northeast plunging Mountain Lake anticline. Both mountains are more than 4000 feet high. Although the high, broad crests of Butt, Doe, and Salt Pond mountains are not directly connected, the overall features constitute a dissected high tableland.

Johns Creek Mountain, the southwest part of Doe Mountain, Fork Ridge, White Rock Mountain, and Peters Mountain are all excellent examples of narrow crested ridges. The crests of Peters, Big, Butt, and Doe mountains are marked by nearly evenly spaced gaps which are the upper reaches of the resequent and obsequent stream valleys which with subsequent streams extending parallel to the strike of the structure, form the typical trellis pattern of Appalachian Valley and Ridge drainage. The local relief along the crests of the mountains averages 500 feet. Evident frost splitting and frost stirring (frost heaving and thrusting in surface zone of annual freeze and thaw, Hopkins and Karlstrom, 1955) is seen in the widely spaced, "walk through"-size fractures developed in the Tuscarora along the crest of Butt Mountain.

The attitude and thickness of the sandstones underlying the mountains appears to be the controlling factor in the amount of erosion along mountains in the area. Bald Knob (altitude 4363 feet), Lookoff Rock (4195 feet), Butt Mountain (4000 feet), and parts of Peters Mountain (3960 feet), are the highest areas and are underlain by nearly flat-lying Silurian sandstones. Most of the crest of Peters Mountain (altitude 3350-3750 feet) is underlain by the gently southeast dipping Silurian sandstones. On the other hand, Fork Ridge (altitude 3130) and White Rock Mountain (3350) are held up by vertical or steeply dipping Silurian sandstones.

The major valleys in the area have developed in direct response to the character and attitude of the bedrock. Although the structure underlying the valley of Stony Creek is the faulted northwest limb of the Fork Ridge syncline, Stony Creek flows along the crestal portion of a minor anticline throughout much of its course in the area. In the

Northeast part of the area the anticline plunges 12° to 15° northeast into the trough of a major syncline in weaker upper Silurian and Lower Devonian rocks. The valley in this area is characterized by broad gentle slopes. Where Stony Creek flows southwest across the area, the sides of the valley become progressively steeper to just north of Olean, Virginia, where the stream passes through a 500-foot gorge. The erosion of the gorge by Stony Creek appears to have been almost wholly controlled by two sets of joints. One set strikes generally N. 45° W. and the other strikes N. 45° E.

The Cascades, along Little Stony Creek (Pl. 3) consist of two prominent cliffs; the upper one is in the "Keefer" Sandstone and the lower one is in the Rose Hill Formation. The lower cataract is approximately 40 feet high. The structure underlying The Cascades is a north-northeast plunging anticline (Pls. 3 and 5). Little Stony Creek valley along The Cascades is characterized by steep sides and in places vertical cliffs. Where the anticlinal flexure plunges out to the northeast, Little Stony Creek flows along a synclinal depression in Devonian strata. Where Little Stony Creek flows down from The Cascades across Martinsburg shales and Middle Ordovician limestones, the underlying structure is probably synclinal. The Cascades occur at an elevation between 2800 feet and 3000 feet.

Mountain Lake

Several authors (Sharp, 1936; Holden, 1937-38, and Anonymous, 1957) have written about Mountain Lake which is perched 2000 feet feet above and as close as six miles away from New River to the west.

The lake stands 3,873 feet above sea level and comprises approximately 0.19 square mile. The lake is tear-shaped with the apex on the north end. The lake is shallow at its south end and gradually increases in depth toward the north where it is approximately 75 feet deep (Sharp, 1936, p. 82).

The lake is situated just north of the crest of the northeast-plunging nose of the Mountain Lake anticline. Pond Drain, a tributary to Little Stony Creek, drains the lake at its only outlet on the north. Doe Creek begins its steep southward descent 0.2 mile southwest of the southern end of the lake and is separated from the lake by a low divide, approximately 100 feet above lake level. The divide is in the relatively nonresistant Martinsburg shales, which also underlie the south end of the lake.

Large loose and variously oriented blocks of Tuscarora and possibly "Keefer" sandstones and conglomeratic sandstones are at the north end of the lake. One large block projects above lake level (Pl. 11 B). Pond Drain just below the lake outlet is clogged with large blocks of Tuscarora Sandstone and the valley is narrow whereas the south end of the lake which is underlain by Martinsburg shales is relatively broad.

Many of the postulated origins of the lake are impossible or improbable. However, Sharp (1936) recognized the importance of the accumulation of large colluvial blocks in stream valleys where they cross Silurian sandstones. The Tuscarora, because of its relative resistance, forms many V-shaped notches along some streams in the area. Large blocks at the north end of the lake strongly indicate that they were the major contributing factor in the formation of Mountain Lake. The hypothesis of origin of the lake suggested below is not unlike that suggested by Sharp (1936).

Erosion of units stratigraphically higher than the Tuscarora Sandstone, exposed a broad gentle structural arch capped by Tuscarora Sandstone across the present site of the lake. Along the northwest flank of that arch a resequent stream, Pond Drain, cut down to the Martinsburg shales along its uppermost reaches. In the vicinity of the north end of the lake this stream did not cut below the Tuscarora Sandstone. Lateral erosion of the stream valley in the Tuscarora produced large blocks which crept down slope and down the dip into the valley and reached the outcrop of the Tuscarora where further movement downstream was arrested. Frost heaving of Tuscarora along its outcrop and movement of large blocks, probably by solifluction, produced more blocks which crept down stream and damed against the already present blocks. Complete damming of the north end of the lake was accomplished by a filling of interstices in the bouldery deposit by smaller blocks and fragments and organic matter.

GEOLOGIC SECTIONS

Geologic section 1. -- Juniata Formation exposed near the crest of Salt Pond Mountain, about 0.5 mile south of Bald Knob, Giles County, Virginia

		Thickness in feet
Tuscarora Sandstone		
11.	Sandstone, tan and white, coarse-grained and conglomeratic, cross-bedded, ripple marks, *Arthrophycus*	25
Juniata Formation (190 feet)		
10.	Sandstone, variegated red and greenish-gray, fine-grained, interbedded with light-gray, conglomeratic, thick-bedded sandstone	6
9.	Sandstone, red, medium- and fine-grained, cross laminated	4.5
8.	Sandstone, variegated red and greenish-gray, medium-grained, cross-laminated, thick- and thin-bedded, weathers light-rosy red	16
7.	Covered, probably red silty shales	37
6.	Siltstone, variegated red and greenish-gray, interbedded with maroon, fine-grained, micaceous sandstone and maroon, micaceous, medium- and thin bedded mudstone	40
5.	Covered, probably sandstones and shales, red ...	20

	Thickness in feet
4. Sandstone, maroon, fine-grained thin-bedded, slabby, laminated, weathers pink and greenish-gray; interbedded with greenish-gray fine- and medium-grained thin-bedded sandstone	24
3. Covered, probably maroon shales and siltstones ..	7
2. Sandstone, maroon, fine-grained, thin-bedded	10
Martinsburg Formation	
1. Covered, soil contains yellow and brown silty shale chips with brachiopods (not measured)	

Geologic section 2. -- Rose Hill Formation and Tuscarora Sandstone 0.5 mile southwest of The Cascades, Giles County, Virginia

	Thickness in feet
"Keefer" Sandstone	
Rose Hill Formation (144 feet)	
15. Shale, greenish-gray, argillaceous	11
14. Sandstone, maroon, coarse-grained, medium- and thick-bedded, clay galls, hematite-cemented, cobbly weathering; contains *Leperditia*	4
13. Sandstone, greenish-gray to maroon, medium- and fine-grained, thick-bedded, massive weathering...	2

Geologic section 2 con't.

		Thickness in feet
12.	Sandstone, maroon, fine- to medium-grained; interbedded with maroon, conglomeratic and coarse-grained clayey sandstone and greenish-gray fine-grained shaly sandstone	18
11.	Covered, probably green shale and thin-bedded greenish-gray sandstone	14
10.	Shale, greenish-gray, silty and clayey; interbedded with green, medium-grained sandstone, contains clay galls and mica flecks	4
9.	Sandstone, dark-maroon, medium-grained, thick-bedded, clay galls, hematite cement, weathers massive	1
8.	Sandstone, maroon, argillaceous, weathers cobbly	2
7.	Sandstone, dark-maroon, fine-grained; contains sparse clay galls, massive weathering	11
6.	Same as unit 7. but weathers shaly, ripple marks	10
5.	Sandstone, dark-maroon, fine-grained; contains clay galls, massive weathering	7
4.	Covered, probably greenish-gray shales	42
3.	Shale, green to gray; interbedded with maroon medium- and fine-grained thick- and thin-bedded hematite cement	18

Geologic section 2 con't.

	Thickness in feet
Tuscarora Sandstone (48 feet)	
2. Quartzite and sandstone, light-gray to white, conglomeratic in part, lower beds have intercalated pebble conglomerate, pebbles, well rounded, 2 inches in maximum dimension, cross-bedded, contains _Arthrophyous_	48
Juniata Formation	
1. Sandstone, red and greenish-gray, fine- and medium-grained, cross-laminated in part	6

Geologic section 3. -- "Keefer", Rose Hill, Tuscarora, and Juniata Formations along County Road 635 0.5 mile northeast of Olean, Virginia

	Thickness Ft.	In.
"Keefer" Sandstone		
40. Quartzite, tan and white, stained brown, thick-bedded; with intercalated 0.5 inch silty brown shale	9	7
39. Sandstone, tan, medium- and fine-grained, weathers friable	3	11
38. Sandstone, red, fine-grained, thick-bedded, weathers reddish-brown; with intercalated red siltstone, weathers friable and shaly, contains		

Geologic section 3 con't.

		Thickness	
		Ft.	In.
38.	Cont.		
	Arthrophycus	6	11
37.	Sandstone, tan, fine- and medium-grained, medium- and thick-bedded, friable; contains _Leperditia_ and _Scolithus_	3	11
36.	Sandstone, red, fine-grained, thick-bedded ..	3	8
35.	Siltstone, dark-gray and brown, weathers shaly ..		4
34.	Shale, red and green variegated, mostly silty, some argillaceous	1	4
33.	Covered;..	5	
32.	Sandstone, reddish-white, fine-grained, thick-bedded	2	
31.	Covered, probably buff siltstone and shale	2	
30.	Sandstone, brown, coarse- and medium-grained, thick-bedded, friable	6	
29.	Covered	3	
28.	Sandstone, white and red, stained brown, coarse-grained and conglomeratic; interbedded with 0.5-inch red and white, fine-grained sandstone	12	
27.	Sandstone, white, stained red, fine- and medium-grained, thick-bedded; intercalated 1-inch reddish-white, fine-grained sandstone, weathers friable...	11	7

Geologic section 3 con't.

	Thickness Ft.	In.
26. Sandstone, red, coarse-grained, hematite cement; interbedded with gray, medium-grained sandstone, beds weather with spherical cavities	1	6
25. Shale, dark-gray, silty, grades down to variegated red, dark-gray, and brown argillaceous shale	5	6
24. Sandstone, reddish-white, coarse- and medium-grained, thick-bedded; with intercalated 2-inch bed of conglomerate, pebbles up to 0.1-inch and 1-inch gray siltstone	5	6
Rose Hill Formation (206 feet)		
23. Covered, probably red silty shale and dark-red and light-gray fine-grained sandstone	5	
22. Shale, greenish-gray, argillaceous and silty ..	4	
21. Sandstone, maroon, fine-grained, hematite cement thin-bedded; interbedded with gray, fine-grained sandstone and greenish-gray shale	6	
20. Sandstone, dark-maroon, coarse-grained, thin-bedded, weathers slabby, contains clay galls; with intercalated greenish-gray argillaceous shale	7	
19. Sandstone, dark-maroon, medium-grained, hematite cement, weathers shaly	9	

Geologic section 3. con't.

		Thickness	
		Ft.	In.
18.	Sandstone, dark-maroon, coarse- and medium-grained, hematite cement; contains clay galls up to 4 inches, weathers shaly	3	
17.	Sandstone, dark-maroon, fine-grained, hematite cement, weathers massive	27	
16.	Shale, variegated green and brown, argillaceous; interbedded with gray and greenish-gray thin-bedded siltstone	10	7
15.	Siltstone, greenish-gray, thin-bedded; interbedded with gray and reddish-gray fine-grained thin-bedded sandstone	1	
14.	Sandstone, reddish-brown, fine-grained, thick-bedded; interbedded with greenish-gray argillaceous shale	10	10
13.	Sandstone, red, fine-grained, laminated, thin-bedded	1	
12.	Siltstone, greenish-gray; interbedded with gray argillaceous shale	6	
11.	Covered	9	
10.	Sandstone, dark-maroon, fine-grained, thin-bedded, hematite cement; contains sparse clay galls	3	
9.	Covered	6	

Geologic section 3. con't.

	Thickness Ft.	In.
8. Siltstone and very fine grained sandstone, greenish-gray, thin-bedded, weathers slabby ...	3	6
7. Sandstone, variegated red and green, fine-grained thin-bedded	9	
6. Covered	12	
5. Shale, green, argillaceous; interbedded with greenish-gray thin-bedded siltstone and very fine-grained sandstone	15	
4. Sandstone, dark-maroon, fine-grained, thick-bedded, hematite cement; contains sparse clay galls	7	
3. Shale and siltstone, variegated red and green ..	35	
Tuscarora Sandstone (125 feet)		
2. Sandstone and quartzite, white and tan, thick bedded and cross-bedded; with intercalated 0.5 inch bed of round and egg-shaped pebble conglomerate in basal part	125	
Juniata Formation		
1. Sandstone, red and greenish-gray, fine-grained, laminated and cross-laminated, scour channels up to 2 feet contain red and greenish-gray cross-laminated siltstone and silty shale	12	

Geologic section 4. -- Tonoloway Limestone exposed along Stony Creek, 0.1 mile north of Interior, Virginia

	Thickness Ft.	In.
Rocky Gap Sandstone		
Tonoloway Limestone (73 feet)		
23. Limestone, gray, fine-grained, medium-bedded, laminated, weathers brown	5	
22. Limestone, brown with black splotches, fine-grained	5	6
21. Limestone, dark-gray, fine-grained, laminated, shaly	1	1
20. Limestone, brown, fine-grained, laminated	2	8
19. Limestone, brownish-gray, fine-grained, thin-bedded, reddish blotches on weathered surface	4	
18. Shale, gray, silty, calcareous		2
17. Quartzite, gray, thick-bedded	3	7
16. Shale, gray, silty, calcareous		6
15. Quartzite, gray, slabby		7
14. Limestone, gray, silty, weathers brown and shaly	1	10
13. Limestone, dark-gray, fine-grained, thin-bedded, contains ostracodes, weathers cobbly ..	1	4
12. Limestone, black, fine-grained, thin-bedded, weathers cobbly and shaly	1	

Geologic section 4. con't.

		Thickness	
		Ft.	In.
11.	Limestone, dark-gray, fine-grained, thin-bedded	2	2
10.	Limestone, dark-gray, fine-grained, thick-bedded, contains brachiopods, algal structures	3	5
9.	Limestone, dark-gray, very fine grained, weathers yellowish-brown; interbedded with brown laminated shale and gray coarse-grained limestone, weathers light-gray; contains *Beyrichia* cf. *B. tonolowayensis*, *Dibolbina producta* *Dizygopleura halli*, *Welleria obliqua*, *Tentaculites gyracanthus*	10	
8.	Limestone, dark-bluish-gray, coarse-grained, 0.5-inch brownish-gray shale partings; inter-bedded with light-gray fine-grained limestone ..	3	7
7.	Limestone, light- to dark-gray, very fine grained, surface weathers pitted, some pits contain pyrite and quartz, weathers massive	5	7
6.	Limestone, gray with orangish splotches, coarse grained, cobbly	4	6
5.	Covered	7	6
4.	Limestone, gray, coarse-grained, fossiliferous .		10

Geologic section 4. con't.

	Thickness Ft.	In.
3. Limestone, light-gray, coarse-grained, weathers dark-orangish-brown with white splotches	4	6
2. Covered	5	
"Keefer" Sandstone		
1. Quartzite, white, coarse-grained, fractures filled with manganese oxide; (not measured)		

Geologic section 5. -- Rocky Gap Sandstone 1.9 miles north of Mountain Lake, Giles County, Virginia

	Thickness in feet
Huntersville Chert (20+ feet)	
4. Covered, soil contains abundant white blocky pitted chert fragments	20
Rocky Gap Sandstone (100+ feet)	
3. Sandstone, steel-gray, coarse-grained, and conglomeratic, calcite cement, weathers brownish-orange, friable; quartz grains up to 0.25 inch in maximum dimension, subrounded and subangular	27
2. Sandstone, dark brownish-gray, coarse-grained friable; interbedded with light-tan to gray fine- and medium- grained sandstone, weathers reddish-gray, friable	11

Geologic section 5. con't.

	Thickness in feet
1. Covered, probably steel-gray medium-grained and conglomeratic sandstone; interbedded with gray very fine grained calcite-cemented sandstone, weathers brown and friable with limonitic boxwork	62

Plate No. 8

A. Southwest part of Butt Mountain showing outcrops of Silurian sandstones from Olean, Virginia, looking south.

B. Alluvial material along Stony Creek, 2.5 miles northeast of Olean, Virginia.


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Plate No. 9

A. Exposure of Tonoloway Limestone, 0.1 mile north of Interior, Virginia.

B. Alluvial material along Stony Creek, 2.5 miles northeast of Olean, Virginia.

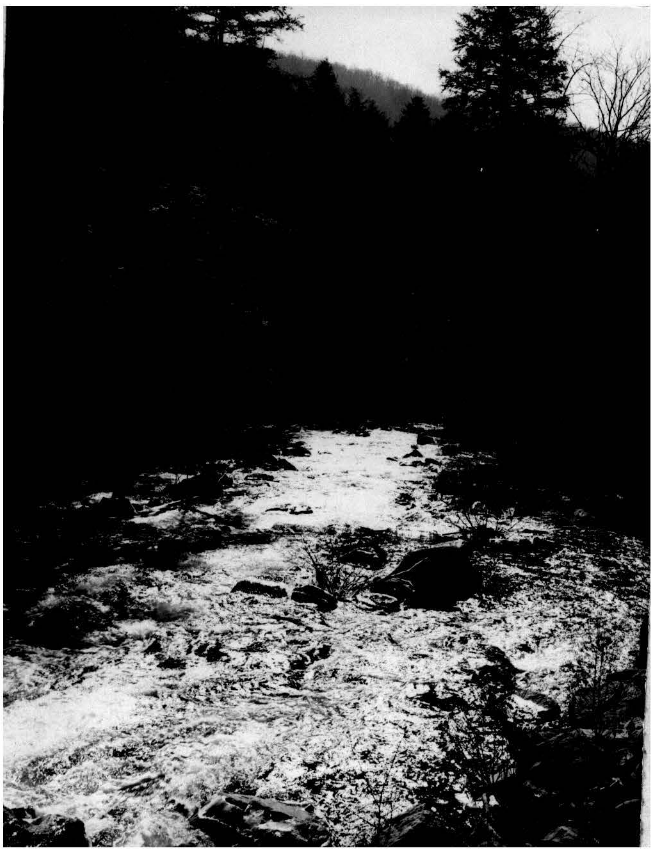


Plate No. 10

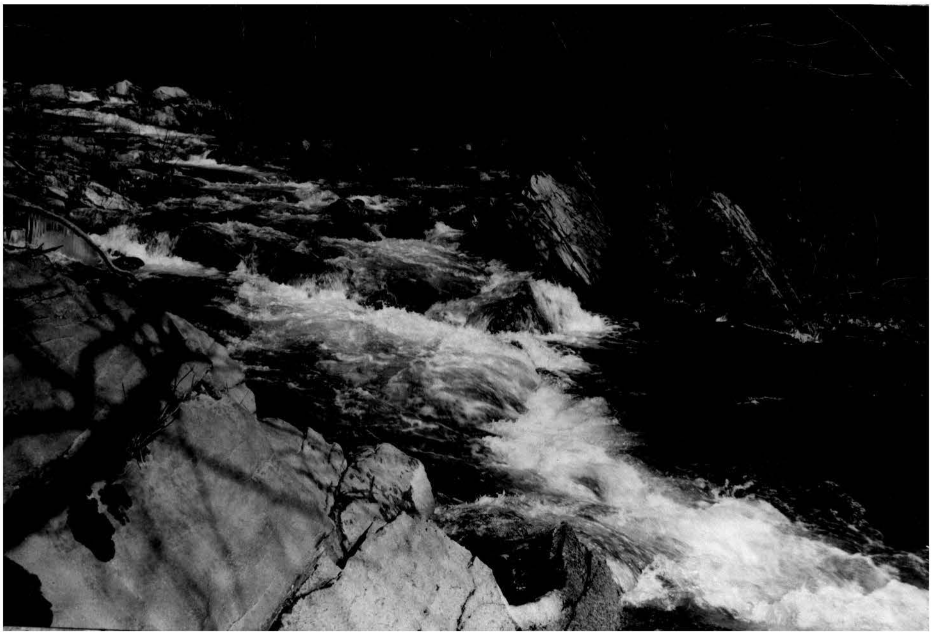
A. Fault zone exposed in road cut at Olean, Virginia.

B. White Rock Mountain fault crossing low ridge north of Olean, Virginia.

Plate No. 11

A. "Keefer" Sandstone along Stony Creek, 0.25 mile northeast of Olean, Virginia.

B. Large block of Tuscarora Sandstone projecting above lake level at north end of Mountain Lake, Virginia.



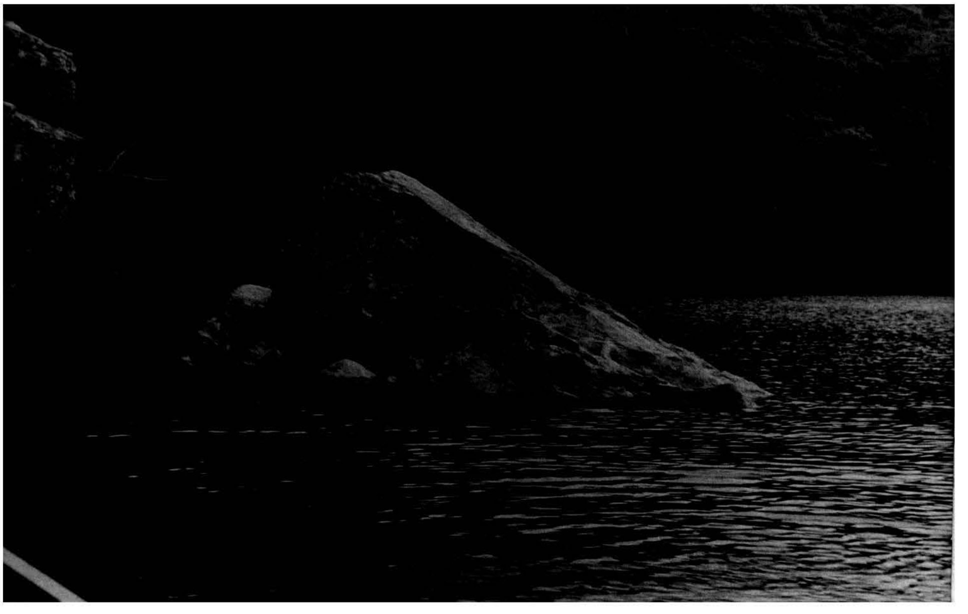


Plate No. 12

Loose blocks of Tuscarora Sandstone on north shore of Mountain Lake, Virginia.

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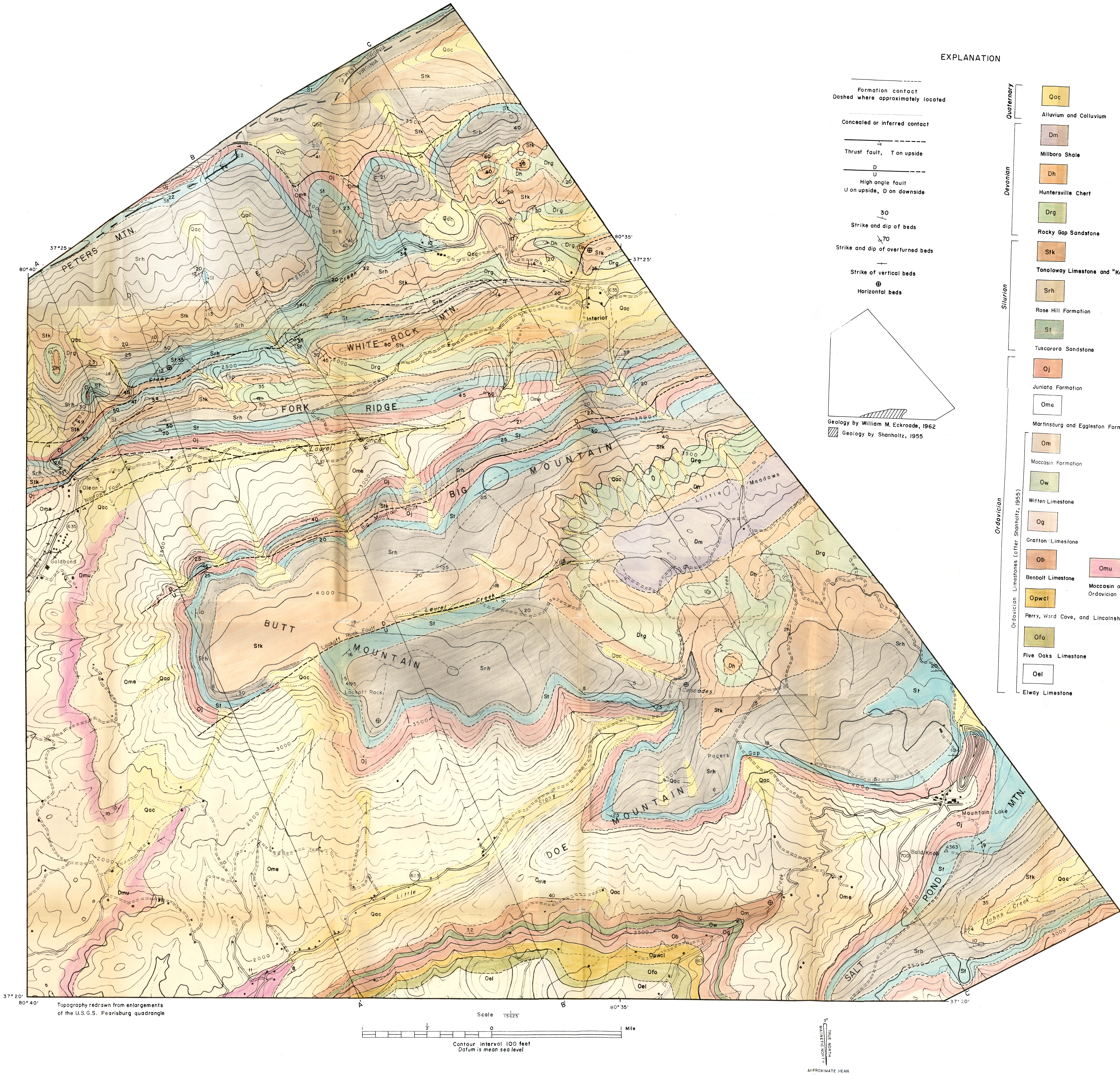
ABSTRACT

The Butt Mountain area is underlain by marine sedimentary rocks of Middle Ordovician to Early Devonian age. The geologic structure in the south part of the area is relatively open and consists of the Mountain Lake anticline and the Butt Mountain synclinorium. Two high-angle faults, downthrown on the northwest, cut the northwest part of the synclinorium. The structure in the north part of the area consists of the overturned Fork Ridge syncline which is faulted on both limbs. The Narrows fault, between the Fork Ridge syncline and the Butt Mountain synclinorium, dies out in the northeast part of the area into the overturned Epling Draft anticline.

Local thickening of the Tuscarora Sandstone between the Lockoff Rock and Big Mountain high angle faults is presented as possible evidence for normal faulting at the time of deposition of Silurian and possibly Late Ordovician strata.

Mountain Lake in the south part of the area was probably formed by accumulation of large blocks and boulders of Tuscarora and possibly "Keefer" sandstones in a deeply eroded resequent stream valley which was completely dammed by filling of interstices by organic matter.

GEOLOGIC MAP OF THE BUTT MOUNTAIN AREA, GILES COUNTY, VIRGINIA



EXPLANATION

Formation contact
Dashed where approximately located

Concealed or inferred contact

Thrust fault, T on upside

High angle fault
U on upside, D on downside

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

Horizontal beds

Geology by William M. Eckroade, 1962

Geology by Shanholtz, 1955

Quaternary

- Qac — Alluvium and Colluvium

Devonian

- Dm — Millboro Shale
- Dh — Huntersville Chert
- Drg — Rocky Gap Sandstone

Silurian

- Stk — Tonoloway Limestone and "Keefer" Sandstone
- Srh — Rose Hill Formation
- St — Tuscarora Sandstone

Ordovician

- Oj — Juniata Formation
- Ome — Martinsburg and Eggleston Formatic

Ordovician Limestones (after Shanholtz, 1955)

- Om — Moccasin Formation
- Ow — Witten Limestone
- Og — Gratton Limestone
- Ob — Benbolt Limestone
- Opwcl — Perry, Ward Cove, and Lincolnshire Limestones
- Ofo — Five Oaks Limestone
- Oel — Elway Limestone
- Omu — Moccasin and Undifferentiated Ordovician Limestones

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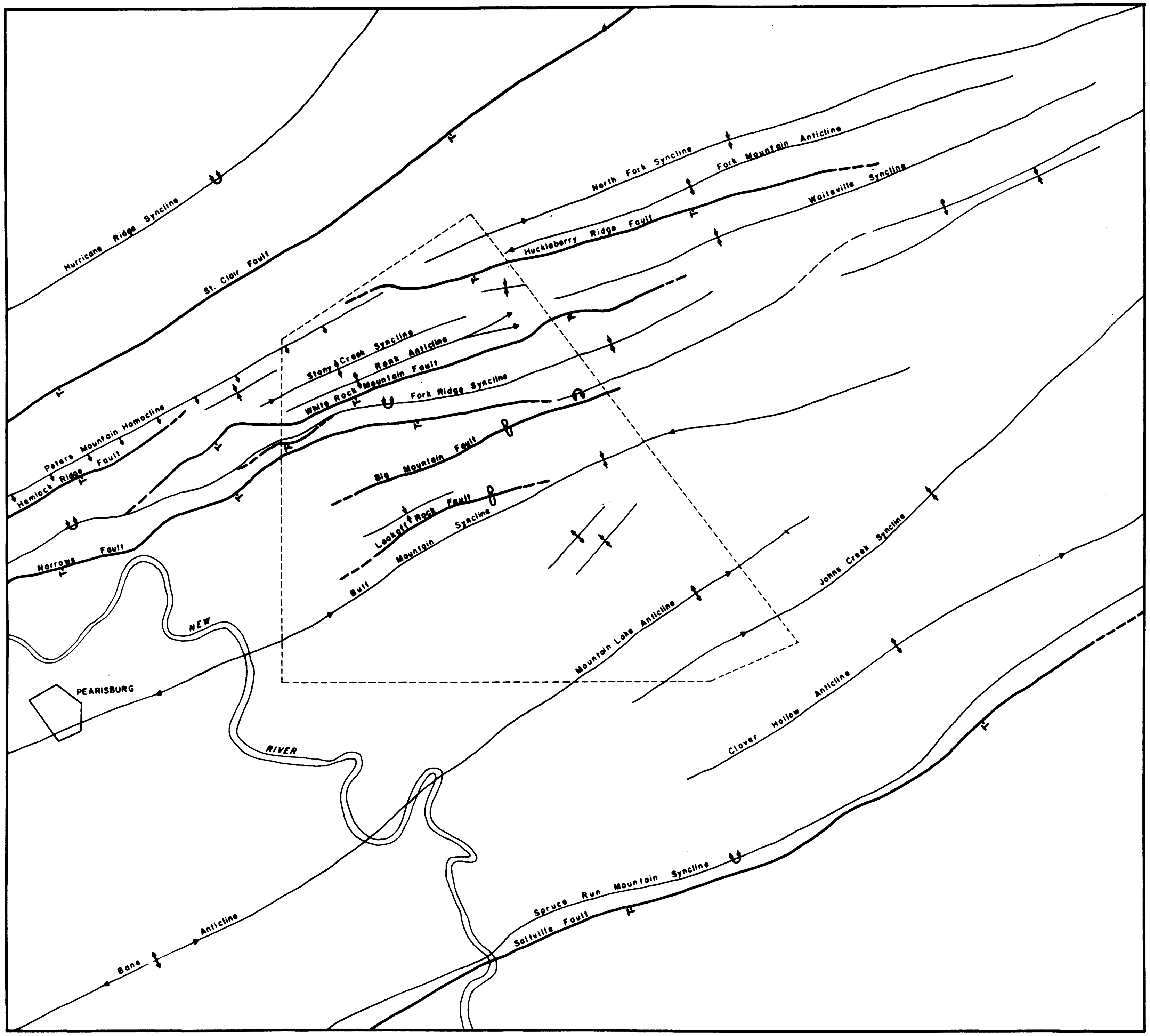

STRUCTURAL INDEX MAP OF THE BUTT MOUNTAIN AREA AND SURROUNDING AREAS

EXPLANATION

Axial trace and plunge of syncline

Axial trace of overturned syncline

Axial trace and plunge of anticline

Axial trace of overturned anticline

Thrust fault, T on upthrown side

High angle or vertical fault, U on upthrown side

1 ½ 0 1 2 3 4 Miles