

GEOLOGY OF THE MILLERS COVE AREA,  
ROANOKE, CRAIG AND MONTGOMERY  
COUNTIES, VIRGINIA

by

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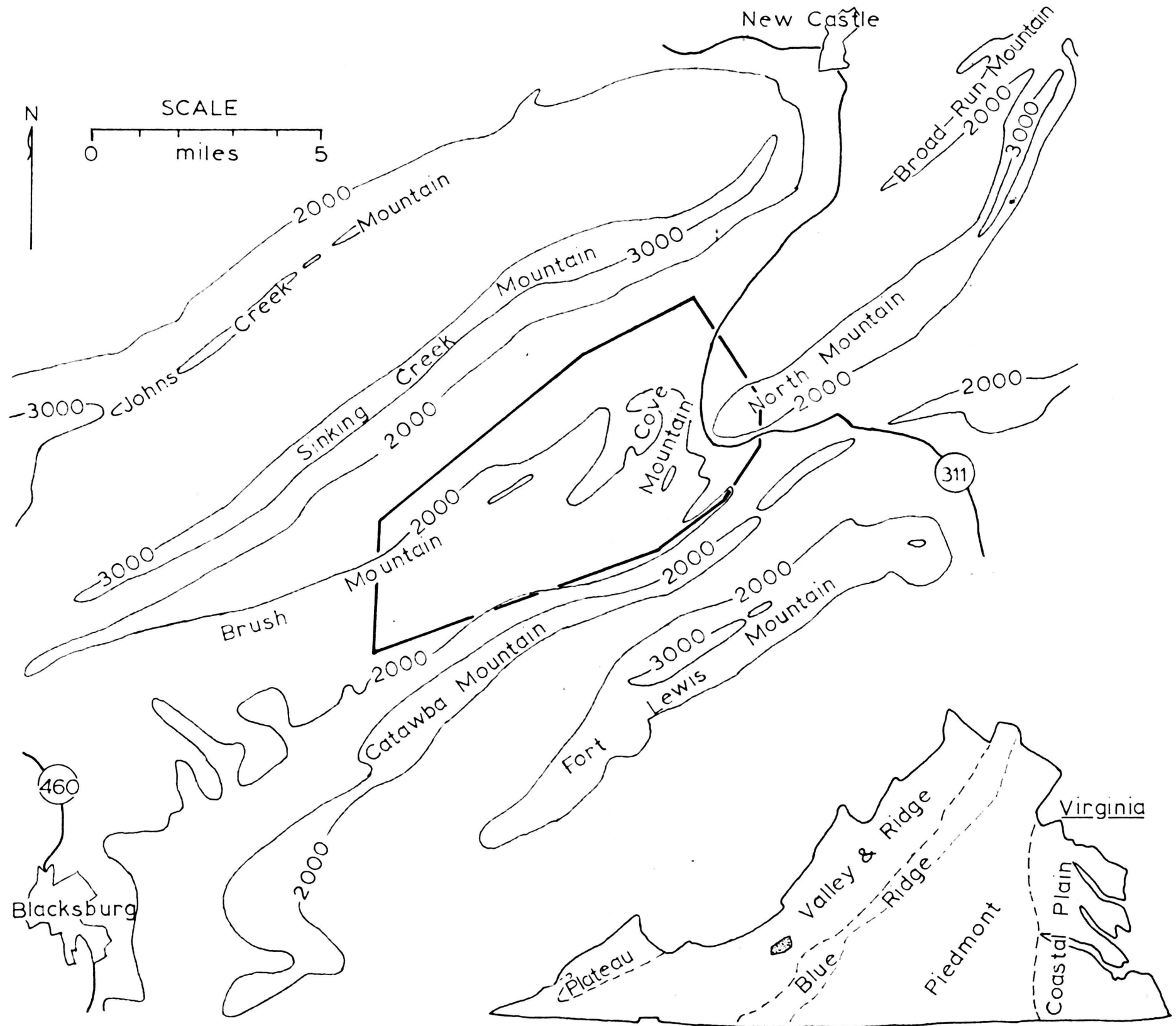
## INTRODUCTION

### Location of the Area

The Millers Cove area (Plates 1 and 2) includes parts of Roanoke, Craig and Montgomery counties, in southwestern Virginia. The area is included within the Glenvar and Looney, Virginia, 7½-minute and the southeast quarter of the 15-minute Waiteville, Virginia, quadrangle sheets of the United States Geological Survey. The area mapped, which is approximately 20 square miles, is roughly triangular in shape. It is about 4 miles wide to the northeast near Virginia Route 311 and tapers to a truncated point southwest of the Montgomery County-Roanoke County line. Most of the woodlands are within the Jefferson National Forest. The Appalachian Trail crosses the area in an east-west direction and follows the crest of Cove Mountain for a short distance.

### Physiography

The Millers Cove area is in the Valley and Ridge Province of the Appalachian Mountains. The highest elevation of 3100 feet is on Brush Mountain which is underlain by Mississippian and Upper Devonian clastics. Offset 3 miles to the east of Brush Mountain is North Mountain (elevation 2900 feet), a parallel ridge, which is also supported by Mississippian and Devonian rocks. Both ridges are synclinal but plunge in opposite directions. Between these two



INDEX MAP - Millers Cove Area, Virginia

ridges is the peculiar central ridge, Cove Mountain, which is shaped like the number "2". The Dragons Tooth, the highest part of Cove Mountain, is formed by an outcrop of Keefer Sandstone near the nose of the Dragons Tooth syncline. The Dragons Tooth is 3050 feet high with the remainder of the ridge about 2500 feet in elevation. The Dragons Tooth provides a superb vantage point for viewing, especially to the southwest and northeast along the valley into which it protrudes. Other ridges in the surrounding region with an elevation of more than 2500 feet include Catawba, Fort Lewis and Sinking Creek mountains. All are supported by resistant sandstones or conglomerates. The total relief of the Millers Cove area is 1700 feet.

Carbonate rocks underlie the lowland between Virginia Route 624 and the foot of Brush Mountain and form the floor of the cove at an elevation of about 2000 feet. Drainage of this lowland is into Craig Creek via Trout Creek and into the North Fork Roanoke River. Underground drainage is extensive along the two major thrust faults and solution openings are common in the carbonate rocks. Colluvial debris covers the southeast slope of Brush Mountain and North Mountain and the slopes of Cove Mountain. The narrow valley containing McAfee Run is underlain by Devonian shale and sandstone and the brook, along much of its course, follows the strike of the bedrock.

### Purpose of the Investigation

The primary purpose was to delineate by means of a detailed geologic map the structure of the Paleozoic rocks in the area bounded by the Pulaski fault on the southeast, by the Miller fault on the northwest and by Virginia Route 311 on the east. Mapping of the adjacent areas was essential for interpreting the structure. Particular attention was devoted to tracing the major faults and axes of major folds. Work in the area along Virginia Route 311 in McAfee Gap was done in order to determine the presence of cross faults.

In order to help determine whether the Millers Cove block is essentially autochthonous or a major slice carried forward by the Pulaski thrust sheet, the stratigraphic succession was studied. The description of measured sections is given in the Appendix. Comparison of the lithology and the thickness of the many stratigraphic units found within the Millers Cove block with those of other areas was made in order to understand better the geologic history of the region. It is not possible to make stratigraphic comparisons along strike to the northeast until one reaches Eagle Rock, 20 miles to the northeast. Similarly, comparisons to the southwest are not possible until one reaches Price Mountain, 20 miles to the southwest, where the character of formations as old as the Middle Ordovician are known from a test well. Comparisons can be made with outcropping formations in the Crockett Cove area, 45 miles southwest of Millers Cove.

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## STRATIGRAPHY

### General Statement

Approximately 10,000 feet of Paleozoic sedimentary rocks are exposed in the Millers Cove area. The oldest formation is the Elbrook Dolomite of Middle Cambrian age and the youngest is the Price Formation of Early Mississippian age. Altogether, 16 stratigraphic units were mapped and 20 stratigraphic units recognized.

The Miller Fault terminates the sequence at the bottom. Rocks younger than the Price Formation probably were present but were either eroded away before faulting or removed during faulting. It is also possible that except for a thin sequence of younger Mississippian rocks removed by thrusting that no younger rocks were ever deposited in this area. This idea is supported by the lack of definite occurrence of either Permian or Pennsylvanian deposits in the entire Valley and Ridge Province in Virginia with the exception of the Pennsylvanian in the Hurricane Ridge Syncline (B.N. Cooper, 1961) and by the occurrence of Mississippian formations as the youngest rocks under many of the thrust faults in the Southern Appalachians of Virginia. Although age relationships in regard to thrust faults may be of great benefit in determining the youngest rocks deposited in a given area, one must assume that thrusting took place not long after deposition and also that no significant amount of

the overridden rock was removed during thrusting.

Correlation of the formations with units outside the mapped area is based mainly on lithology and sequence. Fossils were used in only a few specific cases. All of the formations in Millers Cove older than the Devonian Millboro Shale are not continuous along strike with rocks of the same age outside the area. As a result of this isolation, correlation is more difficult. The Elbrook and Copper Ridge formations occur in both the Miller fault block and the Catawba syncline. Significant lithologic differences between the two areas were not noted.

Although the Millers Cove area is bounded on the northwest by the Miller fault, the block is believed to be para-autochthonous and, thus, the facies represented by the different formations have essentially true geographic relationship with those exposed in the Sinking Creek anticline to the northwest.

In general, the rocks of the lower part of the section are carbonates and those of the middle and upper parts are clastic. Marine rocks predominate but non-marine rocks do occur in the upper part of the sequence.

As already noted, the lower part of the Cambrian System is not exposed. The combined thickness of the Elbrook Dolomite and the Copper Ridge Dolomite is about 2000 feet. Although predominantly dolomite, the Cambrian section does include some limestone, sandstone and chert.

The rocks of the Ordovician System represent a change from dolomite and limestone deposition in the lower and middle part to red shale, red sandstone and interbedded shale, sandstone and limestone deposition in the upper part. The red beds mark a definite change in sedimentation. A major disconformity separates the Lower from the Middle Ordovician. The total sequence is about 3600 feet thick. In ascending order, the formations are the Chepultepec, Upper Knox Interval, New Market, Whistle Creek, Lincolnshire, Effna, Liberty Hall, Bays and Martinsburg formations.

Apparently, the Juniata Formation of Late Ordovician age is missing and the Silurian rests directly on the Martinsburg. Clean quartzitic sandstone, hematitic sandstone and shale characterize the Silurian System. The formations recognized are the Tuscarora Sandstone, the Rose Hill Formation, and the Keefer Sandstone. Together they are about 550 feet thick. The upper part of the Silurian is missing or else represented by sandstones in the Keefer.

The Lower Devonian contains a basal sandstone which is probably the Keyser Sandstone. Although similar to those of the Silurian directly below, there is a distinct change in lithology above this sandstone. The rest of the system contains a sequence which grades upward from shale through siltstone into sandstone. Formations mapped include the Keyser, Millboro, Brallier and Broadford. The aggregate thickness is approximately 4000 feet.

The youngest Paleozoic rocks belong to the Parrott and Price formations of Mississippian age and in this area are, together, only about 1000 feet thick. Red shale, conglomerates and plant-bearing feldspathic sandstones are the dominant lithologies. Although some of the higher Mississippian units have most likely been removed during thrusting, the writer believes that deposition may have ended in the Cove Mountain vicinity in Early to Middle Mississippian time and from that time on this part of the miogeosyncline ceased to exist as a basin of deposition.

The youngest deposits in the area are surficial deposits of alluvium and colluvium. Alluvial deposits of unknown thickness underly the flat floodplain of Craig Creek. The river is presently reworking some of this material but the original time of deposition is unknown. The slopes of Brush, North and Cove mountains are covered by colluvium composed of blocks of sandstone and conglomerate. Although some of this debris is still actively moving downslope, much of the deposit may be the result of severe weathering during the Pleistocene (B.N. Cooper, 1961). Old gullies, filled with this debris, now stand out as sinuous ridges running down the slopes of these mountains. One small hill on the northeastern slope of Cove Mountain overlooking Virginia Route 311 is clad with this resistant material. At one time this hill was part of the talus slope of Cove Mountain but the mountain has since been lowered and a saddle developed between them. At the

present time this hill is by-passed by the fresh debris and remains as an anomolous high on an otherwise even shale slope.

### Cambrian System

Elbrook Dolomite. - The oldest formation exposed in the area is the Late Cambrian Elbrook Dolomite. This formation name is applied, in this report, to those rocks which underlie the basal sandstone of the Copper Ridge Dolomite in both the Millers Cove area and the Catawba syncline. The lowest outcrop of the formation in both places is bounded by a fault and therefore, the original thickness of the unit is not known. Nearly 700 feet of Elbrook Dolomite is present in the southeast flank of the Cove Mountain anticline (see Geologic Section 1 in Appendix) yet the maximum thickness for the whole Miller fault block is probably greater.

Lack of shale equivalent to the Nolichucky Formation or of a change from gray Knox dolomites above to blue-gray, calcite-veined Elbrook dolomites below made necessary an arbitrary delineation of the Copper Ridge-Elbrook contact. The writer chose the bottom of the lowest sandstone in the Copper Ridge Formation as the boundary. Below this sandstone, sand grains seem to be absent from the dolomites and chert is reduced to sporadic occurrence. This boundary is probably close to the actual boundary if the basal sandstone in Millers Cove is considered to be of essentially the same age as the basal sandstone in the Catawba syncline of the Pulaski block. Derby (1965) found Nolichucky trilobites (Llanoaspis, Pemphigaspis and Terranovella) below a basal sandstone and Aronson (1966) reported an inarticulate brachiopod in a shaly dolomite a few

feet below a basal sandstone of the Copper Ridge Dolomite. Both fossil localities are in the Pulaski fault block not far from the Miller fault block.

Except for the bottom 70 feet of Geologic Section 1, where fractured limestone and dolomite are present, the dolomite of the Elbrook is not fractured and it is not blue-gray in any part of the section. Shale is also absent from the Elbrook in this area. Thus, this Elbrook lithology does not fit well the descriptions of Woodward (1932) or Butts (1940). In fact, many of the dolomites are not unlike those of the overlying Knox Group.

The Elbrook Dolomite of the Millers Cove area is composed mostly of gray slabby dolomite with some limestone near the bottom of the section. Similar dolomites and limestones are also present in the hanging wall of the Pulaski fault to the southwest. Exposures of limestone about 20 feet above the Pulaski fault contain some interesting sedimentary structures including oolitic beds, cryptozoan algal heads, stylolitic seams and small pre-lithification slump faults of restricted vertical extent. Abundant cryptozoan algal structures are also present in the dolomites of Millers Cove. Lack of chert or sandstone in the Elbrook Dolomite is striking in contrast with the overlying Copper Ridge Dolomite.

Copper Ridge Dolomite. - The Copper Ridge Dolomite, the oldest formation in the Knox Group, crops out in a long hooked

belt within Millers Cove. It also is present above the Elbrook Dolomite in the Pulaski fault block on the southeast. The lower sandstone unit forms a linear ridge which is easily followed on the topographic map. Sandstones and chert beds near the contact with the overlying Chepultepec Limestone form a break-in-slope which is of help in mapping. The two thin sandstone intervals, together with the Chepultepec Limestone and the thick chert beds associated with the thin Longview limestone, form the basis for subdivision and delineation of the predominantly dolomitic Knox Group.

The contact between the Copper Ridge Dolomite and overlying Chepultepec Limestone is well exposed in many places and the abrupt change from predominant dolomite to predominant limestone is readily ascertainable. At the creek near Virginia Route 704 the highest sandstone bed in the Copper Ridge Dolomite is 17 feet below the first limestone of the Chepultepec Limestone (see Geologic Section 3, Appendix). This lowest dolomite-limestone change above the highest sandstone is used as the upper contact even though some thin dolomites occur as much as 35 feet above this change. The dolomite-limestone transition is found in the field even though the upper sandstone interval itself is more easily followed topographically. Although this contact is probably facies controlled, it is assumed that in an area as small as Millers Cove the boundary is approximately time equivalent.

The Copper Ridge Dolomite in the Millers Cove area is 709 feet thick (see Geologic Section 2, Appendix). Five major subdivisions are recognizable. From oldest to youngest these are: 1) a lower sandstone interval, 43 feet; 2) a lower cherty dolomite interval, 369 feet; 3) a limestone interval, 80 feet; 4) an upper cherty dolomite interval, 193 feet; and 5) an upper sandstone interval, 24 feet. Upper and lower cherty dolomite intervals are similar and difficult to distinguish because the intervening limestone unit is not well exposed and is difficult to locate in places. An 8-foot thick unit of tan crossbedded feldspathic sandstone is present in the lower sandstone unit. In contrast, the sandstone beds of the upper sandstone interval are not thicker than one or two feet. Sandstones in both intervals are usually friable, probably as a result of leaching out of the original carbonate or silica cement. Because of its friability, sandstone float does not move far from the outcrop before it completely disintegrates into sand. Thus, the presence of sandstone float on a low, narrow crest is indicative that the sandstone bed is present beneath the soil.

Most of the Copper Ridge is a gray, fine-to medium-grained, slabby dolomite. The chert within the dolomite is gray or whitish and occurs mostly as masses which range in size from less than an inch to a few inches. Cauliflower chert is also common in the lower cherty dolomite interval. Most nodules are about an inch across and have a center

filled with sparry calcite. Thick masses of algal and oolitic chert are present about 20 feet above the basal sandstone in the lower sandstone interval but the chert bed is not continuous over the whole area. Individual algal heads in the chert are 3 inches across and masses are about a foot across. Oolitic chert is made up of ooids with a dark rim and a white or light gray interior. The ooids are spheroidal and are about 1 mm in diameter.

Another interesting feature of the dolomites is the presence of sparry calcite masses up to 2 inches in size. The occurrence of the calcite along fractures indicates a post-dolomitization precipitation of calcite possibly during expulsion of water during compaction or from water moving downward along fractures into consolidated rock.

## Ordovician System

Chepultepec Formation. - The Chepultepec Formation, in this area, is 168 feet thick (Geologic Section 3, Appendix) and consists primarily of limestone. The lower contact with the Copper Ridge Dolomite is located on the basis of an abrupt change in lithology from a predominance of dolomite to a predominance of limestone. Similarly, the upper contact with the post-Chepultepec part of the Knox Group is located on the basis of an abrupt loss of limestone and reappearance of dolomite. Numerous small sinkholes mark the outcrop belt of the Chepultepec Formation.

There is no evidence of an unconformity between the Cambrian System and the Ordovician System. Limestone conglomerates in the Chepultepec are entirely intraformational and do not represent a major hiatus or major marine transgression. The systemic boundary is located below the Finkelburgia horizon which is thought to be Ordovician. Tellerina, an Upper Cambrian fossil, occurs near the upper sandstone interval of the Copper Ridge Dolomite in the Pulaski fault block on Virginia Route 785. If the upper sandstone interval of the Copper Ridge Dolomite of Millers Cove block is the same age as those of the Pulaski fault block, then the Cambrian-Ordovician boundary is above it. On this basis, the boundary is between the Upper Copper Ridge sandstone interval and the lowest occurrence of Finkelburgia

in the Chepultepec Limestone and for want of any other evidence is placed at the contact between the two formations.

Most of the Chepultepec consists of light blue, fine-grained limestones, but limestone conglomerates, oolitic limestones and algal limestones are also present (Plate 5). Dolomites occur near the contacts with the underlying and overlying formations. A few beds of partially silicified oolitic chert, some nodular black chert and some grayish bedded chert complete the diverse assortment of rocks.

Upper Knox Interval. - The entire 500 feet of rock overlying the Chepultepec Formation and beneath Middle Ordovician rock is mapped as Upper Knox. Overlying the Chepultepec Formation is 279 feet of gray medium-grained dolomite. The upper 50 feet contains some distinctive light gray, coarse-grained dolomite which reacts slightly to acid. The thick dolomite section is overlain by 25 feet of limestones and interbedded dolomite which probably represents the Longview Limestone. Lecanospira was found in the limestone at one locality. Lithologically, the limestones are light blue to blue-gray calcilutites and are similar lithologically to the limestones in the New Market.

Above the presumed Longview Limestone is a 200-foot section of dolomite with massive light gray chert beds. These beds of chert are relatively persistent and some can be traced but others do thin and disappear. Some of these beds

Plate 5



Algal structure in Chepultepec Limestone near Virginia Route 704. The material filling the spaces between algal masses is argillaceous limestone and usually contains sparry calcite up to 3 inches across.

are as much as 5 feet thick and three such chert beds are found in well exposed sections.

The thickness of the Upper Knox Interval is dependent on the amount of relief on the surface of the unconformity between the Knox Group and the Middle Ordovician Limestones. The thick gray chert beds in the Upper Knox are good reference horizons for calculating the relief on the surface of unconformity. However, care must be used in order to insure that the same chert bed is used when measuring sections.

Knox - Middle Ordovician Disconformity. - Following the deposition of the shallow water dolomites of the Upper Knox, the sea floor was exposed and an uneven surface of erosion was developed on the top of the Knox Group. Measured sections using a chert bed in the Knox as a reference horizon reveal that within a distance of 1000 feet along strike the relief on the surface of unconformity is at least 138 feet. At the contact itself the rocks are "welded" so that they will break across the unconformity rather than along it. At a few places a porous chert was found separating the Knox Dolomite from the overlying New Market Limestone.

New Market Limestone. - A gray sparry calcilutite, the New Market Limestone, lies on the surface of unconformity at most places. No conglomerates or clastics were found at the unconformity although they do occur higher in the New

Market. The limestone is thick bedded and ranges in thickness from 0 to 62 feet (see Geologic Section 4, Appendix).

Whistle Creek-Lincolnshire Formations. - These two formations are grouped together because no lithologic criteria were found to separate them during field work. A silicified brachiopod Valcourea austrina has been identified from near the bottom of this unit in a conglomerate bed. This same fossil is reported by Gilbert (1953) from near Ellett, Virginia in the Whistle Creek Formation. Cephalopods, up to 12 inches long, some partially silicified brachiopods, and abundant bryozoans constitute the rest of the faunal assemblage. The interval ranges in thickness between 194 and 105 feet (see Geologic Section 4, Appendix). Lithologically, it is a medium gray to medium light gray, medium-grained, thin- to medium-bedded, in part argillaceous limestone with small black chert nodules in stringers. Much of the rock contains bryozoans, some of which are unbroken and may be still in place.

Effna Limestone. - A 10-to 20-foot interval of coarse, light pinkish-gray limestone overlies the Lincolnshire Limestone. When struck, it gives off a petroliferous odor. Trilobite fragments, Bumastus sp., are common and where their shell material is pink they give the rocks a pink tint.

Liberty Hall Formation. - Approximately 600 feet of dark blue-black, fine-grained limestone which weathers to a punky shale overlies the Effna Limestone in Millers Cove. Near the base is about 10 feet of argillaceous limestone containing abundant large black chert nodules. No shale beds, such as characterize the Liberty Hall of the Catawba syncline of the Pulaski fault block to the southeast, are present. The trilobites Bumastus and Cryptolithus and a few graptolites comprise the fauna found in the Liberty Hall of Millers Cove. The bottom contact appears conformable but the upper contact is marked by a disconformity.

This formation is one of the least competent units in the section. Thrust faults terminate or lose displacement in this unit. The formation is also found adjacent to the Pulaski Fault along Virginia Route 620 and beneath a branch of the Millers fault in the overturned northwest limb of the Cove Mountain anticline.

Bays Formation. - A disconformable contact separates the Liberty Hall and Bays formations. A channel 7 feet deep and 50 feet wide was cut into the Liberty Hall during deposition of the basal Bays Formation. The channel is filled with a conglomerate consisting of reworked Liberty Hall Limestone clasts set in a matrix of argillaceous material. Two pulses of current are inferred to have scoured out the channel and deposited the two cycles of reworked clasts in a graded se-

quence as the currents waned. The largest clast is 10 inches long and 3 inches high (see Plate 6). The time interval represented by this erosional unconformity is probably small.

Red, gray and yellow siltstones and sandstones comprise most of the 192 feet of the Bays Formation (See Geologic Section 5, Appendix). At least two bentonites are present in the section. Linguloid brachiopods are present in the uppermost part of the Bays Formation. A thin bed on the overturned southeast limb of the Dragons Tooth Syncline on Virginia Route 620 contains ostracods. A cephalopod in a piece of Bays rock was brought to the surface during boring of holes for support cables for a high tension tower just west of Virginia Route 620.

Martinsburg Formation. - The 1200-foot thick Martinsburg Formation is a diverse group of rocks. It consists of fossiliferous limestone, limy shale, siltstones and some sandstones. The section is very poorly exposed because it underlies slopes covered by debris from Silurian sandstones. In the upper part of the section a drab brown Lingula-rich siltstone is present. This lithology is similar to the top of the Martinsburg on Virginia Route 311 on Catawba Mountain to the southeast. The Juniata Formation is apparently missing in the Millers Cove area and presumably was eroded off, although, conceivably, it may never have been deposited.

Plate 6



Channel-fill conglomerate at base of Bays Formation near intersection of Virginia Routes 620 and 701, containing large angular clast of reworked Liberty Hall limestone. Hammer marks contact between Bays conglomerate and the underlying Liberty Hall Formation.

## Silurian System

Tuscarora Sandstone. - The Tuscarora Sandstone is a light gray, medium-grained, medium-bedded quartzite whose thickness is at least 162 feet (see Geologic Section 6, Appendix). In the Millers Cove area it is thinner, coarser, more indurated and contains less red or orange discoloration than the Keefer Sandstone. The largest clasts in the Tuscarora were found in a loose block of conglomerate. These clasts are subrounded vein quartz and measure more than an inch across.

Rose Hill Formation. - The Rose Hill Formation is 78 feet thick and consists of maroon hematite-cemented sandstones and interbedded fine-grained brown siltstone (see Geologic Section 6, Appendix). The thickest sandstone interval measured 15 feet. The formation is not well exposed in most places because it is found in low colluvium-filled gaps between resistant quartzitic sandstones.

Keefer Sandstone. - The Keefer Sandstone is 300 feet thick and is largely orange, pink or light gray, medium-grained sandstone with a few light orange and gray quartzites also present. Most of the formation is medium-bedded and covered intervals are small and the result of weathering away of thin-bedded sandstone. Apparently, the sandstones continue up into the overlying Keyser Sandstone without any

intervening lithology. If so, it would appear that either the Tonoloway, Wills Creek, McKenzie and Rochester formations are represented by the thick Keefer Sandstone or that they were eroded away prior to the deposition of the Keyser Sandstone. A somewhat more friable and thin-bedded upper part of the Keefer forms a covered interval in most places directly below the contact with the Keyser.

## Devonian System

Keyser Sandstone. - The Keyser Sandstone is a friable, porous, poorly sorted, red stained and gray sandstone. The identification of this formation is based on its lithologic similarity with probable Keyser Sandstone of the New Castle area. Bryozoan and crinoidal molds are present in some parts of the sandstone and help in distinguishing it from the quite similar thick sandstones of the underlying Keefer Sandstone. The Keyser Sandstone is about 30 feet thick. In this report the Keyser Sandstone is placed in the Devonian System but faunal evidence supporting this classification was not found and the Keyser may be at least partly Silurian in age.

Millboro Shale. - About 1000 feet of blue-black shale is included in the Millboro Shale. The lower part of the section contains some red and brown shale and thin fine-grained sandstone. The lowest part of the sequence is a punky, drab gray mudstone containing ostracods, brachiopods and the trilobites Phacops and Acidaspis. This drab gray shale interval may be equivalent to the Needmore Shale.

Brallier Formation. - Approximately 2500 feet of tan and reddish-brown sandstone, siltstone and shale comprise the Brallier Formation in the Millers Cove area. The contact with the underlying Millboro Shale is based on the first occurrence of thick siltstone beds. The thickness and per-

centage of sandstone beds increase upward in the section.

One limestone bed was found in Trout Creek. It was composed mainly of gastropods.

Broadford Formation. - The Broadford Formation is used instead of the Chemung Formation of earlier reports because the Broadford is in part younger than the type Chemung (Glover, 1953). The contact was drawn at the start of the almost continuous sequence of massive brown sandstone and siltstone beds. It is estimated to be 750 feet thick.

## Mississippian System

Rocks of Mississippian age are shown as a single unit on the map. Presumably, both the Parrott and Price formations of Early Mississippian age are present. Together, they comprise about a 1000-foot section with the Parrott much thinner than the Price. The Parrott is the older unit and is a maroon and olive green, thin-bedded and flaggy siltstone. It is at least 100 feet thick but its exact thickness is unknown because it is difficult to determine the boundary with the underlying Broadford Formation. The Price Sandstone is about 800 feet thick. In one measured section (see Geologic Section 7, Appendix) 300 feet of Price was noted. Part of the top of the Price is missing and none of the coals, which are present in the Price a few miles to the southwest along Brush Mountain, were found. The Price Sandstone is mostly tan, medium- to fine-grained sandstone. The Cloyd Conglomerate Member near the bottom contains at least three conglomerate beds of different thickness. A few tan sandstones and quartzites stained into a liesegang pattern are also present. Only a few wood fragments are found in the lower part of the Price.

## STRUCTURAL GEOLOGY

### Structural Setting

Cove Mountain is part of the Cove Mountain anticline and Dragons Tooth syncline (Plate 7 and Plate 4, structure section D-D'). Both folds plunge to the northeast. Investigation led to the conclusion that the Dragons Tooth syncline is continuous with the North Mountain syncline. A thrust fault, the Miller fault, separates the Millers Cove area from the essentially autochthonous Brush Mountain-Little Mountain syncline which plunges southwest. Thus the Cove Mountain anticline is a structural high between two synclines which plunge in opposite directions away from the high.

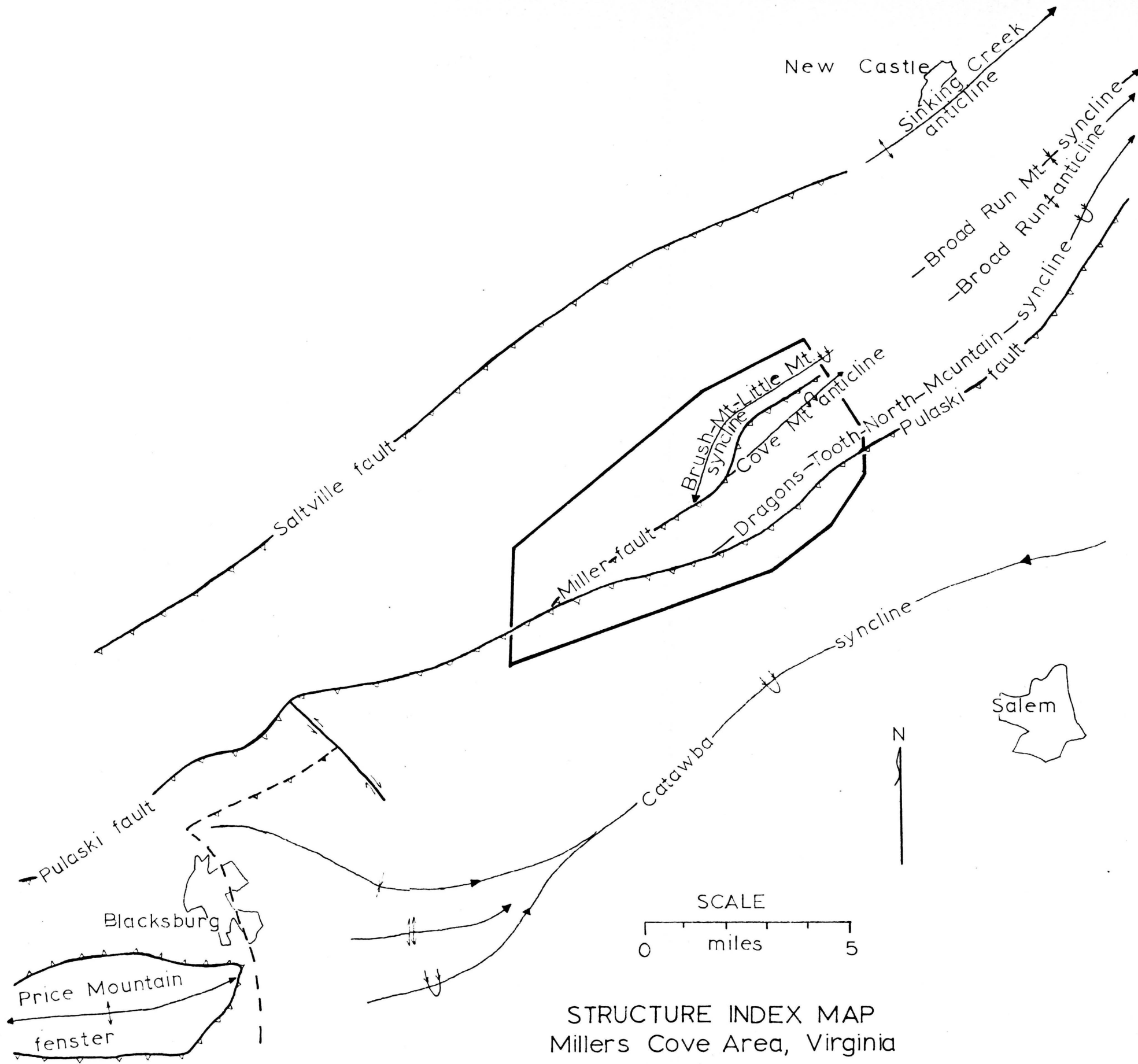
The Millers Cove area is adjacent, on the northwest, to the large doubly plunging Catawba syncline from which it is separated by the Pulaski fault. The Miller fault terminates within the study area; its southwest extent is unknown because it passes under the Pulaski fault. Northwest of the Brush Mountain-Little Mountain syncline is the Sinking Creek anticline whose axial portion is sheared by the Saltville fault.

### Cove Mountain Anticline

The Cove Mountain anticline is a steeply northeasterly plunging structure that has been mapped southwest of Virginia Route 311 but whose extent to the east is unknown. Its plunge is  $60^{\circ}$  to the northeast. Possibly, the anticline is continuous with the northeasterly plunging anticline (see Plate 7) of the Broad Run river valley (Woodward, 1932).

Adjacent on the southeast is the complementary structure, the Dragons Tooth syncline, which also plunges to the northeast. As already noted, the anticline is bounded on the west by the Miller fault, which separates it from the southwesterly plunging Brush Mountain-Little Mountain syncline. This fault, located near the crest of the anticline, cuts out the northwest limb between the point where the anticline first appears from beneath the Pulaski fault northeast, almost, to the intersection of Trout Creek and Virginia Route 620. At this latter point, the steeply dipping overturned northwestern limb of Silurian sandstones may have caused a deflection of the Miller fault away from the axial trace of the fold thereby exposing the entire overturned limb. Another fault branches off the Miller fault (Plate 1) and separates the overturned limb from the rest of the structure (see Structure Sections C-C', D-D' and F-F' in pocket). This branch fault dies out in the incompetent Liberty Hall Shale inside the cove.

An interpretation encompassing two different directions of deformation is inferred from evidence in the region of



STRUCTURE INDEX MAP  
Millers Cove Area, Virginia

the anticlinal nose. A relic of one deformation is the trace of an axis which separates the overturned and normally dipping beds of the Bays and younger units. This axis may have been the original fold axis of the anticline. A second axis separates overturned from normally dipping beds in the pre-Bays part of the section. The two axes are offset and are therefore thought to be the result of two different deformations acting at different times and along slightly different directions. The second axis may be related to thrusting with the deforming force acting at right angles to the direction of fault movement. Bays and younger units were not as greatly affected during thrusting because of the incompetent Liberty Hall that absorbed much of the force.

#### Dragons Tooth-North Mountain Syncline

This structure has been previously called both the Craig Creek syncline and the North Mountain syncline (Campbell, 1925, Woodward, 1932). The name Craig Creek syncline should be abandoned because the axis of the syncline lies far to the southeast of Craig Creek and because of the presence of the Brush Mountain syncline and the Cove Mountain anticline between Craig Creek and the syncline. The writer follows the usage of Woodward (1932) who refers to the syncline northeast of Virginia Route 311 as the North Mountain syncline. Woodward shows the North Mountain syncline to be separated from the Dragons Tooth syncline by a fault. However, work

by the present writer indicates that the North Mountain syncline is continuous with the Dragons Tooth syncline and that no fault is present. This interpretation is supported by the following field observations along Virginia Route 311: 1) the Millboro--Brallier contact can be traced without offset across Virginia Route 311, 2) The axis of the syncline is continuous across the supposed fault, 3) dip and strike readings are consistent on both sides of Virginia Route 311, 4) the plunge of the synclines is in the same direction, 5) Structure Section F-F' (Plate 4) shows a complete sequence of formations of appropriate thicknesses. The Dragons Tooth syncline, as used in this report, will refer only to that part of the plunging syncline southwest of Virginia Route 311.

The axial trace of the Dragons Tooth-North Mountain syncline is highly irregular. At the nose formed by the plunge of the Bays Formation, the syncline bifurcates and forms two synclines separated by a small anticline (see Plate 8). Over much of the area it is difficult to locate the actual axis because of its proximity to the highly overturned southeastern limb and because of the relatively high relief of the area.

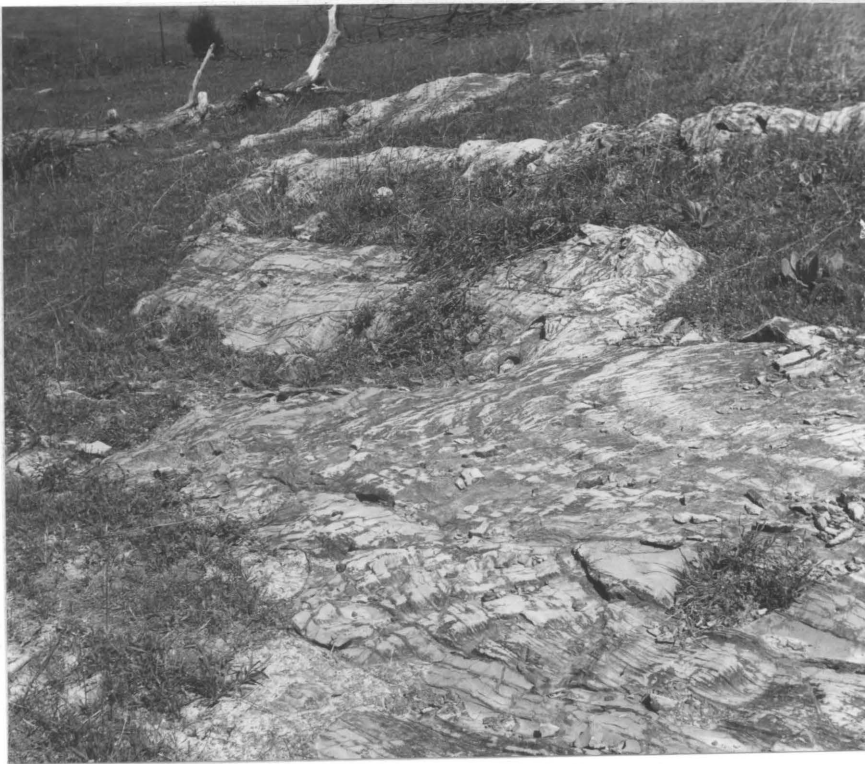
One observes, from the map, that the trend of the synclinal structure, upon approaching the fault trace, tends to conform to the trace of the fault. This effect is probably the result of overriding by the Pulaski fault block which deformed the underlying rocks so as to make them conform to

the attitude of the fault plane. This was only partially accomplished since the entire southeastern limb of the syncline passes obliquely under the Pulaski fault. During overthrusting, rocks beneath or in front of the thrust were more strongly deformed if they dipped in a direction opposite to that of the Pulaski fault plane. Thus, along the northeastern part of the Pulaski fault, where it is in contact with northwesterly dipping formations, the formations are overturned, cross-faulted, tectonically thinned and some of these formations are wedged out. The Silurian sandstones thin and thicken along the overturned limb. The unevenness of the ridge crest and the frequent saddles are the result of this irregular change in thickness. Just short of where they would pass under the Pulaski fault, the Silurian sandstones are completely missing. A similar situation occurs on the overturned northwest limb of the Cove Mountain anticline (see Plate 9).

In contrast, along the southwest part of the Pulaski fault, the fault overlies the western limb of the syncline and bedding and fault plane both dip toward the southeast. As a result, there is no detectable thinning of the formations and the deformation resulting from overthrusting is minor compared with that along strike to the northeast.

The effect of the Pulaski fault on the underlying rocks has produced a situation in which, with the exception of a few small areas, it is possible in certain places to traverse

Plate 8



Liberty Hall limestone folded into two small synclines and intervening anticline. Also note small fault in foreground and suggestion of axial plane cleavage in nearest syncline. These folds are located along axis of the Dragons Tooth syncline near Virginia Route 701.

Plate 9



Three foot thick Silurian sandstone which is all that remains of the entire Silurian System of overturned northwestern limb of the Cove Mountain anticline along Virginia Route 620. The view is to the northeast along strike. In the background is a small rise held up by a somewhat thicker section of sandstone.

the entire area between the Pulaski fault and Miller fault - crossing a syncline and an anticline - without finding any beds dipping to the northwest.

#### Brush Mountain-Little Mountain Syncline

The Brush Mountain-Little Mountain syncline is a southwest plunging structure whose axial trace is irregular. The oldest formation exposed in the axial portion of this syncline in the area studied is the Devonian Millboro Shale. The youngest formation in the area mapped is the Price Formation. Lowry (oral communication, 1965) believes that the top of the section in the Price along the U.S. Forest Service road up Brush Mountain is just below the lowest coal bed as known farther southwest. Campbell (1925) reports that the lowest bed of coal is covered by the Pulaski fault southwest of the point where the Miller fault appears from under the Pulaski fault. The writer has not seen any coal along the Miller fault but a resident said that coal was worked by a blacksmith in the days of his father.

Farther to the southwest, along Brush Mountain, younger and younger parts of the Price Formation are present and in the New River gorge, the overlying Stroubles Formation is present (Cooper, 1961). This decrease in age of the units may be the result of younger beds being present farther down plunge in the syncline.

The western limb of this syncline forms Brush Mountain.

The crest of the mountain is sinuous and variable in height. Some of this irregularity is probably related to small folds such as one present along the U.S. Forest Service road or to the presence of small faults. A large part, however, is the result of the outcrop pattern of the Cloyd Conglomerate member of the Price Formation. The thickest conglomerate crops out as the highest unit in flatirons that occur near the crest of the ridge. The actual trace of the highest part of the ridge follows the apex of these flatirons until they are incised by a stream whereupon the crest line follows the outcrop of a sandstone below the Cloyd Conglomerate member.

Within the Miller Cove area the axis of the Brush Mountain-Little Mountain syncline appears from under the Miller fault and the termination of Brush Mountain is the result of the southwest plunge of this axis. Shortly after appearing from under the Miller fault, the axial plane strikes  $N.20^{\circ}E.$  and cuts across Trout Creek at a highly oblique angle. The structure plunges at a maximum angle of  $5^{\circ}$  to  $7^{\circ}$  to the southwest. Within 2.5 miles to the northeast the strike of the axis changes to  $N.50^{\circ}E.$  and continues along the crest of Little Mountain.

The termination of Little Mountain is the result of loss of Brallier Formation up plunge to the northeast. Beyond this point, the extension of the axis is unknown. Possibly, this structure and the adjacent Cove Mountain anticline are continuous with the syncline and anticline just west of North

Mountain about 5 miles farther to the northeast. Woodward (1932) notes that the syncline forming Broad Run Mountain has Chemung along its axis. This was previously identified as Silurian by Holden (Campbell and others, 1925). Broad Run river valley occupies the axial portion of the anticline which is the possible extension of Cove Mountain anticline.

One serious objection to postulating that Brush Mountain-Little Mountain syncline and Broad Run syncline are actually the same structure is that they do not plunge in the same direction. Moreover, the structures adjacent to the southeast all plunge to the northeast in the same direction as the Broad Mountain syncline. The southwest plunge of the Brush Mountain syncline may be primary and related to the original folding of the strata or it may be a secondary feature which has been imposed on an original northwest plunge during faulting. In this latter hypothesis, the syncline would have been depressed by the Pulaski and Miller fault blocks which overrode the structure. As a result, the syncline's plunge would have been reversed so that now it plunges to the southwest. Careful tracing of the Miller fault and the synclinal axis northeastward along strike might corroborate this hypothesis if the plunge of the syncline reverses in the same locality where the fault dies out.

The eastern limb of the Brush Mountain-Little Mountain syncline is missing in the southwest part of the area and where it is present, it is thin. It is overturned adjacent

to the Miller fault but decreases in dip closer to the axial trace. The decrease in dip may be the result of either of two possible conditions. The fault never overrode the syncline much beyond where it now is, or erosion has removed the overturned beds above the syncline because they were topographically higher up.

#### Miller Fault

The fault herein referred to as the Miller fault was first mapped by Holden (Campbell and others, 1925). As then mapped, the fault emerged from under the Pulaski fault and continued adjacent to Brush Mountain and finally passed into Devonian age rocks, dying out in the vicinity of New Castle. The present writer's interpretation is similar except that he has not mapped the fault farther northeast than Virginia Route 311 nor has he been able to locate the fault trace once it has passed completely into the Devonian Millboro Shale. It is possible that the fault terminates in the mapped area or soon after crossing Virginia Route 311.

The trace of the Miller fault along Brush Mountain was determined, in large part, by stereographic interpretation of aerial photographs (scale of 1:9,6000 and 1:24,000). Mississippian age rocks form prominent flatirons below which the slope is low and covered with talus. This break-in-slope seems to be geologically determined and is interpreted as delineating the thrust contact between Cambrian dolomites and Mississippian sandstones and shales.

Northeast of Brush Mountain the strata on both sides of the fault rapidly approach each other in age until the entire sequence is present with the exception of a small interval of Millboro Shale. Along Virginia Route 311, the Millboro Shale seems to be at its full thickness and the fault cannot be located and is thus inferred to be absent.

Stratigraphic displacement on the Miller fault decreases continuously to the northeast from 10,000 feet at the place where the fault emerges from under the Pulaski fault to less than 1,000 feet in the area in which it is last mappable. The actual loss of displacement is not the result of change in the age of the beds on only one side of a fault. Instead, there is a definite change in age on both sides, with the beds in the essentially autochthonous block on the northwest becoming older as those of the allochthonous block become younger.

Along most of the length of the Miller fault and its branch fault there is stratigraphic control on the location of the shear plane. Adjacent to Brush Mountain, the Miller fault cuts the Elbrook Dolomite at a stratigraphic distance of between 700 to 1,000 feet below the basal sandstone marker bed in the Copper Ridge Dolomite. Within the cove the branch fault can be accurately mapped and is also located in the Elbrook Dolomite along a major part of its trace. The total stratigraphic thickness between the basal sandstone in the Copper Ridge Dolomite and the bottom of the branch fault at

one locality is 569 feet as measured in Geologic Section 1. Similarly, the Pulaski fault is located in the same part of the Elbrook Dolomite as the Miller fault system. However, the reason for these faults developing in such a relatively competent unit is unknown.

The first of two hypotheses concerning the possible continuation of the Miller fault under the Pulaski fault is that the Miller fault is the result of forces that the Pulaski fault block exerted on the overridden structures as the overriding Catawba syncline moved along the Pulaski fault plane. Assuming this hypothesis, the Catawba syncline might have been "held back" or deflected upward by the tight "S"-shaped competent Silurian Sandstone belt of Cove Mountain. However, along strike and up plunge, the less competent units were sheared and overridden and the structures were pushed westward with the Miller fault developing as a rotational fault with its pivot near Cove Mountain. It is not necessary, according to this hypothesis for the Miller fault to be anything more than a local phenomenon.

Field observation of the rocks under the leading edge of the Pulaski fault has revealed that many units are thin and severely deformed. As already noted, the Silurian sandstones, for example, are of variable thickness on the overturned limb of the Dragons Tooth syncline and disappear completely before the limb of the fold passes under the Pulaski fault. The magnitude of the force, developed during thrusting,

which was responsible for such severe deformation directly under the fault plane may have been sufficient to cause the displacement of the whole area and produce the Miller fault.

The second hypothesis is based on the assumption that the Miller fault is a major fault similar to the Saltville fault. On the geologic map accompanying the Valley Coal Fields report (Campbell and others, 1925) the area 4 miles northeast of Blacksburg in Montgomery County is indicated as a separate slice bounded by the Pulaski fault on the southeast and a fault at the base of Brush Mountain on the northwest. It is located just northwest of the Pulaski fault where that fault curves away from Brush Mountain. According to Woodward (1932), the rocks within this slice are Chickamauga Limestone. He suggests that this slice may be a continuation of the Cove Mountain structures which would mean that the slice is bounded by the continuation of the Miller fault. There is some uncertainty as to whether or not such a slice exists as it is not included in Butts (1934) Geologic Map of the Appalachian Valley of Virginia or discussed in his Bulletin 52 (1940). The writer has examined some outcrops of what appear to be Cambrian dolomite in this suspected slice. Also, large sinkholes which dominate the topography are indicative of a carbonate bedrock. It will be important to know the exact nature of this area before a definite conclusion regarding the alternate hypotheses is reached. Although the writer is uncertain as to which of the hypotheses is valid,

he does believe that a large part of the displacement on the Miller fault is the result of force exerted by the overriding Pulaski fault block on the Millers Cove block.

### Pulaski Fault

The Pulaski fault is named from the town of Pulaski, Pulaski County, Virginia, through which it passes (Campbell, 1925). In the same report in which it is named, Campbell and Holden extend the Pulaski fault into the Millers Cove area. The present author uses the name Pulaski fault as it was originally mapped in the Millers Cove area. Such use is also in agreement with Butts (1933, 1940) and Woodward (1932) whose maps include this area. Cooper (1961) has questioned the original extension of the Pulaski fault as mapped by Campbell and Holden. He proposes that the fault, herein called the Pulaski fault, in the Millers Cove area may be an extension of the Tract Mountain fault. The present author has found no evidence, in the Millers Cove area, which would resolve this problem. Breccia along the fault plane, a characteristic of the Pulaski fault in many other areas, is absent although numerous sinkholes along the fault trace are probably the result of solution along fractures. The fault also is somewhat higher in the section, shearing Elbrook Dolomite, than it is south of Blacksburg where it is in the Rome Formation. Whether the lack of breccia is related to the different lithologies at different localities or whether the Pulaski fault is actually two faults cannot be determined in the Millers Cove area.

A good exposure of the fault is on Virginia Route 620, a quarter of a mile northwest of the intersection of Virginia

Routes 620 and 624. At this locality, the fault dips about  $40^{\circ}$  to the southeast. The Elbrook Dolomite at the base of the fault is fractured and friable for a distance of about 10 feet above the fault. Directly beneath the fault is some slaby limestone which resembles those in the Liberty Hall Formation. If this is the Liberty Hall, then this unit is not in its correct stratigraphic position and has probably been dragged up along the fault from some other place farther down in the axial portion of the Dragons Tooth syncline or from an adjoining anticline which is now covered by the fault. This incompetent unit may have acted as a slip surface where it was brought into contact with the fault. At another locality, a zone of drag-folded, punky shale with chert stringers underlies the Pulaski fault (see Plate 10).

The fault trace, itself, is largely inferred but seems to be without major deviation from a smooth shallow curve. This is an indication of at least a moderately dipping fault plane probably on the order of the dip of the beds. This is at variance with the interpretation of Nichol (1960) who illustrated the Pulaski fault plane dipping less than the bedding and, therefore, cutting progressively younger formations as the fault extends farther beneath the Catawba syncline.

The writer's own impression, based on field work, is that adjacent to the Dragons Tooth syncline, the fault is essentially a bedding-plane fault. It seems to remain at essentially the same stratigraphic horizon about 800 feet

Plate 10



Drag-folded shale in Pulaski fault zone along  
Virginia Route 624 east of Wright Branch.

below the basal sandstone in the Copper Ridge Dolomite. At the few places where it is possible to locate the fault with a fair degree of accuracy, it is located about 20 to 50 feet below a distinctive limestone unit in the Elbrook Dolomite. The limestone unit is about 10 feet thick and contains algal colonies, oolites and small soft sediment faults. It is the only thick limestone unit below the Copper Ridge Dolomite along this section of the Pulaski fault and occurs at about the same stratigraphic interval below the basal sandstone. Thus, the stratigraphic position of the fault is well marked and along the length of the Millers Cove area seems to vary little from the same stratigraphic horizon.

Analysis of topographic maps indicates that the leading edge of the fault occupies approximately the same stratigraphic horizon from Mill Creek in Montgomery County, northwest through Roanoke County and into at least a part of Botetourt County. The fault trace is inferred to lie northwest of the low ridge formed by the basal sandstone in the Copper Ridge Dolomite and southeast of the base of the flatirons formed by Mississippian sandstones on the southeast flank of Brush Mountain and on the southeast flank of North Mountain. Thus, the fault is located within a very narrow belt and its stratigraphic position cannot change very much within this belt. The base of the Pulaski fault block is reported to form the northwest border of the Read-Coyner Mountain fenster near Roanoke (Woodward, 1932). At this locality, a thickness

of approximately 500 to 1,000 feet of dolomite underlies the lowest recognizable sandstone in the Copper Ridge Dolomite. Thus, the Pulaski fault is at about the same stratigraphic horizon as at its leading edge which may signify that the fault is a bedding plane fault beneath most of the Catawba syncline.

### Evolution of Faulted Fold Structures

The Millers Cove area is in the most northeasterly part of the thrust-faulted Southern Appalachians. Overthrusts of Paleozoic rocks in broad synclinal and anticlinal structures characterize the Southern Appalachians distinguishing them from the Central Appalachians to the northeast which do not contain such numerous large overthrusts. Major thrusts such as the Richlands fault, Narrows fault, Saltville fault and the Salem fault all die out toward the northeast in the narrow zone between the Southern and Central Appalachians. In this same zone, the Pulaski fault and the Blue Ridge fault, which each have a minimum horizontal displacement of 8-10 miles near Roanoke, abruptly lose displacement when traced into the Central Appalachians (Butts, 1933). Accompanying the termination of the major faults northwest of the Miller Cove area is an abrupt change in strike from N.70°E. on the southwest to N.35°E. on the northeast. Furthermore, as is clearly seen on the Geologic Map of the Appalachian Valley in Virginia (Butts, 1933), the classic "cigar"-shaped structures of the Central Appalachians are replaced by irregular, domal or flat-ended structures. Even the width of the entire Valley and Ridge Province changes. At Salem, 5 miles southeast of Roanoke, its width is 28 miles but at Staunton in the Central Appalachians, 100 miles northeast of Roanoke, its width is 65 miles. The 35 degree difference in strike, the increase in number and displacement of thrust faults, the

presence of peculiar, relatively small steeply plunging folds, and the narrowness of the faulted and folded belt in the Southern Appalachians all seem to be related.

During the present study, evidence was found which has some applicability to a solution of the complex problem of thrusting in the Southern Appalachians. The force which produced the thrusting seems to have had a strong lateral component from the southeast which resulted in movement along the fault planes toward the northwest.

It is not possible at the present time to separate completely the deformation associated with faulting and that associated with earlier or later deformation. However, the writer believes that the almost uniform occurrence of dips to the southeast in the Millers Cove area is at least partly the result of the area being overridden by the Pulaski fault.

Thinning of competent units, such as the Silurian sandstones, adjacent to thrust faults is definitely related to thrusting. These units thin progressively as they come closer to the fault and may disappear entirely before they reach the point where they would be covered by the fault.

Overturning and steepening, extending down to the Cambrian carbonates, of the plunge of the Cove Mountain anticline probably is the result of a later "second" force different from that which caused the original folding at least in its direction of maximum strength. As a result of the earlier deformation a fold developed whose axis was probably

more northerly than the present axis of the Cove Mountain anticline. During the overthrusting, a new fold axis was superimposed on the old axis and the old nose of the anticline became overturned as part of the northwest overturned limb of the present Cove Mountain anticline (see Plate 3).

Deformation during thrusting also occurred over larger areas. During Pulaski thrusting, Catawba Mountain was bowed up and to the southeast because the advance of the Pulaski fault block was retarded in the area of Cove Mountain where a resistant mass of competent strata acted as a buttress. The termination of the Miller fault in the protected area north of Cove Mountain is possibly related to this buttressing effect. Instead of the displacement occurring all in one place along the Miller fault, displacement was distributed by steepening and overturning of strata and by shearing within incompetent formations along a zone reaching from the leading edge of the Pulaski fault through Cove Mountain and across Little Mountain syncline to the northwesterly bow in Sinking Creek Mountain.

Thus, the northwesterly bow in Sinking Creek Mountain may be the result of deformation during thrusting. Similarly, such deformation could have produced the change in strike of the axis of the Brush Mountain-Little Mountain syncline in the area adjacent to Cove Mountain.

An important insight into the mechanics of deformation of the Southern Appalachians can be acquired from the speci-

fic inferences based on the study of the Millers Cove area. That insight is that deformation of both overridden and over-riding blocks during thrusting is of real consequence in explaining the present geometry of Appalachian structure. Some of the peculiar structures of the Southern Appalachians may have been very similar to the "classic" structures of the Central Appalachians but were subsequently deformed during a post-folding interval of faulting which had only a mild effect in the Central Appalachians.

The force responsible for the thrusting could also be responsible for some of the arcuate shape of the Southern Appalachians, although such a shape is probably also primary and typical of a geosynclinal belt. Even if the arc is primary, thrust faulting is mainly associated with it and this may indicate that an arc is a fundamental tectonic unit which is active not only as a depositional basin but also during thrusting.

Thrust faults should terminate at the reentrant of an arcuate belt and gain displacement away from the place of termination. This could be the explanation for the termination of the major faults of the Southern Appalachians near the Roanoke reentrant. Movement on such thrust faults is in part rotational under this hypothesis (oral communication, Sears, 1965) resulting in a change of strike of the allochthonous rocks.

### Facies Comparison

Comparison of strata from different fault blocks can be used as a tool to determine the original geographic position of those fault blocks. Facies comparison is also of use in determining the gross variations in sedimentation over a region.

The lithology of Middle and Late Ordovivian, Silurian and Early Devonian age rocks of the Millers Cove area will be compared with those of three areas. The first, the Catawba syncline (Tillman, 1963), is a major structure adjacent to and just southeast of the Millers Cove area. The Catawba syncline is in the Pulaski fault block which has been moved a minimum of 10 miles to the northwest from its original position (Woodward, 1932). Thus, it is an extreme eastern facies compared to the Millers Cove area. The second, the California Company's No. 1 Kipps Well in the Price Mountain fenster (Cooper, 1963), was drilled in the strata of the Blacksburg synclinorium which is beneath the Pulaski fault block. These strata would probably be continuous with those of the Millers Cove area if the Pulaski fault could be stripped off. However, the strata in the well should be somewhat more southerly and easterly than those of the Millers Cove area. The oldest formation penetrated during the drilling of the test well is the Martinsburg Formation. The third area, the Sinking Creek anticline and New Castle valley (Tillman, 1963), is almost

directly north of Millers Cove and its rocks are indicative of the facies encountered in the next strike belt west of Millers Cove. If, as the writer believes, the Miller fault terminates near Virginia Route 311, then the Millers Cove area is essentially autochthonous and is still in its original depositional position with reference to the New Castle area.

The Ordovician Bays Formation is 192 feet thick in the Millers Cove area and is the result of the first major influx of widespread clastic sedimentation since the Middle Cambrian. It is a red to gray siltstone and sandstone containing bentonite beds. At its base it contains a conglomerate composed of clasts of reworked Liberty Hall limestone and deposited in channels. This unit was not penetrated by the California Company well. In the southwest part of the Catawba syncline, the Bays Formation is over 1000 feet thick but it thins northeastward and is about 135 feet thick along Virginia Route 311 on Catawba Mountain (Tillman, 1963). At the nose of the Sinking Creek anticline, the Bays Formation is represented by only a few feet of reddish sandstone and siltstone. A few clasts of vein quartz up to half an inch across are present in two thin conglomerates near the lower contact. The Bays Formation of the Millers Cove area is comparable in thickness to that of the Bays Formation of the Catawba syncline along Virginia Route 311 but it is also similar litholo-

gically to the strata in the Sinking Creek anticline because it contains a conglomerate near its base. Lithologically, it is more limy than the Bays of the Catawba syncline and in this respect resembles the Moccasin Formation of the Sinking Creek anticline belt.

Overlying the Martinsburg Formation in many areas of Virginia is the Juniata Formation. However, in the Millers Cove area the Juniata Formation is missing and the Martinsburg Formation is overlain by Silurian sandstone. A similar situation occurs in the Catawba syncline where a thin bed of Juniata has been identified only northwest of Bradshaw, Roanoke County (Butts, 1940). In the rest of the syncline, the Juniata is missing and presumably was deposited and then eroded off (Tillman, 1963). Toward the northwest, in the Sinking Creek anticline, the Juniata Formation is 203 feet thick and is a green and pink sandstone with red and green mudstone and shale (Tillman, 1963). Its contact with the underlying Martinsburg Formation is gradational. The lack of any Juniata in the Millers Cove area and a similar lack of Juniata in the Catawba syncline suggests that these areas were topographically high during the Late Ordovician in comparison to the Blacksburg synclinorium and the Sinking Creek anticline.

Resting on the Ordovician Martinsburg Formation in the Millers Cove area is the Silurian Tuscarora Sandstone. This formation is 162 feet thick and is overlain by the

Rose Hill Formation, 78 feet thick, which in turn is overlain by the Keefer Sandstone, 300 feet thick. Together, these three formations are 540 feet thick. These same three formations measure only 311 feet thick (Tillman, 1963) along Virginia Route 311 on Catawba Mountain. To the southwest in the Blacksburg synclinorium, the total thickness is about 550 feet (Cooper, 1963, Plate 2.3) which is comparable to that of the Millers Cove area. Northward at the nose of the Sinking Creek anticline the sequence measures only 247 feet thick (Tillman, 1963). Thus, it seems that during the Silurian, when the Tuscarora, Rose Hill and Keefer formations were deposited, the Blacksburg synclinorium and the Millers Cove area were the sites of accumulation of thick sandstone deposits while in the areas to the west and in places to the east only half as much sandstone was deposited.

No other Silurian formations were identified in the Millers Cove area. Overlying the Keefer Sandstone is the Devonian Keyser Sandstone, a 30-foot thick, pink stained, gray friable sandstone with some tough sandstone interbeds. This section is distinctive when compared to the surrounding areas. To the north in the Johns Creek gorge near New Castle, 219 feet of Tonoloway Limestone separates the Keyser Sandstone from the older Keefer Sandstone (Tillman, 1963). Also, the Keefer Sandstone of the Johns Creek gorge is five times as thick as the Keefer Sandstone of

the Millers Cove area. The section along Virginia Route 311 on Catawba Mountain is, however, very similar to that in the Millers Cove area. The thickness of the Keyser is only 10 feet and it rests directly on the Keefer Sandstone (Tillman, 1963). Thus, there seems to be a progressive thinning of the Keyser from 150 feet at Johns Creek gorge to 30 feet at Cove Mountain to 10 feet at Catawba Mountain. Over the same distance the Tonoloway Limestone either has graded into a sandy phase at the top of the Keefer Sandstone or it has been removed by erosion.

In the four examples of facies comparison described above, the Millers Cove area has been shown to be in approximately its original geographic position in regard to the surrounding localities. At any specific time the Millers Cove area may have been more closely related to one area than another. However, the general stratigraphic analysis supports the hypothesis that the Millers Cove area lay somewhere between the Sinking Creek anticline and the Catawba syncline during the Middle Paleozoic era and that the Millers Cove area has some stratigraphic similarities to the sequence in the Blacksburg synclinorium. These conclusions concur with those deduced from structural evidence and support the conclusion that the Millers Cove area is essentially autochthonous.

APPENDIX

Geologic Section 1 - Elbrook Dolomite along creek adjacent to Virginia Route 620, Roanoke County, Virginia; section starts near sharp bend in Virginia Route 620 and is measured downstream towards the northwest; strike/dip approximately N. 50°E., 34°S.E.

	Thickness Ft.
Copper Ridge Dolomite	
25. Sandstone, gray, medium-grained, massive and cross-laminated; weathers light gray .....	8
Elbrook Dolomite (569 feet)	
24.. Dolomite, light gray, fine-to medium-grained; thin to thick-bedded; weathers light gray .....	105
23. Dolomite, gray-blue; fine-grained; weathers light gray .....	80
22. Dolomite, gray; medium-grained; weathers light gray .....	30
21. Covered .....	5
20. Dolomite, blue-gray, limy, medium-grained, medium-bedded; weathers blue .....	17
19. Covered .....	7
18. Dolomite, light gray, limy, medium-grained, thin-bedded, interbedded argillaceous laminations, spar calcite, <u>algal</u> structures; weathers light gray .....	40
17. Dolomite, light gray, medium-grained, thin-to medium-bedded; soft sediment graben fault of 4-foot displacement .....	5

16.	Dolomite, light gray, medium-grained, medium-bedded, interbedded argillaceous laminations; weathers light gray .....	25
15.	Dolomite, medium gray, medium-grained, thick bedded, <u>algal</u> structures	13
14.	Dolomite, light blue, limy, fine-grained, interbedded fine laminations; <u>algal</u> structures; weathers light blue .....	22
13.	Limestone, blue, argillaceous, fine-grained, thin-to medium-bedded; <u>algal</u> structures; calcite nodules	20
12.	Dolomite, light gray and blue, limy, medium-grained; thick-bedded; weathers light gray .....	63
11.	Covered .....	10
10.	Limestone, dolomitic, blue, thick-bedded, weathers light blue .....	10
9.	Dolomite, light gray, fine-grained; weathers blue-gray .....	10
8.	Covered .....	16
7.	Dolomite, light gray, medium-grained, thick-bedded; weathers light gray .....	21
6.	Dolomite, light blue, medium-grained, thick-bedded; calcite-filled fractures; weathers light gray ...	11
5.	Dolomite, light blue, limy, fine-grained, calcite-filled fractures; <u>algal</u> structures near top; weathers <u>light</u> gray .....	25
4.	Covered .....	10
3.	Limestone, light blue, fine-grained; calcite-filled fractures; stringers of blue-black chert along bedding	7

2. Covered .....	13
1. Limestone, pale gray, fine-grained, irregularly bedded with "chatter" marks on fresh surface; weathers blue-black .....	4
Covered (probably in fault contact with Ordovician limestone)	

Geologic Section 2 - Copper Ridge Dolomite along creek about 2000 feet north of the intersection of Virginia Route 701 and Virginia Route 704; section starts at break in slope and is measured towards the northwest; strike/dip N.55°E., 37°SE.

	Thickness Ft.
Chepultepec Limestone	
32. Limestone, gray-blue, fine-grained; oolitic .....	2
Copper Ridge Dolomite (709 feet)	
31. Covered .....	15
30. Sandstone, tan, medium-grained, medium-bedded, friable .....	1
29. Dolomite, gray, fine-grained, medium-bedded .....	4
28. Sandstone, feldspathic, medium-grained, tan to brown, medium-bedded, friable .....	2
27. Covered .....	2
26. Dolomite, gray, fine-grained; contains a 3-inch thick medium-grained sandstone .....	3
25. Dolomite, gray, silty, medium-grained; silty laminations weather out in relief .....	123
24. Dolomite, light gray, medium-grained; chert nodules, dark gray; algal structures .....	45
23. Dolomite, gray, fine-to medium-grained; dark gray chert nodules; cauliflower chert; sparry calcite inclusions .....	25
22. Dolomite, medium gray, limy, fine-grained .....	10
21. Dolomite, gray, fine-grained; sparry calcite inclusions .....	23

20.	Limestone, dark blue to blue-gray; lower 6 feet are argillaceous .....	12
19.	Dolomite, gray, fine-grained, finely laminated .....	5
18.	Limestone, gray-blue, argillaceous, with shale partings; dolomite clasts in lower part .....	4
17.	Dolomite, gray, fine-grained, wea- thers light gray .....	14
16.	Limestone, gray, fine-grained; lime- stone conglomerate near base; weathers light blue .....	12
15.	Dolomite, gray, fine-grained, thin- to medium-bedded; interbedded limy dolomite; weathers medium gray ...	85
14.	Dolomite, gray, fine-grained; irre- gular light gray chert inclusions; weathers light gray .....	52
13.	Dolomite, light gray to blue-black, fine-grained; gray and gray-black chert; 4-inch oolitic black chert bed; weathers light gray .....	41
12.	Dolomite, silty, gray, fine-grained, laminated; minor amount of dark gray chert; weathers brown-gray ..	60
11.	Dolomite, light to medium light gray, fine-grained; chert in- clusions; <u>algal</u> structures; weathers gray-brown .....	87
10.	Dolomite, gray to grayish white, silty, thin-to medium-bedded; section mostly covered; weathers gray .....	42
9.	Dolomite, gray, fine-grained, massive .....	2
8.	Covered .....	8
7.	Sandstone, tan, medium-grained, friable .....	2

6.	Covered .....	5
5.	Sandstone, tan, medium-grained, friable .....	2
4.	Covered .....	3
3.	Sandstone, gray, medium-grained, friable; weathers reddish-brown ..	1
2.	Covered .....	14
1.	Sandstone, gray, medium-grained, massive; cross-bedded; weathers light gray .....	8

Covered (Elbrook Dolomite)

Geologic Section 3 - Chepultepec Limestone 500 feet north of Virginia Route 704 along creek, Roanoke County, Virginia; section starts at head of the gully and is measured towards the northwest; strike/dip N.36°E., 31°SE.

	Thickness Ft.
Upper Knox Interval	
27. Dolomite, light gray, medium-grained; white chert nodules .....	6
26. Limestone, light blue, fine-grained	5
25. Dolomite, light gray, medium-to coarse-grained .....	48
24. Limestone, blue, fine-grained, in- terbedded .....	
Chepultepec Limestone (168 feet)	
23. Limestone breccia; black nodular chert .....	10
22. Limestone, blue, fine-grained .....	5
21. Dolomite, light gray, medium-grained	2
20. Limestone, blue, fine-grained, thick- bedded .....	16
19. Dolomite, dark gray, fine-grained ..	4
18. Limestone, gray-blue, medium-grained	3
17. Limestone, gray-brown, fine-grained, irregularly bedded .....	3
16. Limestone, dark blue, fine-grained, medium-bedded; sparry calcite ....	3
15. Dolomite, light gray and dark gray bands, limy .....	27
14. Limestone, blue, fin-grained; irre- gular masses of chert, medium gray, occur along bedding plane ..	7

13.	Chert, oolitic, light to medium gray .....	3
12.	Limestone, breccia, light blue .....	2
11.	Dolomite, medium gray, fine-grained .....	18
10.	Limestone, blue, fine-grained; dolomitic stylolites, parallel bedding .....	10
9.	Limestone, blue-black, fine-grained; irregularly fractured and brecciated .....	6
8.	Limestone, blue, fine-grained; dolomitized along bedding surfaces; sparry calcite .....	14
7.	Dolomite, light gray, fine-grained; chert nodules .....	1
6.	Limestone, breccia, blue; dolomitized fractures .....	1
5.	Dolomite, light gray, fine-grained .	22
4.	Limestone, gray-blue; <u>algal</u> heads 3 feet in diameter; matrix between heads is argillaceous limestone with sparry calcite (see Plate 5)	10
3.	Limestone, light blue, fine-grained	3
Copper Ridge Dolomite		
2.	Dolomite, gray, medium-grained .....	12
1.	Sandstone, tan, medium-grained, medium-bedded, porous and friable	1

Geologic Section 4 - New Market, Whistle Creek, Lincolnshire and Effna formations on middle knoll between Virginia Routes 620 and 701, Roanoke County, Virginia; section starts on military crest on the southeast slope of the ridge and is measured towards the northwest towards the crest of the ridge; strike/dip: N.30°E., 39°SE.

	Thickness Ft.
<b>Liberty Hall Formation</b>	
18. Limestone, dark gray, fine-grained, medium-bedded; breaks along a smooth surface; weathers light gray .....	2
17. Covered .....	7
16. Limestone, dark gray, fine-grained, medium-bedded; stringers of nodular black chert, nodules about 6 inches across .....	5
15. Limestone, mottled dark gray, argillaceous, medium-grained .....	1
<b>Effna Limestone (11 feet)</b>	
14. Limestone, light gray and pink, very coarse-grained, thick-bedded; <u>Bumastus</u> sp. ....	11
<b>Whistle Creek - Lincolnshire formations (156 feet)</b>	
13. Limestone, medium gray, medium-to coarse-grained, massive-bedded with irregular bedding surfaces; large unbroken bryozoa; weathers light gray .....	34
12. Limestone, medium gray, coarse-grained, thin-bedded; black chert nodules, about 2 inches across; abundant brachiopods .....	10
11. Limestone, light gray, coarse-grained, thick-bedded; large unbroken bryozoa; thin stringers of black chert; weathers light to dark gray .....	22
10. Covered .....	45

9. Limestone, light gray, coarse-grained, thick-bedded; bryozoa (large), some silicified .....	5
8. Covered .....	30
7. Limestone, medium gray, medium-grained, medium-bedded; brachiopods and bryozoa .....	10

New Market Limestone (27 feet)

6. Limestone, light gray-blue, fine-grained, medium-bedded; sparry calcite; weathers pale blue .....	10
5. Limestone, gray-blue, fine-grained, medium-bedded, pelletiferous; brachiopod fragments .....	4
4. Conglomerate, mottled light gray to medium gray; angular dolomite clasts in a limestone matrix .....	3
3. Covered .....	10

Disconformity

Upper Knox Interval

2. Dolomite, gray, fine-to medium-grained, medium-bedded; interval mostly covered .....	26
1. Chert, cryptocrystalline, light gray, thick-bedded .....	3

Geologic Section 5 - Bays Formation in pasture about half a mile southwest of the southwest end of Cove Mountain, Roanoke County, Virginia; section starts approximately 400 feet S.60°E. from intersection of County roads 620 and 701; section is situated on northwest flank of overturned syncline; much of section is weathered and partly covered; strike/dip: N.55-60°E.; 60-70°SE. (Hergenroder, 1966, Geologic section 91).

		Thickness	
		Ft.	In.
Martinsburg Formation			
25.	Covered; grayish-yellow silty shale chips in soil contain <u>Dalmanella</u> (?) etc. ....		
Bays Formation (193 feet)			
24.	Covered; grayish-yellow silty shale chips in soil .....	10	0
23.	Sandstone, silty, dark grayish-yellow; slightly crumbly .....	7	10
22.	Siltstone, sandy, dark grayish-yellow with grayish-red, limy, crumbly .....	5	1
21.	Clay, reddish-brown, plastic; possibly a very weathered bentonite ...		9
20.	Siltstone, very clayey, sandy in middle; dark grayish-yellow .....	3	11
19.	Sandstone, fine-grained to silty, dark grayish-yellow, slightly crumbly .....	2	10
18.	Siltstone, sandy to clayey, grayish-red with dark grayish-yellow bands, very limy, crumbly .....	8	3
17.	Siltstone, sandy, with interbedded sandstone, light olive-gray to dark grayish-yellow with a little grayish-red in middle, limy, crumbly .....	8	2

16.	Covered .....	3	4
15.	Calclutite, light gray, very clayey to silty, weathers yellowish-gray; slightly crumbly .....	1	10
14.	Covered .....	3	2
13.	Siltstone, sandy, dark grayish-yellow; slightly siliceous .....	1	4
12.	Covered; same small fragments of grayish-red and light olive-brown siltstone in middle .....	17	10
11.	Sandstone, dark grayish-yellow with grayish-red, fine-grained to silty, slightly crumbly; partly covered .	7	7
10.	Covered, some crumbly dark grayish-yellow sandy siltstone .....	11	0
9.	Siltstone, sandy, dark grayish-yellow; crumbly .....	4	0
8.	Covered; undoubtedly bentonite .....	2	11
7.	Siltstone, sandy, with thin sandstone interbeds, dark grayish-yellow, crumbly; top 3-4 inches silicified with light brown upper surface .....	40	7
6.	Covered, some small dark grayish-yellow siltstone fragments in soil .....	7	0
5.	Siltstone, sandy, with sandstone interbeds to 12 inches thick, light olive-brown with dark grayish-yellow above middle, very crumbly .....	23	9
4.	Covered, dark grayish-yellow crumbly to shaly siltstone fragments in soil .....	5	10
3.	Siltstone, sandy, light olive-gray; limy .....	5	0

- 2. Calcilithite, medium gray to medium dark gray; clasts weather light gray; matrix weathers light olive-gray to grayish-orange at top; clasts range up to 10 inches long and 3 inches thick; appear to be from Liberty Hall immediately beneath; matrix is silty at base and in middle, very sandy at top; base of unit is erosion surface with 4 to 5 feet of relief at this locality, thickness measured in old channel ..... 10 6

Liberty Hall Formation

- 1. Calcilutite and very fine calcarenite, medium to medium dark gray, clayey to silty; weathers light gray .....

Remainder not measured.

Geologic Section 6 - Tuscarora, Rose Hill and Keefer sandstones 750 feet north of Pickles Branch on a high knob, Craig County, Virginia; section starts on northwest slope and is measured towards the southeast; strike/dip approximately N.55°E., 65°S.E., overturned.

	Thickness	
	Ft.	In.
Covered (probably in fault contact with Devonian Millboro shale).		
Keefer Sandstone (300 feet)		
27. Sandstone, gray with orange and pink streaks, medium-grained, medium-bedded with some crinkled laminations; weathers medium gray with red outer coating .....	11	2
26. Sandstone, tan-orange with brown spots, pink outer layer, medium-grained, medium-bedded .....	13	7
25. Quartzite, light gray, medium-grained, medium-bedded; weathers medium gray; interbeds of tan sandstone .	7	8
24. Sandstone, tan and pale orange, medium-grained, medium-bedded; weathers brown with pink stains ..	23	6
23. Sandstone, brown, medium-grained, friable; weathers dark brown .....	1	0
22. Quartzite, brown and tan, medium-grained, medium-to thick-bedded; weathers gray to red; interbedded thin tan friable sandstones .....	28	5
21. Sandstone, pale yellow-brown to buff, medium-grained, medium-bedded; weathers medium gray .....	30	3
20. Sandstone, gray, fissile .....	1	0
19. Quartzite, orange, medium-grained, medium-to thick-bedded; weathers medium gray .....	33	2

18.	Quartzite and sandstone, pale orange, medium-grained, medium-bedded; weathers medium gray .....	32	5
17.	Covered .....	8	10
16.	Sandstone, pale orange, medium-grained, medium-bedded; interbeds of thin-bedded sandstone and friable sandstone .....	28	0
15.	Quartzite, pale orange, medium-grained, thick-to medium-bedded; weathers medium gray; some sandstone interbeds .....	59	3
14.	Quartzite, gray, medium-grained; weathers medium-to dark gray, thick-bedded .....	24	11
13.	Quartzite, tan, fine-to medium-grained, blocky bedding; weathers pink or pale maroon; contains weathered "clay" particles .....	1	4
Rose Hill Sandstone (78 feet)			
12.	Covered .....	11	1
11.	Sandstone, maroon, hematite-cement; thin-bedded; weathers red-brown ..	1	4
10.	Covered (probably contains some tan quartzites in upper 5 feet) .....	33	0
9.	Sandstone, maroon, hematite-cement, medium-bedded; "clay" particles; some large quartz grains "floating" in hematite matrix .....	13	11
8.	Sandstone, gray-brown, impure with large "clay" particles and quartz grains: weathers brown and spotted with limonite .....	3	3
7.	Covered (some shale chips ) .....	18	10

Tuscarora Sandstone (162 feet)

6. Quartzite, pale orange; weathers medium gray; top six inches contain <u>Scolithus</u> .....	4	6
5. Quartzite, light gray, mostly medium-grained but some coarse beds, medium-to thick-bedded; weathers medium gray .....	46	0
4. Quartzite, pinkish-orange, medium-grained, medium-bedded; weathers medium gray .....	37	5
3. Quartzite, light gray, medium-grained, medium-bedded .....	17	11
2. Quartzite, pale tan, medium-grained, medium-bedded .....	56	4

Martinsburg Formation ?

1. Sandstone, fine-grained; float .....

Geologic Section 7 - Parrott and Price formations along U.S. Forest Service access road on southeast slope of Brush Mountain, Roanoke County, Virginia; section starts at sharp turn, northeast of gully and is measured uphill to the northwest to about 200 feet below crest of Brush Mountain; strike/dip N.41°E., 42°SE.

	Thickness	
	Ft.	In.
Price Sandstone (289 + feet)		
20. Quartzite, orange-brown to buff, medium-grained, medium-to thin-bedded; weathers light brown with pseudo-crossbedding pattern .....	14	8
19. Sandstone, dark brown, medium-grained, medium-bedded; contains shale chips 5 cm. across .....	1	8
18. Siltstone, tan, shaly; weathers mottled tan, blue and red .....	11	9
17. Sandstone, tan, medium-grained, medium-bedded; weathers light orange to brown .....	9	8
16. Sandstone, tan, fine-grained, thin-bedded; weathers brown and blue ..	49	7
15. Covered (some deeply weathered tan mudstone) .....	74	2
14. Covered .....	86	1
13. Sandstone, conglomeratic, pale orange; pebbles .3 cm. across, well indurated; weathers light brown .....	1	0
12. Covered .....	3	0
11. Sandstone, orange, medium-grained; shale chips 2.5 cm. across; weathers brown and gray .....	1	6
10. Conglomerate, grayish-white, thick-bedded; pebbles 2 cm. across .....	1	11

9.	Quartzite, tan, medium-grained to coarse-grained; weathers gray to light brown .....	13	9
8.	Conglomerate, light gray; gray, red and black quartz pebbles 2 cm. across, well rounded and fractured; some shale chips; weathers light brown .....	3	0
7.	Covered .....	17	8
Parrott Formation (100 + feet)			
6.	Claystone, red, thin-bedded; weathers red and tan .....	3	0
5.	Sandstone, maroon, micaceous, fine-to medium-grained, thin-bedded; weathers reddish-brown .....	8	0
4.	Sandstone, brown, micaceous, feldspathic, medium-to fine grained, thin-to medium-bedded; channeling (?); clay particles near botton of unit; pseudo-crossbedding; weathers tan and red-brown .....	27	11
3.	Covered .....	26	6
2.	Sandstone, brownish-gray, micaceous, feldspathic, fine-to medium-grained, thin-to medium-bedded, channeling; weathers red-brown; interbedded near base with thin-bedded micaceous brown sandstone .....	25	8
1.	Claystone, maroon and olive-green, thin-bedded; deeply weathered; weathers maroon and green .....	9	0

REFERENCES

- Aronson, David, 1966, Stratigraphy, petrography and origin of the Copper Ridge Formation in the Blacksburg area, Montgomery County, Virginia: M.S. thesis (unpub.), Va. Polytech. Inst., 163 p.
- Butts, Charles, 1933, Geologic map of the Appalachian Valley of Virginia with explanatory text: Va. Geol. Surv. Bull. 42, 56 p.
- Butts, Charles, 1940, Geology of the Appalachian Valley in Virginia, Part I: Va. Geol. Surv. Bull. 52, pt. 1, 568 p.
- Campbell, M.R., and others, 1925, The valley coal fields of Virginia: Va. Geol. Surv. Bull. 25, 300 p.
- Cooper, B.N., 1961, Geological Guidebook No. 1, Grand Appalachian Excursion: Blacksburg, Va. Eng. Expt. Sta., 187 p.
- Cooper, B.N., 1963, Blacksburg synclinorium and Pulaski overthrust; in Geological Guidebook No. 2, Geological excursions in southwest Virginia: Blacksburg, Va. Eng. Expt. Sta., p. 19-48.
- Derby, James, 1966, Paleontology and stratigraphy of the Nolichucky Formation in southwest Virginia and northeast Tennessee: Ph.D. Thesis, Va. Polytech. Inst., 465 p.
- Gilbert, R.C., 1953, Middle Ordovician limestone in the valley of the North Fork of the Roanoke River, Montgomery County, Virginia: M.S. Thesis (unpub.), Va. Polytech. Inst.
- Glover, Lynn, 1953, The stratigraphy of the Devonian-Mississippian boundary in southwestern Virginia: M.S. Thesis (unpub.), Va. Polytech. Inst., 39 p.
- Hergenroder, John D., 1966, The Bays Formation and related rocks of the southern Appalachians: Ph.D. Thesis (unpub.), Va. Polytech. Inst., 325 p.
- Nichol, R.F., 1960, Geology and mineral resources of the Tinker Mountain-Fincastle, Virginia area: M.S. Thesis (unpub.), Va. Polytech. Inst.

- Tillman, C.G., 1963, Late Silurian (?) and Early Devonian positive area, Salem syncline; in Geological Guidebook No. 2, Geological excursions in southwest Virginia: Blacksburg, Va. Eng. Expt. Sta., p. 49-76.
- Webb, Fred Jr., 1965, Geology of the Big Walker Mountain-Crockett Cove area, Bland, Pulaski and Wythe counties, Virginia: Ph.D. Thesis (unpub.), Va. Polytech. Inst., 171 p.
- Woodward, H.P., 1932, Geology and mineral resources of the Roanoke area, Virginia: Va. Geol. Surv. Bull. 34, 172 p.

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GEOLOGY OF THE MILLERS COVE AREA,  
ROANOKE, CRAIG AND MONTGOMERY  
COUNTIES, VIRGINIA

by

Henry Jack Bauerlein

Abstract

The Millers Cove area is underlain by rock ranging in age from Middle Cambrian Elbrook Dolomite to Early Mississippian Price Sandstone. Carbonate deposition was dominant into the Ordovician with clastic sedimentation dominant throughout the rest of the Paleozoic.

Cove Mountain is formed by the overturned northeast plunging Cove Mountain anticline and Dragons Tooth syncline. To the southwest the anticline passes beneath the Pulaski fault. The extension of the anticline to the northeast is unknown but it may be continuous with the Broad Run anticline. The Dragons Tooth syncline is continuous to the northeast with the North Mountain syncline but to the southwest passes beneath the Pulaski fault. The southwest plunging Brush Mountain-Little Mountain syncline may be continuous with the northeast plunging Broad Run Mountain syncline.

The Miller fault has 10,000 feet of stratigraphic displacement where it passes under the Pulaski fault

but it loses displacement and apparently terminates to the northeast. Thus, the Miller fault block is para-autochthonous. The Pulaski fault which separates the Miller fault block from the Catawba syncline is an overthrust of 10 mile horizontal displacement and 10,000 foot stratigraphic displacement.

The first of two different deforming forces produced folds whose axes trend N.  $35^{\circ}$  E. The second was associated with thrust faulting and caused refolding along trends of N.  $60^{\circ}$  E. Accompanying faulting was the rotation of the southwestern end of the Miller fault block, the depression of the Brush Mountain-Little Mountain syncline beneath the weight of the Pulaski and Miller fault blocks, and the bowing of the Catawba syncline and Sinking Creek anticline under the buttressing action of Cove Mountain.

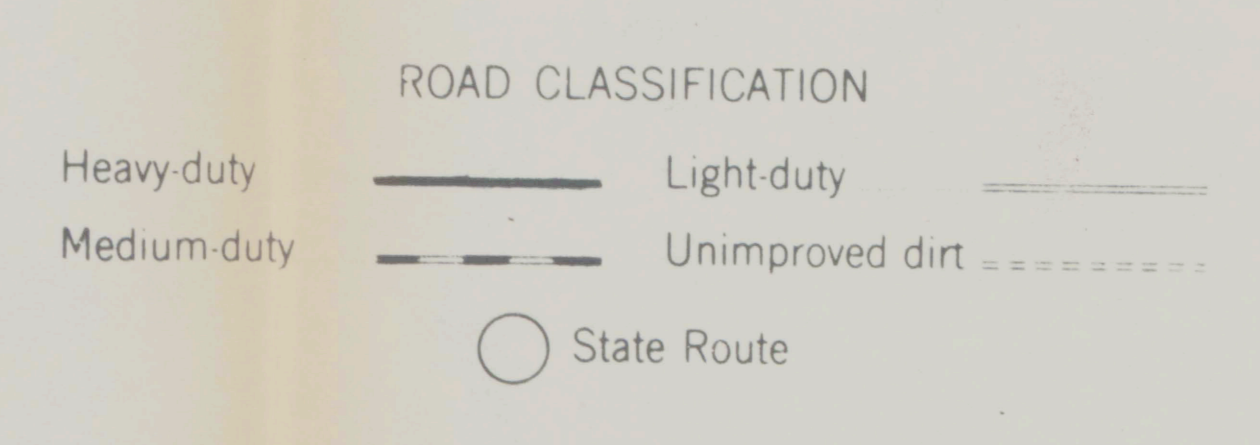
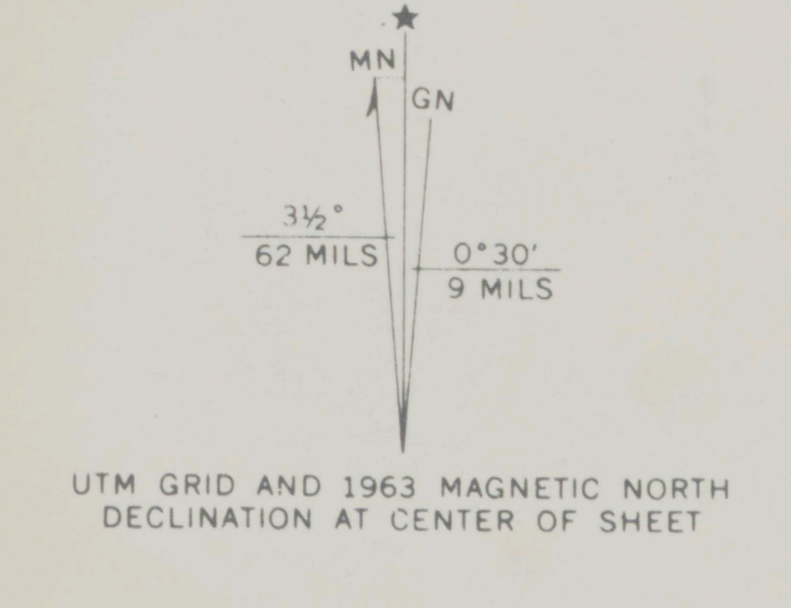
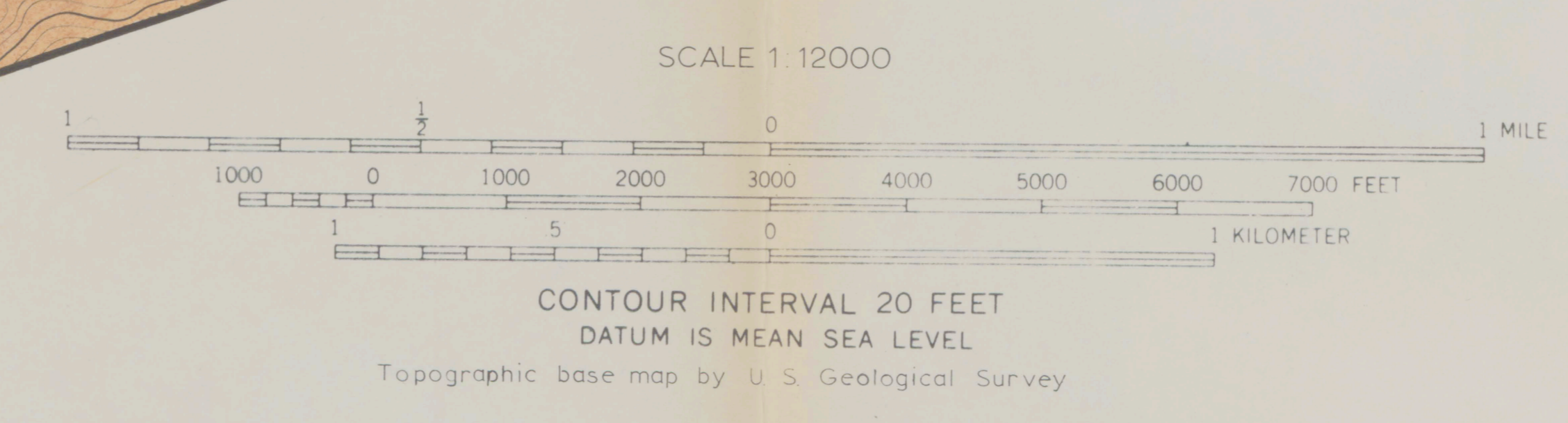
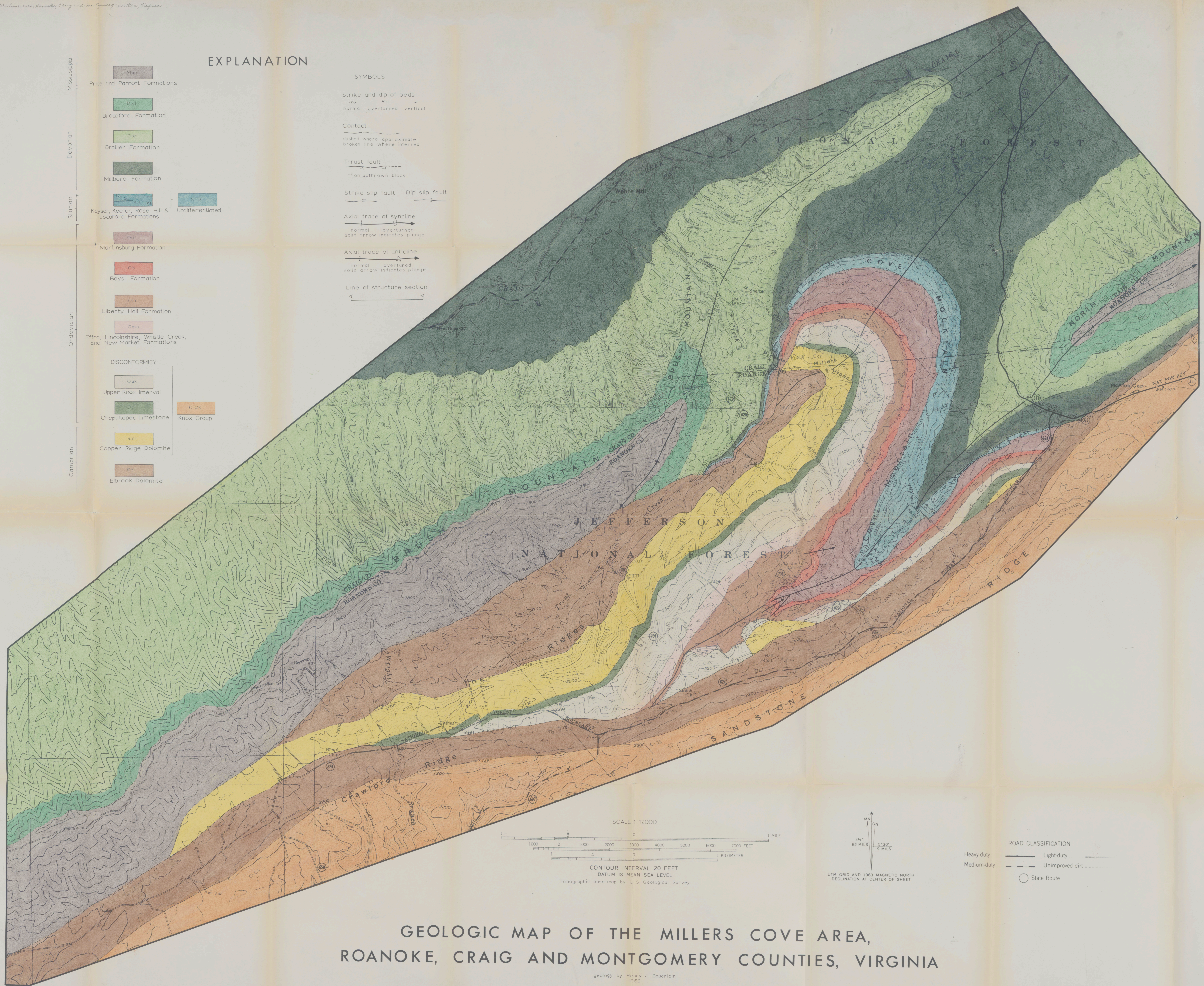
Henry and Bauerlein  
Geology of the Miller's Cove area, Roanoke, Craig and Montgomery counties, Virginia

### EXPLANATION

Mississippian	Mpp	Price and Parrott Formations
	Dbb	Broadford Formation
	Dbr	Braller Formation
	Dm	Milboro Formation
Devonian	Keyser, Keifer, Rose Hill & Tuscarora Formations	Undifferentiated
	Om	Martinsburg Formation
Ordovician	Ob	Bays Formation
	Oih	Liberty Hall Formation
	Oms	Effna, Lincolnshire, Whistle Creek, and New Market Formations
	DISCONFORMITY	
Cambrian	Ouk	Upper Knox Interval
	C-Ok	Chepultepec Limestone
	Ccr	Copper Ridge Dolomite
	Cc	Elbrook Dolomite

### SYMBOLS

- Strike and dip of beds
  - normal
  - overturned
  - vertical
- Contact
  - dashed where approximate
  - broken line where inferred
- Thrust fault
  - on upthrown block
- Strike slip fault    Dip slip fault
- Axial trace of syncline
  - normal
  - overturned
  - solid arrow indicates plunge
- Axial trace of anticline
  - normal
  - overturned
  - solid arrow indicates plunge
- Line of structure section



**GEOLOGIC MAP OF THE MILLERS COVE AREA,  
ROANOKE, CRAIG AND MONTGOMERY COUNTIES, VIRGINIA**

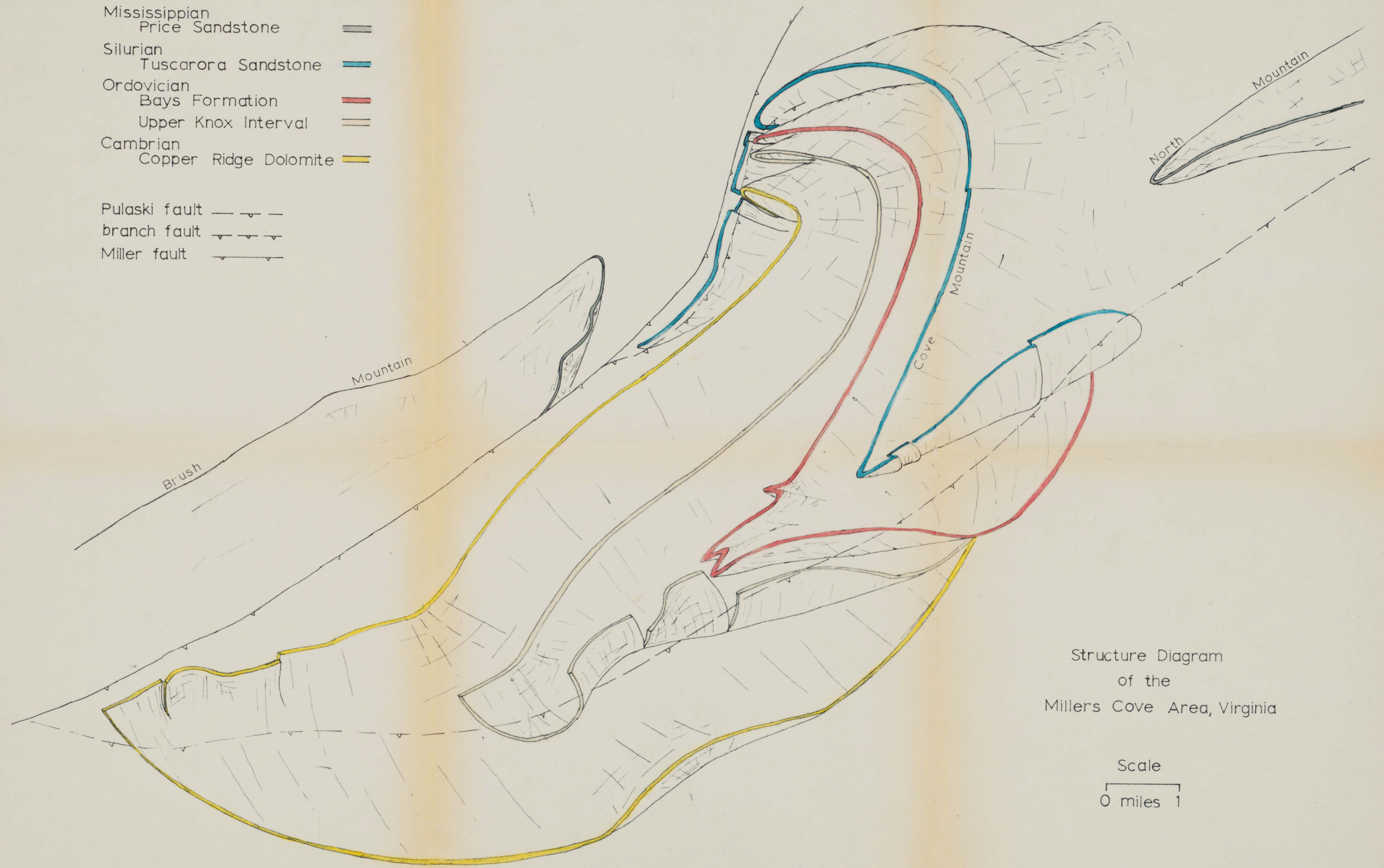
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1965

Henry Jack Bauerlein  
 Geology of the Millers Cove area, Roanoke, Craig and Montgomery counties, Virginia.

Explanation

- Mississippian  
Price Sandstone
- Silurian  
Tuscarora Sandstone
- Ordovician  
Bays Formation
- Upper Knox Interval
- Cambrian  
Copper Ridge Dolomite

- Pulaski fault
- branch fault
- Miller fault



Structure Diagram  
 of the  
 Millers Cove Area, Virginia

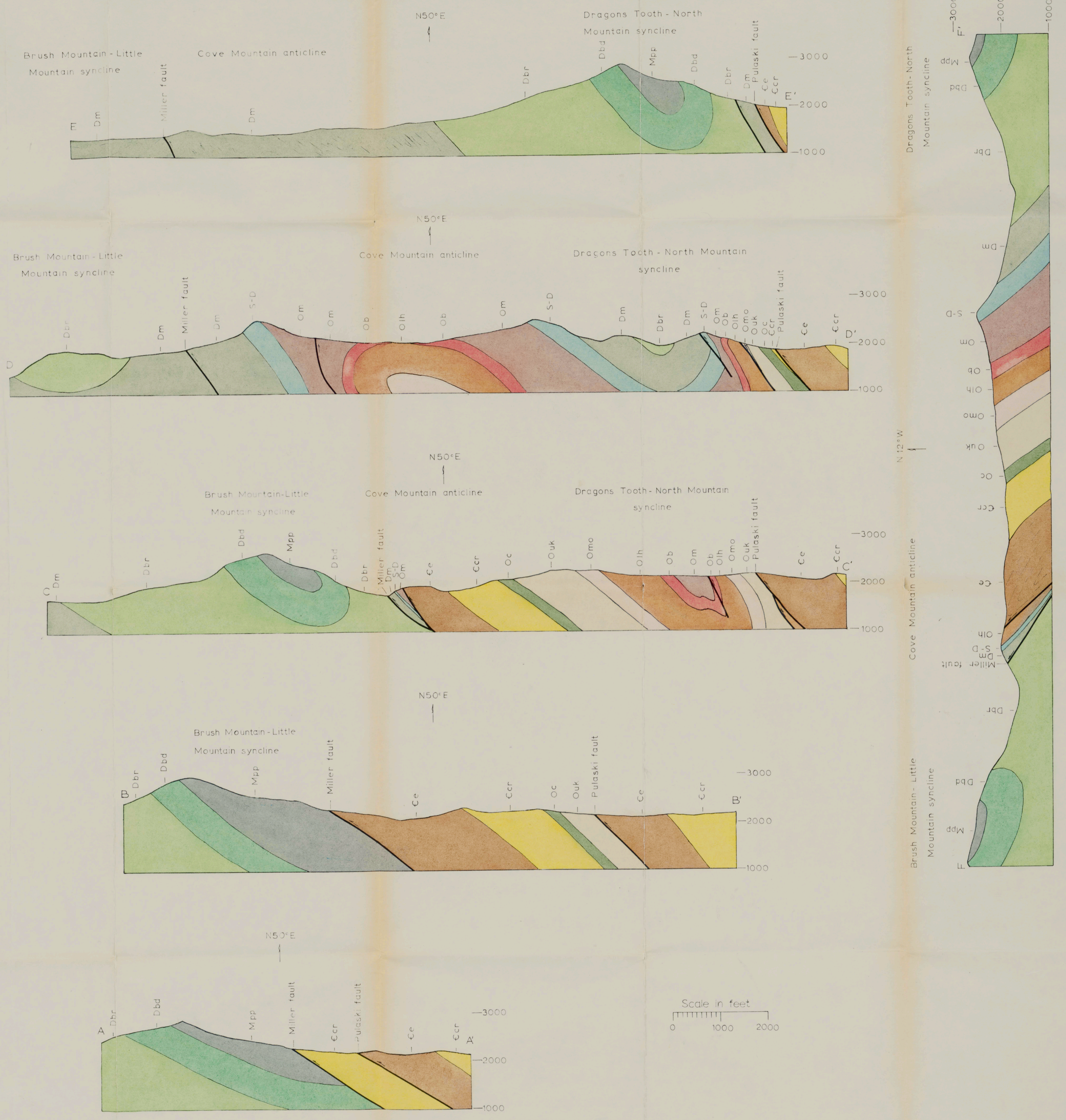
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LD  
 5655 Harry Peak Building  
 1935  
 1966  
 B.S.  
 Spec

Geology of the Millers Cove area, Roanoke, Craig and Montgomery counties, Virginia.

EXPLANATION

- Mississippian
  - Mpp Price and Parrott Formations
- Devonian
  - Dbd Broadford Formation
  - Dbr Bralier Formation
  - Dm Millboro Formation
- Silurian
  - S-D Keyser, Keefer, Rose Hill and Tuscarora Formations
  - Om Martinsburg Formation
- Ordovician
  - Ob Bays Formation
  - Oih Liberty Hall Formation
  - Omo Effna, Lincolnshire, Whistle Creek, and New Market Formations
- DISCONFORMITY
- Upper Knox Interval (Ouk)
- Chepotepec Limestone (Oc)
- Copper Ridge Dolomite (Ccr)
- Elbrook Dolomite (Ce)
- Comarian



STRUCTURE SECTIONS OF THE MILLERS COVE AREA, VIRGINIA