

**GEOLOGY OF THE BIG WALKER MOUNTAIN-CROCKETT  
COVE AREA, BLAND, PULASKI, AND  
WYTHE COUNTIES, VIRGINIA**

by

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## INTRODUCTION

### Geography

The Crockett Cove area lies wholly within the Valley and Ridge province of the Appalachian Highlands. The Appalachian Highlands extend almost unbroken from central Pennsylvania southwestward to central Alabama.

Major topographic features of the Valley and Ridge province consist mainly of subparallel series of relatively high, narrow, sharp-crested linear ridges and narrower, relatively smooth-surfaced valleys that show karst topography. Ridges are held up by resistant clastic sedimentary rocks, such as quartz sandstones and conglomerates. The valleys are underlain by less resistant carbonates and shales. The majority of these valleys and ridges exhibit marked northeastward linearity.

Big Walker Mountain, the most prominent ridge in the Big Walker Mountain-Crockett Cove area, is upheld by orthoquartzites and hematite-cemented sandstones of Silurian age. These rocks dip toward the southeast at about 30 degrees. Big Walker Mountain is one of the most persistent ridges in the Valley and Ridge province and has a total length of over 100 miles in southwestern Virginia. Local variations in the strike of the rocks are responsible for minor shifts in the trend of the ridge. Big Bend is formed by a broad anticlinal cross-fold which plunges to the south and involves all of the rocks from the base of the Middle Ordovician to the top of the youngest Paleozoic rocks that are exposed in this particular strike belt. The maximum curvature of Big Bend coincides with the nose of the cross-fold.

Long Spur is formed by a relatively tightly folded anticline which plunges toward the east from the crest of Big Walker Mountain. The maximum elevation of the crest of Big Walker Mountain is 3984 feet above mean sea level at a point 2.9 miles east of Big Walker Look-out. The minimum elevation is approximately 3000 feet at the common corner of Bland, Giles, and Pulaski Counties near the northeastern corner of the Mapped area (Plate 1). The difference in elevation between the crest of the mountain and the adjacent valleys ranges from 700 to 1700 feet. The average local relief is about 1000 feet.

Little Walker Mountain which is upheld by Devonian and Mississippian sandstones and conglomerates is separated from Big Walker Mountain by a narrow, hummocky valley that is underlain by Devonian shales and siltstones which dip toward the southeast at approximately 30 to 35 degrees. The ridge is rather uneven-crested and ranges in elevation from 2700 to 3300 feet above sea level. This mountain first assumes its identity as Little Walker Mountain 3 miles east of the southwestern corner of the Crockett Cove area and is so identified for a distance of approximately 35 miles along strike to the northeast.

Browns Peak and Griffith Knob which are held up by gently dipping Mississippian sandstones and conglomerates are, in effect, a western extension of Little Walker Mountain. The terrain in the vicinity of these two mountains is greatly dissected and quite rugged. Local relief exceeds 1300 feet within a horizontal distance of less than one mile in some instances.

Cove Mountain and Crockett Cove are formed by a sigmoidal belt of strata which have been folded into a syncline and an anticline that

plunge to the northeast. The anticline, the more northern of the two folds, has been reverse faulted upon the strata which form the southern base of Little Walker Mountain. The southern limb of the syncline has been overturned and overridden by the carbonate rocks of the Pulaski thrust sheet. The Cambrian and Ordovician carbonate and shale sequence underlies Crockett Cove, whereas Silurian and Devonian sandstones and chert make Cove Mountain and its southwestern extension - Queens Knob. The rocks which form the cove and the mountain dip, in most instances, from 30 to 45 degrees southeast. Elevations range from 2200 to 3400 feet above sea level, but local relief seldom exceeds 800 feet.

Little Brushy Mountain lies southeast of Cove Mountain and is separated from it by a narrow valley underlain by Devonian shales and siltstones that dip approximately 45 degrees southeast. Little Brushy Mountain loses its identity about four miles east of Queens Knob as the Devonian and Mississippian sandstones and shales which cap it are concealed beneath the Pulaski thrust sheet. The total length of the mountain along strike is approximately ten miles. At the water gap formed by Eddys Branch, the mountain on strike with Little Brushy Mountain northeast is named Chestnut Mountain. The summit elevation of Little Brushy Mountain averages 2800 feet, whereas the adjacent valley floors average about 2200 feet above sea level.

#### Accessibility

Most of the area is readily accessible by means of federal, state primary and secondary, and private roads. The major highways

which cross the area in a north-south direction are U. S. Route 21-52 which links Bluefield, West Virginia, with Bland and Wytheville, Virginia; and Virginia Route 99 which links Mechanicsburg and Pulaski via Little Walker and Big Walker mountains. East-west access is afforded by Virginia Route 42 which traverses the length of the area in the valley between Brushy and Big Walker mountains. U. S. Route 11 is parallel to and follows a route located a few miles south of the southern border of the area.

The principal east-west secondary roads include Virginia Routes 610, 600, 601, and 617. North-south access is relatively limited, but travel on Virginia Routes 603, 712, 659, and 661 enables one to get within several miles of the mountain tops.

U. S. Interstate Highway 81 which is under construction will pass just south of the area and will essentially parallel the present course of U. S. Route 11. Interstate 77, to be built by 1970, will pass through the area in a north-south direction from Bland to Wytheville via the water gap between Queens Knob and Cove Mountain, over the crest of Little Walker Mountain near where Virginia Route 603 now crosses it, and to the north through Big Walker Mountain via a tunnel in the area just southwest of Bland.

#### Previous Work

No detailed mapping of the Big Walker Mountain-Crockett Cove area had ever been undertaken until the initiation of this study in 1960. M. R. Campbell's map of the Tazewell 30 minute quadrangle (1897) covered the area north of 37°00' north latitude on a

reconnaissance scale. Many of Campbell's formation names are now obsolete, some of the age designations were inaccurate, and contacts were only approximately located as the base map was of a small scale.

M. R. Campbell (1925) compiled a larger scale map (1:62,500) of the Valley coal fields of Virginia which contains the Big Walker Mountain-Crockett Cove area. The age designations are more nearly correct in Campbell's 1925 report, but the inadequacy of the base map effectively negated much of the accuracy of his work.

Charles Butts' (1940) map of the Appalachian Valley includes the Big Walker Mountain-Crockett Cove area on a reconnaissance scale of 1:250,000. As some of Butts' formation names have been discontinued or redefined and new names have been introduced since 1940, some revisions and more detailed work on modern large scale base maps have been needed for the past ten years.

#### Method of Study

Most of the area was mapped during the summer of 1960, and portions of the springs and summers of 1961 and 1964. Small areas were studied and mapped during several days of the intervening years.

The base map consisted of 2X photographic enlargements of portions of the Bland, Pulaski, Speedwell, and Max Meadows 15 minute topographic quadrangle maps of the U. S. Geological Survey and on U. S. Department of Agriculture 1:20,000 aerial photographs. The final copy of the base map was prepared by tracing the photo-enlarged sheets on a scale of 1:31,250 with a contour interval of 100 feet.

The map of the Bland window was prepared and mapped on superimposed tracings of an enlarged (3.33X) aerial photograph and an enlarged (about 10X) portion of the Bland quadrangle.

Sections were measured with a steel tape and Brunton compass. In some places representative samples of the rocks were collected and later studied as polished sections and hand specimens by binocular microscope. Thin sections of some rocks were also used to supplement the study.

Fossils were collected wherever their exact stratigraphic position could be determined and their state of preservation was good. Some silicified fossils were obtained by etching limestone slabs in baths of dilute acetic acid.

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## STRATIGRAPHY

### General Statement

The Big Walker Mountain-Crockett Cove area comprises two separate strike belts which, from north to south, are the Big Walker Mountain belt and the Crockett Cove belt. In most places the lithologies are similar enough to warrant the use of the same names for the formations in both belts. However, where notable differences are present and different formation names are applied, the formations in each belt are discussed separately.

Stratigraphic differences which are noted in the two belts resulted from somewhat different depositional histories in areas which were, at the time of deposition, probably farther apart than they are now. The Big Walker Mountain belt is part of the Saltville fault block whereas the Crockett Cove belt is separated from the Saltville block on the north by the Tract Mountain fault.

The most striking stratigraphic difference between the two areas occurs within the interval between the Knox-Middle Ordovician disconformity and the base of the Middle Ordovician Martinsburg Formation. Other stratigraphic differences that are less striking and not so amenable to study as a result of poor exposure and relatively difficult accessibility are also present and discussed in as much detail as possible.

All of the rocks in the area are sedimentary and Paleozoic in age and were deposited in the Appalachian miogeosyncline. The lower one-third of the sequence of beds is composed mainly of carbonate rocks and the upper two-thirds consists mostly of shales and impure sandstones. The formations range in age from Middle Cambrian to Early Mississippian.

Neither the oldest nor the youngest formation is exposed in its entire thickness because they are both involved in major faults which cut this area.

The Cambrian System, the base of which is not present as it lies concealed beneath the overthrust sheets, has a thickness of approximately 1500 feet and consists of dolomite in most places.

The Ordovician System is composed of carbonates in the lower two-thirds and mainly shale in the upper third. The upper part of the Ordovician is marked by the presence of red clastics which are overlain by nearly white orthoquartzites that comprise the basal Silurian.

The Silurian is the thinnest, but one of the most prominent systems in the area due to the fact that these hold up the major ridges in the area. The Silurian System is approximately 250 feet thick.

The Devonian System is characterized by brown-colored shales and impure sandstones that form the relatively poor lands south of Big Walker and Cove mountains. The total thickness of the Devonian is approximately 3500 to 4000 feet.

The Mississippian System, which the thrust sheets have overridden, is incompletely exposed. The Mississippian strata are composed of conglomerates, sandstones, and red and brown shales, and range from 150 to 600 feet in thickness.

Most of the rocks present in this area are of shallow water marine origin. The upper portion of the Ordovician, parts of the upper Devonian, and the coal-bearing portions of the Mississippian are of non-marine origin.

## Middle Cambrian Series

### Honaker Dolomite

Name. - The Honaker Dolomite, which was first described by M. R. Campbell (1897), was named from exposures near Honaker, Russell County, Virginia.

Distribution. - The Honaker crops out in both belts in the area. The northern limit of each belt is determined by the locations of the Saltville fault and the Tract Mountain fault which terminate the allochthonous blocks on which the Honaker is present. In general, the Honaker underlies the low-lying series of gently rolling hills that are cleared and used for farm and pastureland at the southern bases of Brushy and Little Walker mountains. The width of the belt of outcrop ranges from less than 0.3 to nearly 1.0 miles.

Lithology. - Dolomite is the predominant type of rock present in the Honaker. The most common type of dolomite is dull, medium to dark gray, medium grained and granular. The rock is commonly autobrecciated and the fractures are filled with white sparry secondary calcite. Where the rock crops out and is weathered, it is quite blocky. The ledges of the Honaker are commonly about three to four feet thick and in most places are coated with a thin dark-gray crust of soft calcareous silt.

The Honaker contains two other types of dolomite which are common, though not so abundant as the previously described variety. The beds in the upper part of the formation are generally medium gray and fine grained. Freshly broken surfaces of this rock emit a faintly fetid odor. The beds in the middle part of the formation are light gray to white, fine grained and granular. These latter two types of dolomite are commonly micro-laminated.

The best exposures of the Honaker are along Virginia Route 42 which runs to the northeast and southwest from Bland. Other good exposures are on Bland County Routes 603, at the base of Little Walker Mountain, and 667 which leads from Virginia Route 42 to the Bland Correctional Farm near White Gate.

Geologic section 1. -- Honaker Formation along Virginia Route 42 and Bland County Road 608 at Point Pleasant, Bland County, Virginia

	Thickness in feet
Nolichucky Formation	
Honaker Formation (1,005 feet)	
9. Dolomite, medium brownish-gray, coarse-grained, granular; a single three foot-thick ledge exposed .....	3
8. Dolomite, light-gray to white, coarse to very coarsely crystalline; contains a few irregular vugs that are surrounded by a reddish-brown stain of iron oxide; approximately one-fourth of the interval consists of interbeds of dolomite, light- to medium-gray, fine to very finely crystalline, laminated; weathers to one to three inch-thick ledges; approximately 75 per cent of the interval is covered .....	145

Geologic section 1. cont.

	Thickness in feet
7. Dolomite, light-gray, finely crystalline, laminated; weathers into 6 to 12 inch-thick ledges; a few thin interbeds of white, coarsely crystalline dolomite .....	21
6. Dolomite, medium-brownish-gray, medium to coarsely crystalline; contains a few thin interbeds of light-gray to white coarsely crystalline dolomite that weather to four to eight inch ledges .....	61
5. Dolomite, light-gray, very finely crystalline; laminated; weathers to one to three inch ledges; autobrecciated .....	87
4. Dolomite, light brownish-gray, medium to coarsely crystalline; weathers saccharoidal ....	5
3. Dolomite, medium brownish-gray, fine to medium crystalline; autobrecciated; fractures healed with white calcite; weathers into two foot ledges; generally lighter color near top and laminated .....	45
2. Dolomite, very light-gray to creamy-white, finely to very finely crystalline compact texture; irregular wavy and crinkly laminae; weathers into ledges that are two inches to two feet thick .....	40

Geologic section 1. cont.

Thickness  
in feet

- 1. Dolomite, interval to base covered and  
disturbed by faulting adjacent to  
Saltville Fault ..... 600

Fossils. - No fossils were found, despite attempts to find them, in the Honaker in either of the two belts of exposure. However, B. N. Cooper (1944, p. 19) reported a fauna of trilobites and brachiopods from the lower 200 feet of the Honaker near Wittens Mills in Tazewell County, Virginia. For the most part, these fossils were found in shale and limestone partings. As the amount of limestone present in the Honaker in the Big Walker Mountain-Crockett Cove area is very small, the possibility for finding recognizable fossils is reduced and hindered due to the absence or cover of the lower part of the Honaker in most places.

Age and correlation. - The apparent absence of fossils complicates the task of assigning an accurate age to the Honaker in this area. However, Butts (1940, p. 74) states that it is equivalent to the lower and larger part of the Elbrook Dolomite and is at least partially of Middle Cambrian age. Cooper (1944, p. 19) assigned it to the Middle Cambrian and correlated it with the Rutledge Limestone, Rogersville Shale, and Maryville Limestone of the area southwest of the type area of the Honaker.

Cooper (1961, p. 26) states that the Honaker is equivalent to a major portion of the Elbrook, but that the latter also includes younger beds of Dresbachian age. In the area of this report the base of the Honaker is not present, but the overlying Nolichucky Formation which

contains abundant identifiable fossils has been assigned Dresbachian age by Moon (1961) in Giles County just a few miles along strike to the northeast of Mechanicsburg.

Stratigraphic relations. - The Nolichucky Formation overlies the Honaker with apparent conformity. In a few places, notably at some locations along Virginia Route 42 southwest of the Giles-Bland County line in the northeastern portion of the area and along Wythe County Road 658 along St. Lukes Fork in Wythe County, the basal portion of the Nolichucky is difficult to distinguish from the uppermost beds of the Honaker.

#### Upper Cambrian Series

##### Nolichucky Formation

Name. - The Nolichucky was named by Keith (1896, p. 2) for exposures of shales and limestones which lie between the Maryville Limestone and the Knox Dolomite in Greene County, Tennessee, along the Nolichucky River.

Lithology. - The Nolichucky is commonly called a shale rather than a "formation". However, in the area of this report the unit consists mainly of carbonate rock rather than shale. The predominant type of carbonate is dolomite, but there are a few beds of impure limestone present. Where the rock is fresh, it is commonly drab-steel-gray, fine grained, and irregularly laminated. Where the rock has been weathered, it consists of a bright orangish-yellow, thinly bedded residue of weakly cemented silt. One-half mile north of Fairview Church on Wythe County Road 659 trilobite fragments are common on many of the weathered surfaces and the impressions are so abundant on some bedding surfaces

that it is difficult to distinguish individual fossils. In the Bland area the Nolichucky contains a few beds of medium olive-drab shale. The thickness of the Nolichucky is approximately 100 feet in the Big Walker Mountain belt and less than 75 feet in the Crockett Cove belt. Eight miles southwest of the northwest corner of the mapped area the Nolichucky is approximately 150 feet thick near Ceres, Bland County (Cooper, 1944, p. 21). Southwest of Bland the amount of limestone in the Nolichucky is greater, whereas to the northeast the amount of shale and dolomite is greater.

Geologic section 2. -- Nolichucky Formation along Mill Creek and Bland County Road 608 near Point Pleasant, Bland County, Virginia

	Thickness in feet
Copper Ridge Formation	
Nolichucky Formation (77 feet +)	
7. Dolomite, dark bluish-gray, very finely crystalline, in irregular blocky-weathering ledges one foot thick; calcite-filled fine fractures .....	7
6. Magnesian limestone, dark bluish-gray, very fine-grained; wavy silt laminae; weathers into ledges that are from two to eight inches thick .....	19
5. Dolomite, dark-gray, medium crystalline, one bed .....	4

Geologic section 2. cont.

	Thickness in feet
4. Dolomite, light-tan to medium-gray, finely crystalline; laminated; forming even ledges one to five inches thick .....	6.5
3. Magnesian Limestone, medium- to dark-steel-gray, fine- to very fine-grained, silty; weathers to drab brownish-gray 0.1 inch-thick slabs; wavy laminae .....	12
2. Limestone, medium brownish-gray, fine-grained; intraformational conglomerate of subrounded pebbles of yellowish-tan, fine-grained, silty dolomite; a few fragments of inarticulate brachiopods and probable trilobites .....	0.5
1. Magnesian limestone and limy dolomite, medium-drab to greenish-gray, less than five inch ledges; a few beds have been partially reworked and contain disturbed, crinkly laminae of dark gray, medium crystalline dolomite. Unidentifiable trilobite fragments at 10 to 20 feet above base of unit; fossils occur as impressions on leached yellow silty bedding surfaces .....	28.5

Honaker Dolomite

Distribution. - The Nolichucky is present in both belts of outcrop. The most common topographic position of the formation is on the northwest, or outcrop, slope of the low, prominent ridge which lies just southeast of the Saltville fault and the Tract Mountain fault. The formation extends across the entire length of the Big Walker Mountain belt. In the Crockett Cove belt the formation is terminated by the Tract Mountain fault at both its southwestern and northeastern extremities. The Nolichucky is no where more than 0.25 miles south of Virginia Route 42 at any location in the northern belt.

Fossils. - The Nolichucky is abundantly fossiliferous at several localities within the area. The most fossiliferous locality is on the western side of Wythe County Road 659, 0.5 miles north of Fairview Methodist Church in Crockett Cove, Wythe County, Virginia. The following is a list of trilobites collected by the writer and tentatively identified by Mr. J. R. Derby, formerly of the Department of Geological Sciences at the Virginia Polytechnic Institute, from the Nolichucky at the Fairview locality:

Blountia sp.

Coosia sp.

Crepicephalus buttsi Resser

Terranovella sp.

Moon (1961) found trilobites identified by J. R. Derby that include Llanoaspis, Cedaria, and Crepicephalus in the Nolichucky of the Big Walker Mountain belt in the Poplar Hill area, Giles County, Virginia, which is 15 miles northeast of the Big Walker Mountain-Crockett Cove area.

J. R. Derby, who has recently (1965) completed a study of the stratigraphic and paleontologic aspects of the Nolichucky in southwestern Virginia and Tennessee, has made collections in both the belts of exposure in this area. B. N. Cooper (1944) reported the occurrence of Crepicephalus, Coosia, Dicellomus, and Holstonia in the Walker Mountain belt just a few miles west of the western edge of the mapped area.

Age and Correlation. - The Nolichucky Shale is assigned to the Dresbachian stage of the Upper Cambrian series (Howell and others, 1944, chart 1). B. N. Cooper (1944, p. 23) found that the Nolichucky of the Burkes Garden quadrangle was equivalent only to the middle and upper portions of the type section in Tennessee. Stratigraphic equivalents in the Appalachians include the upper Elbrook Formation and parts of the Conasauga Shale (Howell and others, 1944; B. N. Cooper, 1944). J. R. Derby (personal communication) has used fossils to tentatively correlate the Nolichucky of Crockett Cove with the Dresbachian stage.

#### Cambrian and Ordovician Systems

##### Knox Group

Name. - The first usage of Knox as a stratigraphic term was by J. M. Safford (1869). The term was originally used to describe a thick succession of sandstones, shales, and dolomites of Cambrian age in Knox County, Tennessee. However, the term has been used by later workers in the Appalachians to denote the interval of strata that lie between the top of the Nolichucky and the base of the Middle Ordovician Chazy Group (see B. N. Cooper, 1961, p. 26).

Usage of the term Knox in this study. - The Knox of this part of the Appalachians contains probable equivalents of the Copper Ridge, Chepultepec, Longview, Kingsport, and Mascot formations of Tennessee (B. N. Cooper, 1961, p. 26-31). In some areas, such as in the Crockett Cove belt, the Copper Ridge Formation which is the stratigraphically lowest formation in the Knox Group is sufficiently well exposed to be mapped separately. The overlying formations of the Chepultepec-Mascot interval are rarely mappable in this part of the Appalachians on maps of comparatively small scale. Where the Copper Ridge can be accurately delineated and mapped, it seems appropriate to do so.

However, where the Copper Ridge Formation is mapped separately, the usage of the term Knox Group for the Chepultepec through Mascot interval is not, in a strict sense, completely applicable.

The Knox Group is used in accordance with its strict definition, that is it includes Copper Ridge through probable Mascot equivalents, in the Big Walker Mountain belt. However, as this usage of Knox is not, in the most strict sense, followed in the Crockett Cove belt because the Copper Ridge can be mapped separately, the name Knox Dolomite is applied in a restricted sense. Therefore, the unit which overlies the Copper Ridge Formation and includes probable equivalents of Chepultepec, Longview, Kingsport, and Mascot of Tennessee is shown on the map in Crockett Cove as Knox Dolomite (restricted) and keyed to the symbol Okd.

In the discussion of stratigraphy in the text that follows, beds of probable Copper Ridge equivalence in both belts are discussed under the same heading even though the top of the formation cannot be mapped accurately in the Big Walker Mountain belt.

### Copper Ridge Formation

Name. - E. O. Ulrich (1911) first named the Copper Ridge for exposures on the ridge of the same name in the northwestern part of Knox County, Tennessee.

Distribution. - The Copper Ridge is exposed in both belts of outcrop in this area. The formation crops out on the dip slope of the low, prominent ridge which runs southeast of, and parallel to, the Saltville and Tract Mountain faults. The width of exposure ranges from 0.25 to 0.40 miles in the Crockett Cove belt and from 0.5 to 0.75 miles in the Big Walker Mountain belt. The Copper Ridge is mapped separately only in the Crockett Cove belt.

Lithology. - The Copper Ridge is relatively poorly exposed in most of the area. For this reason, it is difficult to determine the precise lithologic characteristics of the formation. Where sufficient exposures are available for study, the most common rock observed is dolomite. Medium- to coarse-grained quartzose sandstones that weather to bright yellowish-brown friable sand are the most distinguishing feature of the formation. The amount of chert present in the Copper Ridge is significant, but much less than the amount present in stratigraphically higher units of the Knox Group. Very little limestone is present in the Copper Ridge.

The dolomite, which comprises approximately 85 to 90 per cent of the formation, is usually either light-gray and medium crystalline or medium-gray, medium crystalline and saccharoidal-weathering. Much of the dolomite is laminated with silt and stringers of quartz grains. The rock shows many features which are characteristic of beds deposited in a

shallow water environment. The evidence for a shallow water environment of deposition includes ripple marks, mud cracks, slump structures, and cross stratification which is especially prevalent in the sandstone members of the succession.

In the Crockett Cove belt the thickness of the formation averages 1,000 feet. The thickness in the Big Walker Mountain belt is approximately 1,000 feet in the southwest and approximately 1,300 feet in the north-east. The thickness of the formation is generally greater in the northwestern belt than in the southeastern belt. In Crockett Cove the basal sandstone beds range from 40 to 50 feet thick, whereas the probable equivalent beds in the Big Walker Mountain belt are from 20 to 30 feet thicker. Although no continuously exposed sections are present in this area, several attempts were made to measure sections of the Copper Ridge.

Geologic section 3. -- Copper Ridge Formation along St. Lukes Fork and Wythe County Road 658 in Crockett Cove, Wythe County, Virginia

	Thickness in feet
Knox Dolomite (restricted)	
Copper Ridge Formation (987 feet)	
10. Sandstone, light creamy-yellow to tan, quartzose, coarse-grained; less than three inch to laminated beds; cross laminated; weathers to bright orangish-yellow, friable, 2.5 foot ledges .....	38

Geologic section 3. cont.

	Thickness in feet
9. Covered interval composed mostly of dolomite, light-gray, medium crystalline, cherty .....	146
8. Dolomite, interbedded light- and dark-gray, medium crystalline; irregularly bedded, weathers to 2 inch to 18 inch ledges .....	53
7. Covered interval; float of deeply weathered chert, dolomite, and friable sandstone .....	514
6. Dolomite, light- to medium-gray, medium to coarsely crystalline, saccharoidal-weathering .....	92
5. Dolomite, light-gray, medium crystalline, laminated .....	62
4. Sandstone, quartzose, rusty-yellow-weathering, coarse-grained .....	4
3. Dolomite, light- to medium-gray, medium crystalline .....	21
2. Sandstone, quartzose, medium pinkish-gray, medium- to coarse-grained; dolomitic cement; weathers to two foot-thick ledges .....	16
1. Transitional beds between Nolichucky and Copper Ridge; composed of dolomite, mostly medium- to dark-gray with a few light-gray beds, medium crystalline; lowermost beds are laminated; weathers to ledges that are one foot thick .....	41

Nolichucky Formation

The best exposures of the Copper Ridge sandstones are, for the most part, limited to roadcuts. Among the best exposures along roads, the following are noteworthy: the portion of Wythe County Road 658 which parallels the course of St. Lukes Fork, along Wythe County Road 659 just northwest of Fairview Church; along Bland County Road 604 just south of Bland, and along Bland County Road 634 approximately 0.75 miles south of Mechanicsburg. The basal sandstone in the Copper Ridge is exposed in the bed and along the banks of the stream that flows southeast from the junction of U. S. Routes 21-52 and Virginia Route 42.

Fossils. - There are no known fossils in the Copper Ridge of this area except for a few specimens of Cryptozoon.

Age and correlation. - Determination of the age of the Copper Ridge presents a problem as there are no fossils within it or in beds immediately above it. B. N. Cooper (1944) lists its age as Franconia-Trempealeau-Jordan of the Late Cambrian type section. Butts (1940) and Cooper (1961) correlated the Copper Ridge with the Conococheague Limestone of the southeastern belts of outcrop in the Great Valley of Virginia. In the Crockett Cove area the approximate upper limits of the formation are set between the last appearance of sandstone in the dolomite sequence and the first definite beds of limestone above the sandstone. This boundary probably is not consistent enough to be used for mapping of very large areas that embrace several strike belts, but in an area as small as Crockett Cove the variations in thickness and, probably, the stratigraphic equivalence of the included units are not

too great and the method serves as a satisfactory tool for subdividing an otherwise large, monotonous sequence.

The Copper Ridge is poorly exposed in the Big Walker Mountain belt and, therefore, the formation was not mapped separately in that belt. Attempts to locate and map the contact between the Copper Ridge and the overlying formation were unsuccessful in most places.

Stratigraphic relations. - The contact between the Copper Ridge and the underlying Nolichucky is probably conformable as the basal beds of the Copper Ridge contain no positive evidence of any period of erosion or marked disturbance after the deposition of the Nolichucky and during the deposition of basal Copper Ridge beds. The relatively clean nature of the quartz sand in the beds of the Copper Ridge may be an indication that the source area of these sediments was not undergoing any rapid uplift or the basin of deposition was not being subjected to any markedly strong subsidence. On the contrary, the presence of primary features such as ripple marks and mud cracks indicate a shallow water regimen of deposition in both the Upper Nolichucky and the entire sequence of the Copper Ridge seems to indicate a transitional contact.

The upper contact between the Copper Ridge and the overlying Knox Dolomite (restricted) in Crockett Cove and the remainder of the Knox Group in the Big Walker Mountain belt is probably transitional as the basal beds of the Knox were apparently deposited in an environment not too unlike that of the Copper Ridge.

### Knox Group and Knox Dolomite (restricted)

Name. - The nomenclature and definitions of the Knox as it is used in this report have been previously discussed on page 18. Lower beds of the Knox Group in the Big Walker Mountain belt are discussed with the Copper Ridge Formation because of their lithologic similarity to the same formation in the Crockett Cove belt.

Distribution. - The valley at the northwestern base of Big Walker Mountain is equivalent to Rich Valley of areas to the southwest and is underlain, for the most part, by the Knox Group. The northern side of the Crockett Cove valley is also underlain by the Knox. Generally, the land which is used for the pastures and growing of corn is underlain by the Knox. The land used to grow produce and for orchards is usually underlain by the Middle Ordovician limestones. In most places the lower part of the Knox has remained forested despite clearing of other valley lands. The farm access roads that trend parallel to strike are located within a few hundred feet of the top of the Knox. Good exposures of the Knox are located along Bland County Road 617 between its junction with Virginia Route 42 and its junction with Bland County Road 616, 3.75 miles southwest of Bland. Other good exposures are along the banks of Walker Creek south of Crandon and Mechanicsburg. In Crockett Cove the Knox is relatively well exposed along Wythe County Roads 603, 658, and 659 in the western end of the Cove.

Lithology. - Dolomite forms about 70 per cent of the Knox Group and the restricted Knox Dolomite. Chert probably accounts for 10 per cent of the formation; limestone forms the remaining 20 per cent. Knox limestones

are limited, for the most part, to the Chepultepec and Longview parts of the Knox succession.

The most common type of dolomite present is light tan to bluish-gray and medium grained. There are a few beds of dark-gray, very finely crystalline almost glassy-textured dolomite that emits a faintly fetid odor from freshly broken surfaces. All of the dolomites have a rough, walled and deeply furrowed surface on weathered exposures.

The chert in the Knox is most common as nodules that are generally less than 2 x 4 x 6 inches in size and are of light-gray color. In a few places, notably Unit 16 of Geologic Section 4, bedded chert is present. The bedded chert is generally light creamy-gray and has a rough gnarled surface. The thickness of individual chert beds is usually less than two feet.

Limestone in the Knox is generally of two distinct types. The first and more abundant is a pelmicrite that is light greenish- to brownish-gray and contains abundant stylolitic seams of greenish-gray to light brownish-red mottled clay. The second type of limestone, though not so abundant, is more widely distributed than the first. The color is generally bluish-gray and the grain size is somewhat coarser even though the rock ranges from a pelmicrite to intramicrite. The second type of limestone is more dolomitic or magnesian than the first. This type of limestone is characterized by edgewise conglomerates and is intimately associated with and intermixed with a type of calcitic dolomite such as described in Units 7 and 11 of Geologic Section 4.

The presence of edgewise conglomerates, interlaminated limestone and dolomite, slump structures, and other features of disturbed bedding

indicate that the Knox was deposited in shallow water.

Geologic section 4. -- Knox Group measured along St. Lukes Fork and Wythe County Road 658, four miles north of Wytheville, Wythe County, Virginia

	Thickness in feet
Giesler Limestone	
Disconformity	
Knox Group (1,307 feet)	
33. Dolomite, medium-gray, medium crystalline; laminated; interbedded with light-gray chert that is exposed in up to three foot ledges .....	95
32. Dolomite, calcitic, light-gray, finely crystalline, cherty .....	3
31. Covered interval, mainly dolomite as above .....	14
30. Limestone, light brownish-gray, pelmicrite; nodular; laminae of greenish-gray silt and clay .....	3
29. Dolomite, dark-gray, medium to coarsely crystalline; interbedded with light-gray to nearly white, medium crystalline dolomite; cherty; weathers to one foot-thick furrowed ledges .....	121
28. Mainly covered interval; chert and dolomite float .....	14

Geologic section 4. cont.

	Thickness in feet
27. Limestone, light brownish-gray, pelmicrite, weathers to less than four inch slabs .....	20
26. Dolomite, dark brownish-gray, coarsely crys- talline, weathers saccharoidal .....	5
25. Dolomite, dark bluish-gray, medium crys- talline .....	10
24. Limestone, light brownish-gray, pelmicrite to intramicrite; weathers to one foot-thick, blue-gray ledges, weathered surfaces show <u>Lecanospira</u> .....	3
23. Dolomite, medium-gray, coarsely crystalline ....	3
22. Limestone, as unit 24 above .....	10
21. Limestone, as above, contains scattered white chert nodules in upper two feet .....	44
20. Limestone, light- to medium-gray, pelmicrite and intramicrite .....	4
19. Limestone, as unit 24 above .....	55
18. Dolomite, light-gray, finely to coarsely crystalline, interbedded; weathers saccharoidal; less than 10 per cent white chert nodules; contains one eight inch bed of medium crys- talline dolomite with floating quartz grains 23.75 feet above base .....	64

Geologic section 4. cont.

	Thickness in feet
17. Chert, bedded, light-gray, rough-surfaced, irregular ledges two feet thick .....	13
16. Covered interval .....	2
15. Dolomite, light-gray to medium-gray, finely crystalline, some beds are laminated, weathers to one foot-thick ledges .....	49
14. Covered interval, bedrock is probably dolomite, as above, and light-gray chert .....	147
13. Dolomite, light- to medium-gray, finely crystal- line to aphanocrystalline; contains irregularly shaped nodules of white "cauliflower" chert; laminated, weathers to one foot in thickness ...	108
12. Dolomite, light-gray, finely crystalline .....	5
11. Dolomitic limestone and limy dolomite, dark- gray to dark bluish-gray, finely crystalline; intermixed in interbedded and interlaminated beds as ridges of honeycombed network of dolo- mite that encloses small patches of limestone; few beds of intraformational conglomerate; black chert as pebble-sized nodules .....	68
10. Covered interval; probably same as above .....	21
9. Limestone, bluish-gray, pelmicrite, inter- bedded with dolomite, medium-gray, finely crystalline; weathers to two foot ledges .....	18

Geologic section 4. cont.

	Thickness in feet
8. Dolomite, medium-gray, finely crystalline .....	8
7. Dolomitic limestone, intramicrite, bluish-gray, laminated in two foot ledges .....	8
6. Dolomite, dark-gray, medium crystalline, silty .....	8
5. Dolomitic limestone, intramicrite, bluish-gray .....	22
4. Dolomite, light to medium-gray, medium crystalline; light-gray chert nodules .....	34
3. Dolomite, calcite-bearing, dark-gray, medium crystalline, laminated; weathers to less than four inch slabs; interbedded with magnesian limestone that is light bluish-gray, compact; laminated to three inch beds; ledges are generally 18 inches thick; scattered quartz grains in some of the upper beds of dolomite ...	82
2. Dolomite, medium-gray, medium crystalline, nearly 50 per cent of interval is covered .....	160
1. Dolomite, medium to light-gray, medium crystalline; laminated, ledges of two feet thickness; few beds of limestone intraformational conglomerate near base .....	36

Copper Ridge Formation

Fossils. - The Knox Group contains a sparse fauna that consists mainly of gastropods and cephalopods. Most of the fossils seen occur in loose fragments of chert as internal and external molds. Poorly preserved fragments of unidentifiable trilobites occur in beds of limestone in the basal beds of the formation. Calcite replacement fossils of gastropods are abundant in some beds of limestone near the middle of the succession. Most Knox fossils are found out of place but they can be useful in helping to recognize divisions in the group.

The gastropods present in the limestones near the top of the lower half of the Knox are identified as Lecanospira. Lecanospira is a rather characteristic Longview fossil and is present in limestone and associated cherts in both belts of the Knox Group in this area. Very good displays of Lecanospira-bearing limestones are present in Crockett Cove along St. Lukes Fork just south of Wythe County Road 600.

Cherts near the top of the Knox succession contain the gastropod Orospira sp. in the Crockett Cove belt near the Charles King farm at the northeast end on the valley. The identification of the poorly preserved fossil is a bit uncertain; but if the determination is correct then beds of Mascot equivalence are present in the Crockett Cove belt.

The cherts of the upper Knox in the Big Walker Mountain belt have yielded fair specimens of the gastropods Orospira and Hormotoma along U. S. Route 21-52 (Butts, 1940) and just a few feet below the Knox-Five Oaks contact in the fields south of Bland County Road 617 south of Bland. These fossils indicate a Late Canadian age for the Upper Knox in the Bland area as they are both characteristically present in beds of Kingsport-Mascot equivalence (Cooper, 1961).

Paleontological evidence for the age of the basal portion of the Knox is completely lacking in this area. Lithologically, however, the basal part of the Knox contains beds that are typical of the Chepultepec Limestone in other belts. At a quarry just off Montgomery County Road 785, two miles northeast of Blacksburg, Virginia, the lithologic character of the Chepultepec is quite similar to that of the basal Knox in the Bland-Mechanicsburg area and apparently has the same relative stratigraphic position. The Chepultepec of the Blacksburg area contains characteristic Lower Canadian fossils such as Finkelburgia virginica. Thus it is quite possible that basal Canadian beds are present in the Big Walker Mountain belt although proof of this will have to wait until paleontologic evidence is found. The precise location of the Cambrian-Ordovician boundary must remain uncertain within the Copper Ridge-basal Knox Group for the present.

#### Disconformity

The stratigraphic position of the contact between the top of the Knox and the base of the Champlainian Series is not the same everywhere. The cause of variation is the presence of an erosional unconformity at the top of the Canadian Series.

The disconformity is absent in many places in the Appalachian Province. Josiah Bridge (1955) studied the disconformity in the Douglas Lake, Tennessee, area and concluded that 140 feet of Knox beds were removed during a time of widespread, though not necessarily universal in extent, erosion. In the Burkes Garden quadrangle B. N. Cooper (1944) reported a local relief of as much as 400 feet on the top of the Knox.

Cooper (1935) noted the erosional contact at the top of the Knox in the Marion, Virginia, area. In the Draper Mountain, Virginia, area, Cooper (1939) noted up to 450 feet of local relief on the upper surface of the Knox.

In Rich Valley, Smyth County, Virginia, there is more than 450 feet of relief on the surface of disconformity and relatively large island-like inliers of Knox (up to one and one-half acres in area) which project as erosional remnants through the basal beds of the Champlainian Series. The amount of relief developed on the ancient Knox erosion surface in the Crockett Cove belt is probably relatively small and is measurable in terms of a few feet. However, in the Big Walker Mountain belt just south of Bland it is obvious that as much as 40 feet of cherty dolomite in the upper Knox has been removed by erosion within less than 200 feet along strike. Lack of exposures in the Knox Group prevents accurate study of the amount of relief that was developed on the Knox in most places in the Big Walker Mountain belt.

The association of conglomerates, breccias, and highly impure carbonates in the basal beds of the Chazy Group has been noted by many workers in the Appalachians (see Cooper, 1944, 1945, and 1961; Bridge, 1955; Webb, 1959; and Fisher, 1960). In the Crockett Cove area the amount of detrital material in the basal Middle Ordovician is extremely small and consists of no more than a few small, scattered granules and pebbles of chert and dolomite. In the Big Walker Mountain belt, however, there are several excellent exposures of basal breccias and conglomerates in the Five Oaks and Blackford. An especially noteworthy occurrence of

breccia is just north of the Halsley farm which is located about a mile south of Bland. At the Halsley farm the basal beds of Five Oaks limestone contain angular to subangular fragments of pebble to boulder-size chert and dolomite that was undoubtedly derived from the Knox. The local relief on the Knox in that locality is more than 25 feet.

The Knox-Middle Ordovician disconformity is one of the major breaks in the entire Paleozoic succession in the Appalachians. The most nearly complete records of deposition of Late Canadian and Early Champlainian units in the Appalachians are found in the troughs of synclines which, according to B. N. Cooper (1961, p. 33), were major depositional basins. Anticlinal crests were the site of the most profound erosion of the Knox (B. N. Cooper, 1961, p. 33-34).

B. N. Cooper and Josiah Bridge were the first to note and attach great significance to the break. The widespread occurrence of the break must be the result of an eustatic change in sea level in latest Canadian or earliest Champlainian time. During this time, there was widespread deposition of coarse clastic, Knox-derived, material that is represented by formations in the Appalachian region such as the Blackford, Tumbes, and the locally conglomeratic facies of the Mosheim and Lenoir. The detrital material was probably eroded from the exposed structural highs and deposited in local depressions and primary synclinal troughs and, in some places, left behind as deposits of lag gravel on the highs (B. N. Cooper, 1961, p. 33-34).

Champlainian Series of the Crockett Cove Belt

Mosheim Limestone

Name. - The Mosheim was named by E. O. Ulrich (1911) from exposures at Mosheim Station in Greene County, Tennessee. At the type section the Mosheim overlies the Knox Group and underlies the Lenoir. In 1956, B. N. Cooper and G. A. Cooper (Cooper, 1956) recognized the Mosheim as a part of the Lenoir Limestone belt that includes the type section.

Lithology. - The predominant type of rock present in the Mosheim in the Crockett Cove area is light brownish- to bluish-gray sparsely fossiliferous, pelletiferous, micrite. In a few instances the lithology approaches that of a dismicrite which is Folk's term used to describe the so-called typical birdseye limestones (Folk, 1959). Locally the rock contains small amounts of silt and clay which are distributed through the rock as yellow to dark-gray bands. Fossils in the rock occur as calcite-replaced fragments and include brachiopods and gastropods. The weathered rock is usually smooth-surfaced and forms rounded ledges two feet thick. The sparry calcite "eyes" weather more slowly than the microcrystalline calcite matrix and, consequently, the eyes stand out in relief on the weathered surfaces. In a few places the basal beds of the Mosheim are dolomitic and contain sparse fragments of Knox-derived chert and dolomite that seldom are larger than pebble size.

The Mosheim is present in most of the Crockett Cove area with the exception of the area northeast and southwest of the Joseph Kelley farm near the southwest end of Crockett Cove. At this locality the Mosheim

is absent for a distance of nearly a mile along strike. In the areas where the Mosheim is present its thickness ranges from 50 to 80 feet.

Distribution. - The Mosheim Limestone is exposed in an essentially unbroken belt that extends from the southern base of Queens Knob at the Crowgey farm to the northeast end of Crockett Cove where it is cut off by the Tract Mountain fault. There is no Mosheim present in the Walker Mountain belt.

Age and correlation. - The Mosheim is in the Marmorian Stage (Cooper, 1956). The only identifiable fossil present in the Mosheim of this area is the gastropod Maclurites magnus which occurs in rocks of White Rock and Marmorian age. The correlative formations in the Appalachians are the Tumblez, Blackford, and Lenoir Formations (see Cooper, 1956, Chart 1). In areas where the Mosheim and Lenoir are well exposed, such as in the Rich Valley area of Smyth County, Virginia, the two formations can be seen to intertongue, hence they are facies of each other.

#### Giesler Limestone

Name. - The name Giesler was introduced by B. N. Cooper (1961, p. 35) for beds of the middle and upper parts of the Lenoir Limestone where the lower Lenoir can be separated and mapped as Tumblez or Mosheim. The type section is at Giesler Mill, Washington County, Virginia.

Distribution. - The Giesler Limestone is present across the entire length of Crockett Cove and is well exposed at several localities. On the Joseph Kelley farm near the southwest end of the Cove the entire section of Giesler is well exposed. Good exposures may also be seen along Wythe County Road 600 in the vicinity of the Van-Mar Farms' White Oak Farm.

Lithology. - The Giesler Limestone at its type is described by Cooper (1961) as an "impure, crumbly limestone". This description is quite applicable to the Giesler in the Crockett Cove area. The limestone is typically dark brownish- to purplish-gray, emits a fetid odor from freshly broken surfaces, and contains numerous wavy laminae of black silt. The rock is a medium to coarse calcarenite and, where weathered, is quite crumbly and occurs in irregular slabby ledges. The rock contains poorly preserved fragments of brachiopods and gastropods that are silicified, but quite fragile. Some weathered surfaces are characterized by knobby projections of siliceous pebble-size ovoidal masses of fragmented bryozoans. The thickness of the Giesler reaches a maximum of 140 feet near the trough of the Queens Knob syncline on the Joseph Kelley farm and progressively thins so that it is absent near the crest of the Crockett Cove anticline at the Charles King farm.

Fossils. - The fossils present in the type Giesler include Mimella, Multicostella, Bumastus, Calliops, Billingsaria, and Maclurites magnus (Cooper, 1961).

Age and correlation. - The fauna of the Giesler at the type section is typical of that of the Chazy Limestone of New York (B. N. Cooper, 1961, p. 35). In the Crockett Cove area the fauna is essentially the same as that of the type area in Washington County in the southwest part of the Rich Valley strike belt. Butts (1940) cites the Crockett Cove area in his discussion of typical exposures of the Lenoir Limestone.

The Giesler is correlated with the middle and upper beds of the Lenoir (B. N. Cooper, 1961, p. 35) and, therefore, the formation is equivalent to portions of the Blackford and Tumbez in the Appalachians.

The age of the formation is Middle to Late Marmorian. In most areas the Giesler overlies the Mosheim with apparent conformity. However, the Mosheim is absent on the Joseph Kelley Farm and here the Giesler lies in direct superposition on the Knox Group. This place is near the trough of the Queens Knob syncline and the relation there may be explained by noting that the Giesler, which is poorly sorted and quite impure, may represent an influx of essentially petrologic "rubbish" into a local basinal trap. The Giesler is absent on the crest of the Crockett Cove anticline probably because marine currents swept away the accumulation of parent sediment and deposited it in the nearby synclinal downwarp.

#### Fetzer Limestone

Name. - The Fetzer was named by B. N. Cooper and G. A. Cooper (Cooper, 1961) from exposures of dark, impure, granular limestone at Fetzer Creek in Benton County, Tennessee. The original description of the formation includes it as a tongue of the Arline Limestone (Cooper, 1961).

Distribution. - The Fetzer Limestone is present in Crockett Cove in a thin eight-mile-long belt of from 25 to 50 feet width along the northwest base of Cove Mountain.

Lithology. - The outstanding feature of the Fetzer is its high degree of impurity. The rock is very silty and contains a sufficient amount of iron-bearing minerals to cause the limestone to weather into rusty brown, soft, crumbly ledges. The dark bluish-gray color of the rock is due, for the most part, to the abundance of finely divided, sulphide-bearing organic material which also is responsible for the fetid odor emitted by freshly broken rock. The Fetzer is a medium to coarse

calcarenitic, silty intrasparite. Weathered exposures of the limestone are commonly quite slabby whereas the fresh, unweathered rock most often occurs in thin irregular beds. The maximum thickness measured in the area is 25 feet. Generally the average thickness is from 10 to 15 feet and the greatest thicknesses are in the southwest end of the area near the trough of the Queens Knob syncline, whereas the thinnest sections are present to the northeast on the Crockett Cove anticline.

Fossils and correlation. - The Fetzer is abundantly fossiliferous throughout the entire area. Most of the fossils are, however, somewhat broken and abraded due to reworking and transport prior to deposition. Fossils that are most abundant in the limestone include crinoid columnals, gastropods, cephalopods, brachiopods, and trilobites. The state of preservation is poor in most instances and the best views of them are on weathered surfaces of the rock.

The Fetzer, which is a tongue of the Arline Limestone at the former's type section, is equivalent to the Effna Limestone and portions of the Rich Valley Formation as all of these units interfinger at various localities in the Appalachians (such as the Porterfield Quarry in Smyth County, Virginia) (Cooper, 1956). It is the equivalent of the "Whitesburg" Limestone as used by Butts (1940) in his studies of the Crockett Cove area where the Fetzer conformably overlies the Giesler Limestone. In the southwest end of the Cove near the trough of the Queens Knob syncline the Fetzer is conformably overlain by the Rich Valley Formation. However, it is probably absent in the extreme northeast portion of the area,

## Champlainian of the Big Walker Mountain Belt

### Blackford Formation

Name. - The name of the formation was originally proposed by Butts (1940) as a name for part of a limestone sequence which he mistakenly called the Murfreesboro Formation. In 1944, B. N. Cooper elevated the name to group rank and later (1948) raised it to the rank of formation. The type locality is at Blackford, Russell County, Virginia.

Distribution. - In the Big Walker Mountain belt the formation is present just southeast of the top of the Knox Group and extends from Effna in Bland County, northeast along the floor of the valley to the Giles County line and beyond.

Lithology. - Chert and dolomite fragments are common in the basal beds of the Blackford. The matrix of the basal conglomerate or breccia is generally light yellowish-gray, fine- to medium-grained, dolomitic limestone. The chert fragments are generally angular to subrounded pebbles, but in some places the size ranges to cobble and boulder dimensions. Detrital dolomite fragments are more rounded than the chert debris, and have a wider range of particle size. The upper and middle beds of the Blackford are generally finer grained and cleaner than basal beds. The limestones of the upper portion are intramicrites and pelmicrites that are light-gray to bluish-gray. Intercalations of granular-weathering dolomitic limestone are common throughout the entire succession of Blackford beds. The dolomitic limestones are generally fine grained, light bluish-gray, and weather into ash-gray thin slabs.

The thickness of the lower beds is quite variable, but usually averages about 15 feet and seldom exceeds 25 feet. The upper beds have

an average thickness of 10 to 40 feet. The Blackford has its greatest thickness adjacent to areas where the top of the Knox experienced the greatest amount of post-Canadian, pre-Chazy erosion. This suggests that the Blackford was deposited in trenches or sluiceways that were carrying debris off exposed highs downslope into lower areas. The best exposures of the Blackford are in the fields to the northeast and southwest of Bland County Road 603 south of Bland.

Age and correlation. - There are no identifiable fossils in the Blackford of the Big Walker Mountain belt. However, B. N. Cooper (1944) reported the presence of detrital Knox fossils in the basal beds of the Blackford in the Burkes Garden area. Cooper (1945) reported the occurrence of typical Chazy fossils in limestone intercalations of the red Blackford of Russell and Scott Counties, Virginia.

The Blackford is Middle to Late Marmorian age (Cooper, 1956). Elsewhere in the Appalachians the Blackford is equivalent to part or all of the Tumblez, Mosheim, Marcem, and Lenoir formations.

Stratigraphic relations. - The base of the Blackford forms the upper surface of the post-Canadian, pre-Chazy disconformity. The Blackford is conformably overlain by the Elway Limestone. In many places the contact between the Elway and the Blackford is transitional and difficult to map with certainty. As originally defined by Cooper (1944), the Blackford Member included beds that were later separated out and named the Elway Limestone. In the belt between Walker and Clinch mountains, Cooper (1944) called the basal unit of the Middle Ordovician succession the Blackford Formation and designated it as the lowest unit of the Clifffield Group. The latter term is no longer used (B. N. Cooper, personal communication, 1965).

### Elway Limestone

Name. - The Elway Limestone was named by B. N. Cooper (1945) from exposures at Elway, on U. S. Route 19, near Lebanon, Russell County, Virginia.

Distribution. - The Elway Limestone is relatively thin and poorly exposed in the Walker Mountain belt. Generally, the thickness of the formation is less than 25 feet and good exposures are rare. Indeed the presence of the Elway in most places can be inferred only by the loose blocky chert in the characteristically rocky soil which develops on the formation. There are fair exposures in the fields south of Bland County Road 617 and west of Bland County Road 603 on the Halsley farm.

Lithology. - The limestone of the Elway is light- to dark-gray intra-sparite that contains an abundance of black chert beds and nodules.

### Lincolnshire Limestone

Name. - The Lincolnshire was named by B. N. Cooper and C. E. Prouty (1943) from exposures near Lincolnshire Branch in Tazewell County, Virginia.

Distribution. - The exposures of Lincolnshire are present in a narrow strike belt that extends along the entire length of the base of Big Walker Mountain. In most places, the formation crops out either at the top of or on the dip slope of the low-lying ridge held up by the upper beds of Knox in the valley. Good though often incomplete sections are common. The best exposures are on the farm of M. H. Bowen, Jr., on Bland County Road 604 southeast of Bland; and the Halsley farm one mile southwest of the intersection of Bland County Roads 617 and 603. No Lincolnshire is present in the Crockett Cove belt.

Lithology. - The dark-gray color of the limestone and the abundance of black, blocky-weathering chert characterize the Lincolnshire. The rock is generally quite impure and granular, and contains many silty laminae which, after weathering, are responsible for the rock's having a cobbly to slabby appearance. The limestone is a silty intrasparite which, in some instances, approaches a biosparite, as a result of large numbers of brachiopod, bryozoan, and trilobite fragments. The irregularly bedded rock contains abundant nodules and lenses of black to dark-gray chert that in some places contain numerous impressions of brachiopod and gastropod shells. Locally, silicified brachiopods are abundant, but the shells are broken and abraded for the most part and, consequently, large numbers of individual shells must be studied in order to make satisfactory identifications. The soil profile developed on the Lincolnshire is typically a sticky, plastic clay which is characterized by a deep, almost blood-red color. This soil can, in most instances, be distinguished from the soil of the overlying Effna as the latter has a lighter brownish-orange color.

Fossils, age, and correlation. - Fossils were collected from the Lincolnshire on the farm of M. H. Bowen, Jr. located on Bland County Road 604, southeast of Bland. The fossils were etched by dilute acetic acid bath for a period of six weeks. The collecting place can be reached by travelling southeast four miles on County Road 604 from Bland to the Bowen farm where the Lincolnshire is exposed in the fields about 300 yards southwest of the family dwelling. The silicified fossils include the following:

Sowerbyites gildersleevi

S. triseptatus

Hesperorthis biconvexa

H. longirostra

Taphrorthis peculiaris Cooper

Monotrypa sp.

Batostoma sp.

The chert residuum from the Lincolnshire yielded a few molds of unidentified gastropods and brachiopods most of which included forms tentatively identified as Hesperorthis sp.

#### Champlainian Series Present in Both Outcrop Belts

##### Effna Limestone

Name. - B. N. Cooper (1944) gave the name Effna to a sequence of coarse limestones that had formerly been called "Holston" by Butts (1940) in the Bland-Smyth Counties area. The type section of the Effna is at the McNutt Quarry, near the village of Effna which is seven miles southwest of Bland, Bland County, Virginia.

Distribution. - In the Crockett Cove belt the Effna is present only on the farm of Charles King where it crops out in the fields just a few hundred feet south of Wythe County Road 600. The sole occurrence of the Effna in the Cove is limited to an elongate bioherm about 100 feet thick persisting for several hundred feet along strike.

In Rich Valley, which lies between Big Walker and Brushy mountains, the Effna occurs as a long, narrow strike belt which extends from the northwest corner of the mapped area to the northeast across the entire width of the area. The limestone generally crops out at the base of and along the dip slope of the first low ridge northwest of the base of Big Walker Mountain.

Lithology. - The Effna in the Crockett Cove belt is a bioherm that is composed of light-gray to white biomicrite and biosparrudite. Algal and coral debris comprise the bulk of the fossils present in the reef, but there are large numbers of bryozoans, trilobites, crinoid columnals, and gastropods present. The algal and coral-bearing portions of the limestone consist of wavy laminated biomicrite and dolomitic biomicrite, respectively. Lenses and tongues of biosparrudite comprise less than 45 per cent of the Effna. At the base of the reef rock, intertongues of dark limestone which is lithologically similar to the Arline and Fetzer are present. The dark limestones of the overlying Rich Valley Formation dip steeply off the flanks of the reef and locally show primary disturbed bedding and slump structures.

In the Walker Mountain belt the Effna is composed of several types of distinctive limestone. In a few places, such as in the fields southwest of the end of Bland County Road 622 near Effna, the rock is a light-gray biosparrudite and probably represents a reworked deposit of biolithite. Elsewhere, the rock is generally medium-gray, medium grained intrasparite and biosparite. A few occurrences of dark shale partings between irregular slabby beds of bryozoan biomicrite were noted in the basal one-third of the Effna in the extreme southwestern portion of the Big Walker Mountain belt. The thickness of the Effna decreases rather uniformly to the northwest.

The maximum thickness of the Effna is five miles southwest of Bland about 0.25 miles west of the abrupt curve in Bland County Road 617. The section is 160 feet thick. The minimum thickness is less than 80 feet on the farm of J. S. Penley, 2.5 miles southwest of Crandon 100 yards north

of Bland County Road 608. In Crockett Cove the maximum thickness is slightly less than 100 feet.

Fossils, age, and correlation. - Butts (1940) lists six good localities for collecting fossils from the so-called "Holston" in Virginia. Three of the Butts' localities are located within the area of this report and a fourth, the McNutt Quarry, is just outside of the area. The John Grayson farm is located five miles southwest of Bland on Bland County Road 617 at the locality given in the preceding paragraph. The Hoge and Waddle farms are located southwest of the old Grayson farm and northeast of the McNutt Quarry. Although Butts (1940) gives the location of the Hoge farm as being southwest of the Grayson farm in one instance (p. 151) and southeast of Bland in another instance (p. 152) it is likely that the locality to which he refers is located just north of U. S. Route 21-52 1.5 miles south of its junction with Virginia Route 42 near the base of Big Walker Mountain. The Waddle farm locality is probably just at the northwest terminus of the mapped area on the abandoned farm which is located at the western end of the private road that turns west off Bland County Road 622 0.5 miles south of Effna.

The fossils that have been collected by Raymond (1925) and Willard (1928) indicate that the age of the Effna in the area of this report is early Porterfieldian. The formation is equivalent to portions of the Arline, Rockdell, Rich Valley, Botetourt, and Paperville formations in other areas of the Appalachians (G. A. Cooper, 1956, Chart 1).

#### Rich Valley Formation

Name. - The Rich Valley Formation was named by B. N. Cooper and G. A. Cooper (Cooper, 1956) from exposures of black graptolite-bearing

limestones and shale in Rich Valley, Smyth County, Virginia. It is the old "Athens" of Butts (1940) and Decker (1951).

Distribution. - The Rich Valley Formation is present in both belts of outcrop in the area. It crops out as a long, narrow belt that is confined to the low-lying, trough-like depression immediately north of the outcrop slopes of both Cove and Big Walker mountains. Good exposures are relatively rare, but in Crockett Cove the formation is well exposed along Wythe County Road 603 just north of the gap in Cove Mountain. The fields to the northeast of Wythe County Road 603 have good exposures of basal Rich Valley limestones. In the Walker Mountain belt exposures are quite small in areal extent and seldom reveal more than 20 or 30 feet of section. Exposures of shale beds within the Rich Valley are virtually absent except near the trough of the Queens Knob syncline in the fields north of Wythe County Road 600 in the vicinity of Fairview Church. The lowermost 30 to 50 feet of the Rich Valley Formation are usually exposed where the Effna makes bold outcrops on the Walker Mountain belt and the Rich Valley crops out at the top of and on the adjacent dip slope. The Rich Valley Formation is well exposed on the J. S. Penley farm located on Bland County Road 608, 3.5 miles south of Mechanicsburg.

Lithology. - The color of the Rich Valley Formation is its most diagnostic feature. Most of the beds are dark gray to black, but chocolate brown sulphide-bearing shales are present in some places in the southwestern end of Crockett Cove. Chert is practically absent except for a few black nodules that occur in the basal beds on the Charles King farm at the northeast end of Crockett Cove. Most of the rock in the formation

is black, coarse calcilutite, intramicrite with interlaminae and thin intercalations of dark-brown shale and silt. The beds are remarkably even-bedded in generally four to eight inch beds which, as weathering progresses, become thin and slabby and eventually are altered to a light yellowish-brown silty residuum. Beds of shale in the Rich Valley Formation must be inferred by the lack of exposure for wide intervals and the abundance of shale chips in the residual soil. It is estimated that the amount of limestone in the formation in the Crockett Cove belt is approximately 60 per cent, whereas in the Walker Mountain belt limestone probably makes up less than 50 per cent of the sequence. In both belts limestone is most abundant in the upper and lower thirds of the formation.

Fossils, age, correlation, and stratigraphic relations. - Butts (1940,

p. 156-158) and B. N. Cooper (1944, p. 66) list about 75 genera and species of mostly trilobites and brachiopods from nearly black, highly impure, slabby-weathering biosparites at the McNutt Quarry and the Grayson farm in the Bland area. At both of these places the dark limestones occur between beds of the typical Effna and rather typical Rich Valley lithologies. These granular limestones were called "Whitesburg" by Butts (1940). However, B. N. Cooper and G. A. Cooper (see G. A. Cooper, 1956) note that a similar limestone of the same relative position in the Porterfield Quarry is "full of Rich Valley fossils". Therefore, on the basis of the lithology and the apparent transitional nature of these black limestones, the writer mapped these beds at the base of the Rich Valley Formation. The writer recognizes the apparent equivalence of this unit to parts of both the Rich Valley and Effna formations.

The writer collected Glyptorthis cf. G. glypta Cooper from the basal beds of the Rich Valley Formation at the base of Big Walker Mountain, just north of Bland County Road 738. The fossils in the Rich Valley Formation indicate that it is Porterfieldian (G. A. Cooper, 1956, Chart 1). The Rich Valley (old "Athen" of Butts) has been correlated with portions of the Paperville, Effna, Botetourt, Liberty Hall, and Arline formations in the Appalachians (G. A. Cooper, 1956, Chart 1). Most of these formations interfinger with the Rich Valley Formation in areas such as at the Porterfield Quarry, near Saltville, Smyth County, Virginia. The overlying Chatham Hill Formation also probably inter-fingers with the uppermost beds of the Rich Valley. In the Big Walker Mountain-Crockett Cove area the upper part of the formation apparently is transitional with the basal beds of the Chatham Hill Formation.

Geologic section 5. - Rich Valley, Chatham Hill, and Witten Formations on the J. S. Penley farm, 2.5 miles southeast of Point Pleasant, Bland County, Virginia

Thickness  
in feet

Moccasin Formation

Witten Limestone (301 feet)

31. Limestone, light brown to tannish-gray and light pinkish-maroon interbedded with a few salmon pink ledges that range from 6 to 24 inches thick, intramicrite, very fine calcarenite to medium calcilutite, in part reworked to pebbly-textured calcirudite

Geologic section 5. cont.

	Thickness in feet
that forms ledges eight inches thick.	
All beds are hard and dense and break with conchoidal fracture; interference ripple marks on several bedding surfaces .....	18
30. Limestone, light grayish-brown, intramicrite, fine calcilutite, irregular network of anastomosing reddish-brown silt laminae in basal four feet. Upper eight feet is light maroonish-gray, calcirudite of intramicrite pebbles in six inch ledges that show crinoid columnals on weathered surfaces .....	12
29. Limestone, reworked pebbly calcirudite of light to medium brownish-gray intramicrite; weathers slightly nodular, dark grayish-brown silt laminae .....	8
28. Limestone, light to medium brownish-gray, biosparite, medium to coarse; slabby-weathering; impure; light-brown to yellow silt laminae between ribbony-bedded ledges three inches thick; trilobite, crinoid, and brachiopod fragments .....	6
27. Covered interval .....	18
26. Limestone, dark grayish-brown, intramicrite; partially reworked; .....	27

Geologic section 5. cont.

	Thickness in feet
25. Limestone, medium-pink to brownish-gray, intrasparite to biosparite, rounded four inch ledges. Becomes finer-grained upward. Fossils include a few silicified brachiopods, with abundant bryozoans and crinoids .....	7
24. Limestone, dark brownish-gray, intramicrite, silt laminae in lower 12 feet. Upper 31 feet contains less silt and is grayish-brown; weathers to hard, dense, rounded ledges that are less than 12 inches thick; a few thin intercalations of partially reworked intrasparite as in unit 25, above .....	33
23. Limestone, dark brownish-gray, biosparite, crinoid fragments .....	2
22. Limestone, light to medium-gray, intramicrite, less than five per cent light-brown silt laminae, dense, very small calcite "eyes" .....	4
21. Limestone, dark brownish-gray, interbedded intrasparite and intramicrite, fetid odor from freshly broken surfaces, abundant yellowish-brown silt laminae, ribboned ledges .....	11
20. Limestone, upper 18 feet is dark brownish-gray, biosparite with abundant bryozoans, brachiopods, gastropods, and crinoids; lower	

Geologic section 5. cont.

Thickness  
in feet

- 10 feet is dark gray, intramicrite with a few calcite "eyes"; contains a few light-brown wavy silt laminae and bryozoans; all beds weather to rounded ledges that are less than 2.5 feet thick ..... 28
19. Limestone, bluish- to brownish-gray, intramicrite, silty; interbedded with calcareous mudstone, brownish-red in alternating irregularly laminated and ribbon-banded ledges; limestone about three times more abundant; a few gastropods, some fucoids, bryozoans, and one coarse-ribbed brachiopod; weathers to one inch thick pitted and furrowed ledges ..... 12
18. Limestone, brownish-gray, interbedded intrasparite and biosparite and some brownish-gray intramicrite with brownish-orange mottles, composes upper 70 feet; lower 35 feet is mainly brownish-gray intramicrite that weathers slabby; about 60 per cent of unit is covered; fossils include brachiopods (Hesperorthis mainly), a few trilobites, algae, and fucoids ..... 105
17. Limestone, yellowish-gray to brownish-gray with some mottling of light reddish-brown,

Geologic section 5. cont.

	Thickness in feet
intrasparite and intramicrite; 3 to 18 inch irregular, wavy ledges; a few brachiopod fragments .....	40
<b>Chatham Hill Formation (335 feet)</b>	
16. Concealed interval, probably composed of limestone as in unit 15, below .....	30
15. Interval that is approximately 40 per cent covered, composed mainly of limestone, steel- gray to black, intramicrite, few lenticular patches of very fossiliferous black intra- micrite that contains a few brachiopods and abundant silicified trilobites that are reddish-brown; irregularly shaped black chert nodules in upper 40 feet .....	125
14. Limestone, drab brownish-gray to dark-gray, intramicrite, argillaceous; mottled with irregular lenses, bands, and laminae of reddish- gray silt, abundant silicified <u>Sowerbyella</u> in middle 10 feet .....	35
13. Covered interval .....	25
12. Limestone, drab brownish-gray to black, intra- micrite, wavy brown silt laminae; ribbonary ledges; contains a few silicified reddish-brown trilo- bite and fragments of coarse-ribbed brachio- pods .....	10

Geologic section 5. cont.

	Thickness in feet
11. Limestone, as unit 13 above, fossils more abundant .....	20
10. Limestone, black, intramicrite, argillaceous, some reddish-brown silt laminae; fetid odor emitted from freshly broken surfaces; relatively even-bedded in ledges that are three inches thick; basal eight feet is highly impure, black biosparite which is composed of broken trilobites, gastropods, and brachiopods; weathers into irregular, thin slabs, some of which show silicified fossils on weathered surfaces; markings that resemble fucoids or bryozoans are present on bedding surfaces in the upper 15 feet of this unit .....	30
*9. Limestone, dark-gray to black, intramicrite, contains irregular-shaped black chert nodules in lower 20 feet; sparse silicified brachiopods (cf. <u>Sowerbyella</u> ) and gastropods; well preserved trilobite fragments in middle of unit; white calcite "eyes" are common .....	60

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\*Southeastern side of Bland County Road 608 present at base of this unit.

Geologic section 5. cont.

Thickness  
in feet

Rich Valley Formation (268 feet)

8. Limestone, as in unit 10 above; but, contains no chert, and has fewer fossils; few black wavy silt laminae and some rusty-brown ribbony argillaceous ledges ..... 22
7. Limestone, at base, greenish- to brownish-gray, argillaceous intramicrite with brown silt laminae, weathers cobbly; grades upward into limestone that is black, intramicrite, dense and hard, breaks with conchoidal fracture, contains a few trilobites and weathers to uniformly thick three-inch ledges ..... 56
6. Limestone, black, intramicrite, contains a few laminae of brownish-gray silt, fresh rock breaks with conchoidal fracture, two to three inch regular ledges ..... 7
5. Limestone, brownish-gray to yellowish-gray intramicrite; interbedded with biomicrite; wavy brownish-tan silt laminae..... 10
4. Limestone, black, biosparite with yellowish-brown silt laminae; abundant large fragments of trilobites ..... 3

Geologic section 5. cont.

	Thickness in feet
3. Limestone, dark-gray to black, biosparite; fetid odor emitted from freshly broken surfaces; argillaceous; light reddish-brown silt laminae; a few trilobites and ostracodes .....	20
2. Covered interval .....	35
1. Covered interval, about half of the interval is composed of limestone, brownish-gray, intra-micrite, with wavy pinkish-brown silt laminae ...	135

Effna Limestone

Chatham Hill Formation

Name. - The name was given this formation by B. N. Cooper and G. A. Cooper (1956, p. 53) from exposures near Virginia Route 16, near Chatham Hill, Smyth County, Virginia.

Distribution. - The Chatham Hill Formation is present in both the Walker Mountain and Crockett Cove belts. In both places it crops out and forms the base of the lowest secondary ridge at the northern bases of the two mountains. Both belts of Chatham Hill are long and narrow and extend across each of the areas in continuous outcrop bands. Good exposures of complete sections of the formation are rare, but there are numerous partially exposed sections. The best exposures are along Wythe County Road 600 in the southwestern end of Crockett Cove and along the fields which lie on each side of Wythe County Road 603 which runs from Wytheville to Crockett Cove. In the Walker Mountain belt the formation is well exposed in a

dry stream bed on the abandoned farm that is located in the northwestern corner of the area where Bland County Road 622 turns northeast and the private road turns southwest toward Bland County Road 621 which extends from the crossroads at Effna to the summit of Big Walker Mountain. Other good exposures of the Chatham Hill Formation are located on the farms of M. H. Bowen, Jr. and the Halsleys which are just south of Bland and may be reached by travelling on Bland County Roads 604 and 603, respectively.

Lithology. - The limestones of the Chatham Hill Formation are generally dark to medium shades of bluish-gray and are characterized by a compact texture. These limestones, where weathered, are quite slabby and nodular owing to the presence of irregularly laminated silt and clayey organic material. Nodules of black chert are abundant in the Chatham Hill Formation, but they are confined mostly to the lower and upper thirds of the sequence. There is less chert present in the Crockett Cove belt of Chatham Hill than there is in the Big Walker Mountain belt. In the Big Walker Mountain belt there is less buff, yellow-weathering shale present than there is in the Crockett Cove belt. At the junction of Wythe County Roads 659 and 600 in the southwest end of Crockett Cove near the trough of the Queens Knob syncline, there is a minimum thickness of 50 feet of bluish-gray, yellow-weathering calcareous shale present in the upper one-fourth of the Chatham Hill Formation. This shaly sequence, which is not present in the Walker Mountain belt, rather abruptly thins to the northeast in the Crockett Cove belt and is absent within three miles of the place where it is thickest.

In the Big Walker Mountain belt the only notably shaly interval in the Chatham Hill of this belt was seen on the farm of M. H. Bowen, Jr.

Here, the shale interbeds are dominant and the nodules of limestone appear to be almost completely isolated in a drab shale matrix. The shaly intervals within the Chatham Hill Formation are, in some places such as the Bowen farm, sheared and locally disharmonically folded with the planes of differential slippage being marked by slickensided surfaces.

In the northeastern end of Crockett Cove the Chatham Hill contains a few thin beds of light pinkish-gray to drab orangish-red intramicrite which bears fragments of many silicified brachiopod shells. Brownish-red fragments of trilobites are abundant in many of the darker limestone beds near the middle of the formation. A few beds of bluish-gray limestone containing silicified brachiopods are present in the southwestern end of the Crockett Cove belt also, but apparently no prominent silicified interval is present in any of the equivalent interval in the Big Walker Mountain belt.

The thickness of the formation ranges from 165 feet to more than 500 feet in the Crockett Cove belt. The thicker section is near the trough of the Queens Knob syncline, whereas the thinner section is located along the axial portion of the Crockett Cove anticline.

In the Big Walker Mountain belt the thickness ranges from less than 150 to 350 feet. The maximum thickness of the Chatham Hill is located on the farm of J. S. Penley (see page 48 for location) and the minimum thickness is located near the junction of Bland County Roads 738 and 670 near Mechanicsburg.

Fossils, age, and correlation. - The most abundant fossils in the formation are trilobites and most of these are poorly preserved fragments that have been silicified or partially retain the chitinous nature of the original shell material.

In the Crockett Cove belt the Chatham Hill Formation contains fragments of trilobites that are approximately 1.5 inches across the cephalic region. However, the very large fragments are rare and only present at one locality which is in the field northeast of Wythe County Road 603, 0.5 mile south of its junction with Wythe County Road 600.

In the Big Walker Mountain belt the formation contains several intervals that are trilobite-bearing. Large slabs of this black, fine-grained limestone may be obtained from the formation on the farm of M. H. Bowen, Jr., (see p. 42 for location) near Bland and treated with weak baths of acetic acid in order to obtain trilobites from the etched residue.

The Chatham Hill Formation is of Porterfield age (G. A. Cooper, 1956, Chart 1). Its stratigraphic equivalents (Cooper, 1956) in the Appalachians are the lower Dryden and upper Benbolt, Tellico, upper Arline, Martin Creek, and lower Hurricane Bridge formations. In the work of Butts (1940, p. 174) the Chatham Hill was discussed and studied under the name "Ottosee" Limestone in both the Crockett Cove and Big Walker Mountain belts. However, the type Ottosee includes beds that range in equivalence from Lincolnshire through Wardell and the application of the term in this area is of little use because the corresponding interval may be readily divisible into at least four formations.

The upper portions of the Rich Valley and the lower part of the Chatham Hill Formations interfinger in the Marion and Porterfield Quarry areas of Smyth County, Virginia, where both have their type sections (Cooper, 1956, Chart 1). Indeed, in the Big Walker Mountain and Crockett Cove areas the contact between the two is difficult to map. The

difficulty is in part due to the cover of colluvium, alluvium, and residuum; but, for the most part the difficulty arises from the fact that the contact is transitional and gradational in nature. There is a marked difference in the lithologic character of each of these two formations, but it is only obvious where the interval under consideration is well within the bounds of one or the other.

#### Wassum Limestone

Name. - The Wassum Limestone was named by B. N. Cooper and G. A. Cooper (Cooper, 1956, p. 97) for exposures in Wassum Valley, four miles northwest of Marion, Smyth County, Virginia.

Distribution. - The low-lying series of spurs that are present at the northwest base of Cove and Big Walker mountains are underlain by the Wassum Limestone. In Crockett Cove the best exposures of the Wassum are on the Joseph Kelley farm which is along St. Lukes Ford and in the pastures which are located northeast of Wythe County Road 603. In the Big Walker Mountain belt the Wassum is poorly exposed and thin in the Bland area, but to the northeast near the Giles County line the exposures are more numerous and the formation is considerably thicker. Good exposures of the limestone are present in the fields just south of Bland County Road 738 which crosses Big Walker Mountain south of Mechanicsburg.

Lithology. - The predominant type of limestone in the Wassum is coarse-grained biosparite which is generally light-colored and ranges from shades of golden-tan to pinkish-gray. The second type of limestone common in the Wassum is medium bluish-gray biomicrite with yellow wavy clay and silt laminae. Some beds in the Wassum are shaly, but most of these are limited to the basal one-third and occur as interbeds between larger thicknesses

of limestone. The fine-grained limestones are generally predominant in the lower three-fourths of the formation whereas the coarse limestones are most abundant near the top of the sequence. Fossils crowd most of the weathered surfaces of the formation. The thickness of the Wassum in the Crockett Cove belt ranges from a minimum of 20 feet near the crest of the Crockett Cove anticline to a maximum of 75 feet near the trough of the Queens Knob syncline. In the Big Walker Mountain belt the formation is less than 20 feet thick or absent in most places.

The age of the Wassum Limestone is earliest Wildrenesian (Cooper, 1956, Chart 1). The stratigraphic equivalents of the Wassum are the Wardell, Sevier, upper Dryden, Gratton, middle Liberty Hall, the lowermost portion of the Witten, and most of the Woodway limestone in the southwest Virginia and eastern Tennessee areas (Cooper, 1956, Chart 1). Butts (1940, p. 174) termed the coarse-grained limestones now called Wassum as the "local development of ... beds of marble is characteristic of the Ottosee ...".

#### Witten Limestone

Name.- The Witten was named by B. N. Cooper and C. E. Prouty (1943, p. 878). The name is taken from Witten Valley and the type section is along Virginia Route 16, southwest of Tazewell, Tazewell County, Virginia.

Distribution. - The Witten Limestone is present in both belts of outcrop in the area. It underlies the red Moccasin Formation in the Big Walker Mountain belt and the red Bays Formation in the Cove Mountain belt. The topographic position of the formation is approximately two-thirds of the distance up the low spur which lies at the northwest base of Big

Walker Mountain and near the top of and on the dip slope of the spur at the northern base of Cove Mountain.

Lithology. - Limestone comprises essentially all of the Witten in both belts of outcrop. The limestone is commonly light to medium dove-gray or bluish-gray, medium to fine grained and contains a few wavy laminae of dark greenish-gray, brown-weathering silt and clay. The rock is, in most instances, an intrasparite to a biomicrite. The underlying coarse-grained biosparite limestones are grouped with the Wassum Limestone.

In the Crockett Cove area the Bays appears to have cut into the top of the Witten and, in fact, the basal Bays contains a few pebbles of Witten or Wassum Limestone in at least one place on the Joseph Kelley farm along St. Lukes Fork.

In the Big Walker Mountain belt the Witten apparently grades upward into the basal impure limestone beds of the Moccasin Formation and, probably, the two units interfinger in this area.

In the Cove Mountain belt the thickness of the Witten is less than the thicknesses measured in the Big Walker Mountain belt. In the trough of the Queens Knob syncline the thickness of the Witten is 225 feet, but on the crest of the Crockett Cove anticline the thickness decreases to 20 feet. In the Big Walker Mountain belt the thickness of the Witten ranges from less than 50 feet near the western edge of the mapped area to 350 feet in the northeast on the Harmon farm which is located on Bland County Road 608, one mile south of Point Pleasant.

Most of the ledges of the Witten are less than four inches thick where weathered. In fresh exposures the beds are generally from one to two feet thick. The thicker bedded Witten generally occurs in the upper

portion of the formation, whereas the thinner, slabby ledges are near the base of the formation.

Fossils, age, and correlation. - The fauna of the Witten is large and varied. The most common fossils include the sponges Camarocladia and Cryptophragmus and fucoids which are probably Buthotrephis or Phytopsis. The fucoids and sponges are especially abundant in the Crockett Cove area and appear on weathered surfaces of the rock as yellowish-gray-weathering clay fillings of the once hollow tubes which stand out in sharp contrast on the deep bluish-gray weathered surface of the thin limestone slabs. The coarse-grained limestone intercalations that are present in the lower one-half of the Witten contain the brachiopods Zygospira recurvirostris and Hesperorthis sp. The age of the Witten is Wildernesian and it is correlated with the lower Bays, upper Wassum, the upper Woodway, and Liberty Hall formations of Virginia and Tennessee, and the Lebanon of Alabama, Tennessee, and Georgia (Cooper, 1956, Chart 1).

#### Middle and Upper Champlainian Series of the Crockett Cove Belt

##### Bays Formation

Name. - The Bays was named by Arthur Keith (1895) from exposures of red sandstone in the Bays Mountains of Hawkins and Greene Counties, Tennessee. In the Knoxville Folio, Keith (1895) stated that the Bays was overlain everywhere by the white Clinch Sandstone. However, the white sandstone that Keith called Clinch is actually overlain by some 700 feet of Martinsburg Formation (Rodgers, 1953, p. 96). Thus, Keith and Campbell mistakenly identified and mapped the Bays as a Juniata (Upper Ordovician) equivalent and mapped the white sandstone in the Bays as the Clinch (Lower Silurian) equivalent and, in a few instances, did not recognize or note the presence

of the Martinsburg in the Bays Mountain synclinorium. In 1911, E. O. Ulrich first recognized the mistaken identity of the Bays with Juniata and stated that the typical Bays is succeeded by shales and sandstones of Cincinnati (Late Ordovician) Age. Butts (1940, p. 186) noted that the Bays, which he considered to be a sand facies of the Moccasin, had been identified as Clinch in Bays Mountain, Tennessee, is probably a thicker development of the sandstone in the Moccasin at the southwest end of Walker Mountain in Washington County, Virginia. B. N. Cooper (in Twenhofel and others, 1954, Fig. 2) and Rodgers (in Twenhofel, 1954, Fig. 1) recognized the Bays-Moccasin relationship as being a sandy vs. carbonate, respectively, depositional relationship with the Bays as the southeastern sandy equivalent of the more northern carbonate- and shale-rich Moccasin Formation. Both Cooper and Rodgers agree that the Bays is a perfectly valid formational name for the sandy phase of the Moccasin in Virginia and Tennessee and reject the idea proposed by Butts (1940, p. 186) that there is no Bays Sandstone in Virginia.

Distribution. - The Bays per se is present only in the Crockett Cove belt in this area. In the Walker Mountain belt the Bays is represented by less than 10 feet of brown, granular feldspathic sandstone and a few feet of dirty siltstone near the base of the Moccasin Formation on the northwest slope of Big Walker Mountain along U. S. Route 21-52 and on old Bland County Road 603, 1.9 miles south of Bland. In Crockett Cove the Bays Formation crops out in a long, narrow strike belt that forms the low spur at the northwest base of Cove Mountain along the entire length of the mountain. The best exposures of the Bays are along St. Lukes Fork and Wythe County Road 603 which runs north from Wytheville to the Cove.

Lithology. - In the trough of the Queens Knob syncline the Bays Formation reaches a maximum thickness of approximately 320 feet. The Bays in the Queens Knob syncline is characterized by the presence of 45 feet of polymict granule conglomerate which is cross-bedded with the foreset beds dipping to the northwest. The conglomerates are generally light brownish-gray to tan and, in a few instances, almost white. The conglomerates contain rounded to subrounded quartz granules, rounded ellipsoidal chert granules, angular blocky shale pebbles, and granules and pebbles of medium to dark-gray fine-grained limestone. A second similar conglomeratic interval which is 25 feet thick is present 100 feet above the base of the formation. The shales and siltstones of the Bays are generally greenish-gray to drab-tan, maroon, and mottled maroon and green. Where weathered, the fine clastics break up into thin, blocky chips. The sandstones which make up approximately 50 per cent of the formation are generally drab yellowish-brown in color and are fine- to medium-grained subgraywackes. Most of the sandstones weather into blocky, two to six inch-thick ledges that are relatively porous and friable. In the northeastern end of the Cove on the Charles King farm, the Bays consists mainly of a basal light-gray to white, relatively clean, slightly conglomeratic quartz sandstone at the base. The basal sandstone is approximately 30 feet thick. Overlying the basal sandstone is 75 feet of maroon and yellow-drab shale and siltstone that contain a few thin intercalations of fine-grained impure sandstone. The upper portion of the Bays is quite susceptible to rapid weathering and is characterized by deep, steep-sided gullies that are practically devoid of vegetation.

Age, correlation, and stratigraphic relations. - The only fossil found in the Bays of this area is Lingula which, though ubiquitous, is of little value in correlation of the unit. However, the underlying Witten and Wassum limestones contain a wealth of fossils and the overlying beds of basal Martinsburg contain many brachiopods. By the use of the fossils in higher and subjacent beds it is possible to date the Bays as Late Wildernesian to Early Trentonian Age (see G. A. Cooper, 1956, Chart 1). The Bays is equivalent to the Bowen plus the Witten plus the Moccasin, where the predominant lithology is sandy rather than limy (B. N. Cooper, 1965, Personal Communication).

In the Crockett Cove area the Bays contains a few pebbles of limestone that closely resemble the uppermost beds of the Witten. However, there is no other positive evidence of any marked unconformity between the two formations in the area. In the Porterfield Quarry area of Smyth County, Virginia, the Witten and Bays interfinger (see Cooper, 1956, Chart 1). No positive evidence of an interfingering relationship between the formations in the Crockett Cove area was seen. The upper contact of the Bays with the Martinsburg is not well exposed in most of the area, but it is apparently normal for no marked deviations in the trace of the contact between them is apparent in mapping the area. The overall thinning of the Bays to the northeast is characterized by a thinning of most of the individual units within the formation as well as the total thickness of the formation.

Middle and Upper Champlainian Series of the Big Walker Mountain Belt

Moccasin Formation

Name. - The Moccasin Formation was named for exposures of limestone and shale in Big Moccasin Gap, near Gate City, Scott County, Virginia, by M. R. Campbell (1894, p. 2).

Distribution. - The Moccasin Formation is present only in the Big Walker Mountain belt. It crops out approximately three-fourths of the way up the side of the lowest secondary ridge that is usually partially cleared at the base of Big Walker Mountain throughout the entire length of the strike belt. Good exposures are present along old Bland County Road 603 which crosses Big Walker Mountain a few miles south of Bland; along U. S. Route 21-52 just north of Big Walker Lookout; and, in the fields just off Bland County Road 738 which crosses Big Walker Mountain south of Mechanicsburg.

Lithology. - The basal beds of the Moccasin Formation in most instances consist of beds of pinkish-brown to light-maroon shaly limestone that weathers into thin, irregularly bedded slabs. The shale content increases toward the top of the sequence where most of the beds are either shales, mudstones, or siltstones. Essentially all of the clastics in the Moccasin are maroon, light grayish-brown, drab-tan, yellowish-gray, or olive-drab. A few thin intercalations of medium- to coarse-grained brown impure sandstone are present about 75 feet above the base of the formation. Locally, as along Bland County Road 603 on the northwest flank of Walker Mountain, a few five feet-thick lenses of blocky-weathering impure sandstone are present.

There is evidence of at least two probable beds of bentonite in the Moccasin in the Walker Mountain belt. Near the middle of the succession

of shale beds there are two intervals of less than 18 inches each in thickness which consist of light yellowish-tan, blocky-weathering silicified claystone. The silicified claystone was probably formed as the result of seepage of ground water from above where the silica from volcanic glass in the bentonites was taken into solution, carried downward, and absorbed by the porous claystone. No positively identifiable beds of unweathered bentonite were seen in the field however. The average thickness of the Moccasin in the Big Walker Mountain is about 100 feet.

Age and correlation. - The only fossil that has been reported from the Moccasin Formation in the Big Walker Mountain belt is the alga Solenopora (Cooper, 1944, p. 97). The age of the Moccasin is Late Wildernesian (Cooper, 1956, Chart 1).

Although the Moccasin and Bays interfinger and are essentially the same age in most instances, the stratigraphic range of the Bays is greater both downward and upward than the Moccasin (Cooper, 1956, Chart 1). The stratigraphic range of the Moccasin is less than that of the Bays which includes equivalents of the Bowen, Witten, and Moccasin. The Appalachian equivalents of the Moccasin in addition to the Bays include the Ben Hur, Hardy Creek, Cane Creek, and the Carters limestones. In the Big Walker Mountain belt the presence of sandy beds in the basal Moccasin suggests that the Moccasin of this belt and the Bays of the Crockett Cove belt to the southeast may have been at one time part of a connected body of sediment and that the Crockett Cove clastics are thinning toward the northwest in the Big Walker Mountain belt. The lower contact of the Moccasin appears to be gradational with the underlying Witten Limestone

as there is a transitional sequence of beds at the top of the Witten that contains the lithologies of both units.

### Champlainian and Cincinnati Series of Both Outcrop Belts

#### Eggleston Formation

Name. - The Eggleston was named by A. A. L. Matthews (1934, p. 11) from exposures at Eggleston and Narrows, Giles County, Virginia.

Lithology and correlation. - The Eggleston Formation, as mapped and where present, forms the basal part of the belt mapped under the symbol Omb, which also includes the Martinsburg Formation. However, in the Crockett Cove belt there is probably no recognizable Eggleston present, but the Eggleston is probably represented in bentonite-bearing beds of the Bays, which are directly overlain by the lowest Sowerbyella-bearing beds of the Martinsburg. B. N. Cooper (1961, p. 42) pointed out that generally no Eggleston can be identified where Bays is present probably because the Bays includes facies equivalents of both the Moccasin and Eggleston. No fossils were found in beds of the Eggleston in the Big Walker Mountain-Crockett Cove area.

In the Walker Mountain belt there is probably as much as 75 feet of drab to dark-gray siltstone, mudstone, and argillaceous limestone present between the Moccasin and Martinsburg and, therefore, probably referable to the Eggleston.

#### Martinsburg Formation

Name. - The Martinsburg Formation was named by Geiger and Keith (1891, p. 156-163) for a sequence of limestones and shales near Martinsburg, West Virginia. In the Big Walker Mountain-Crockett Cove the unit shown

as Martinsburg (Omb) in Plate 1 includes, at its base, beds probably referable to the Eggleston Formation (see page 68 for discussion)

Distribution. - The Martinsburg Formation is the largest single unit, other than the Knox Group, that is mapped on the outcrop slope of Big Walker Mountain. Over three-fourths of the outcrop slope of Big Walker Mountain and Cove Mountain is underlain by the Martinsburg Formation. Although there are no completely exposed sections of the formation, the best partial exposures are along Wythe County Road 603 where it passes through the gap in Cove Mountain and along U. S. Route 21-52 on Big Walker Mountain. There are other good exposures on Big Walker Mountain to the northeast along Bland County Road 738 and Bland County Road 622 which is at the western edge of the mapped area (see Plate 1). Much of the Martinsburg is covered by grassy pasture-land, but practically all of the upper one-half of the formation is forested and most of the obsequent streams that flow down the sides of Walker and Cove mountains are colluvium- and alluvium-choked and, therefore, effectively obscure much of the actual character of the formation.

Lithology. - The lowermost beds of the Martinsburg Formation consist of mostly all limestone that is characteristically dense dark bluish-gray biomicrite and biosparite that weathers to relatively thin slabs. The lower one-fourth to one-third of the formation contains numerous thin intercalations of drab yellow-weathering fossiliferous calcareous shale that weathers to orange and yellow chips of soft punky clay.

The middle third of the formation consists mostly of calcareous drab green and yellowish-brown shale and siltstone that contain abundant molds

and casts of fossils. In this interval there are a few limestone intercalations that are very much like the beds of limestone that are predominant in the lower third of the succession.

Toward the top of the formation the beds are more sandy and the color is redder. At the top, most of the beds are bright maroon. The upper third of the formation is composed mainly of siltstone and sandstone which are calcareous and abundantly fossiliferous in some places.

In Crockett Cove the middle portion of the Martinsburg is more sandy than the corresponding interval along the Big Walker Mountain belt. There are considerably more pelecypods present in the middle division in Crockett Cove. The more sandy portion of the formation in Crockett Cove is apparently limited to the trough portion of the Queens Knob syncline (see Plate 6). The limited exposures near the crest of the Crockett Cove anticline (see Plate 6) are more like the Big Walker Mountain section than the southwestern extension of the same formation in the Cove Mountain belt.

The thickness of the Martinsburg ranges considerably in the Cove Mountain belt. In the trough of the Queens Knob syncline the formation is at least 1800 feet thick allowing for crumpling and consequent repetition of some beds. However, on the crest of the Crockett Cove anticline which is less than 8.5 miles to the northeast the thickness is less than 900 feet. In the Big Walker Mountain belt the average thickness is approximately 1500 feet.

Fossils, age, and correlation. - The lowermost beds of the Martinsburg Formation in Crockett Cove contain the brachiopod Sowerbyella cf. S. curdsvillensis (Foerste) which is an index fossil of the Lower Martinsburg

but not necessarily of the basal Trentonian. The uppermost beds of the formation contain abundant specimens of Orthorhynchula sp. which has a range of Middle Trenton to Upper Maysville (Twenhofel, et. al., 1954, Chart 2). Therefore, the age of the Martinsburg must be at least medial Trenton and probably is as young as latest Maysville.

Although no attempt was made systematically to collect fossils from the entire section of the Martinsburg, many of the fossils illustrated by Butts (1940, pt. II, p. 117-128) were noted in the formation.

The basal limestone section in the Martinsburg is probably an equivalent of the limestones commonly called "Trenton" in other areas in the Appalachians.

The upper portion of the Martinsburg Formation which contains abundant Orthorhynchula cf. O. stevensoni Grabau in a relatively impure calcareous maroon siltstone-sandstone and limestone sequence is probably the equivalent of the Maysvillian Stage of the type area around the Cincinnati Arch. An excellent exposure of the upper, Orthorhynchula-bearing Martinsburg is present approximately half a mile from the summit of Big Walker Mountain on Bland County Road 622.

#### Juniata Formation

Name. - The Juniata Formation was named by Darton (1896, p. 2) for exposures along the Juniata River in central Pennsylvania where the interval had formerly been termed the Red Medina Sandstone.

Distribution. - The Juniata Formation is exposed near the summits on the outcrop slopes of Cove and Big Walker mountains. Good exposures are present along Wythe County Road 603 which passes through the gap cut in

Cove Mountain by St. Lukes Fork 2.9 miles north of Wytheville. The Juniata is well exposed near the summit of Big Walker Mountain along U. S. Route 21-52 near Big Walker Lookout; along the old Bland-Wytheville Pike, now abandoned, which is a southward extension of Bland County Road 603 which travels south from Bland; and along Bland County Road 738 which crosses the mountain south of Mechanicsburg.

Lithology. - The Juniata Formation is characterized by its maroon color which is in sharp contrast with the overlying white orthoquartzites of the basal Silurian. However, beds near the top of the underlying Martinsburg Formation have a maroon color which is similar to that of the Juniata. The Juniata Formation does not contain any fossils, whereas the Martinsburg contains a wealth of brachiopods, pelecypods, and gastropods near the upper contact with the Juniata.

The predominant type of rock present in the Juniata is maroon and light greenish-gray siltstone which is sandy in most places and almost always shows raindrop impressions, flow and load casts, and sole and ripple markings. Many of the beds in the formation are marked by current action and the coarser clastics are usually cross-stratified. Fine-grained blocky-weathering sandstones are abundant as thin intercalations in the siltstone sequences and are usually the same color as the siltstones except for light greenish-gray to yellowish-brown laminae. The coarser sandstones are generally medium grained, quite impure, and are commonly drab-brown to, in a few instances, light-brown in color. Most of the sandstones are subgraywackes that are blocky-weathering, usually cross-bedded, lenticular in three-dimensions, and show many primary features indicative of shallow water deposition including mud cracks, ripple marks, slump features, raindrop impressions, load casts, and cross-stratification.

The dearth of marine fossils (as well as any other fossils) combined with other evidences such as red color and features of shallow water deposition is highly suggestive of a non-marine environment of deposition very much like a deltaic environment.

The thickness of the Juniata Formation in the Walker Mountain belt ranges from 200 to approximately 350 feet. B. N. Cooper (1965, p. 16) reported 320 feet of pyritic gray orthoquartzite in the Juniata revealed in test borings for the projected Interstate Route 77 tunnel through Big Walker Mountain about 4.5 miles south of Bland. In the Crockett Cove belt the formation ranges from a maximum of 275 feet in the trough of the Queens Knob syncline to a minimum of 200 feet on the crestal portion of the Crockett Cove anticline.

Age and correlation. - No fossils are present in the Juniata. However, Butts (1940, pp. 221-223, 226-229) suggested that the Sequatchie Formation of far southwestern Virginia and eastern Tennessee interfingered with beds of the Juniata and, therefore, that the Juniata was the non-marine equivalent of the Sequatchie and thus deposited during Richmond time. Later work by B. N. Cooper (see Twenhofel et al., 1954, p. 283-284) showed that the Sequatchie contains Maysville as well as Juniata correlatives. Therefore, it is likely that the Juniata includes equivalents of the Bald Eagle and Oswego formations (Lower Richmondian and Upper Maysvillian) which Butts had thought to be absent in many areas of the Appalachians (see Cooper, in Twenhofel, et al., 1954, p. 272). B. N. Cooper (1961, p. 53) supports the thesis that the age of the Juniata is probably Richmondian.

## Silurian System

### Clinch and Tuscarora Formations

Name. - The Clinch Sandstone was named by James Safford (1869, p. 292) for the ridge-forming sandstone on Clinch Mountain, Tennessee. The Tuscarora Sandstone was named by N. H. Darton (1896, p. 2) for exposures of sandstone on Tuscarora Mountain, Pennsylvania. Butts (1940, p. 229-237) used the names to apply to the sandstones that are essentially equivalent but crop out in different geographic areas. Butts used the Clinch to describe the white sandstone of the Lower Silurian in areas south of the 38th Parallel and the name Tuscarora for the same rocks north of that line.

However, John Rodgers (1953, p. 100) showed that the type Clinch may include beds of Clinton age, whereas the type Tuscarora is Medinan in age and, therefore, the terms should not be used interchangeably for different areas of exposure.

Distribution. - The Clinch and Tuscarora formations are the principal ridge-forming units in the area. Both Cove and Big Walker mountains are capped by the orthoquartzites of this designation. The name Tuscarora is applied to the white orthoquartzites that cap Big Walker Mountain throughout this area. The Clinch caps Cove Mountain and forms the upper portions of the dip slope of that ridge.

In the Crockett Cove area the Clinch consists of up to 165 feet of light yellowish-brown to almost white, medium- to coarse-grained orthoquartzite that crops out in cross-stratified ledges that range from less than one to more than three feet thick. Pebbles of white to light-gray vein quartz are scattered throughout the entire sequence of the Clinch.

There is no recognizable equivalent of the Rose Hill Formation present in the Crockett Cove belt.

The Big Walker Mountain belt contains the Tuscarora Orthoquartzite as its principal ridge-former. The Tuscarora averages 100 feet in thickness and is similar in most respects to the Clinch of Cove Mountain. The Rose Hill overlies the Tuscarora on Big Walker Mountain.

Evidence which indicates the degree of washing and sorting of the Clinch and Tuscarora sediments prior to deposition is shown by the relative lack of any iron or manganese oxide stains and the nearly white color of freshly exposed surfaces of the rock. Where the rock is deeply weathered, it is quite friable and is easily crushed to loose quartz sand grains by hand. However, the amount and depth of the weathering is quite shallow and, in most places, extends downward for less than three feet.

The most effective nature-induced manner of reducing the summit elevation of ridges upheld by these two formations is by the oversteepening and undercutting of the lower outcrop slopes of Juniata which is considerably less resistant than either the Clinch or the Tuscarora. After the quartzites have been undercut sufficiently, the process is completed by gravity-impelled creep which results in the breakage of orthoquartzite ledges under their own weight and the fall of huge blocks of material down the outcrop slope of the ridges. Many of the blocks of colluvium weigh more than 200 tons and approach the size of small houses.

Fossils. - The only fossils present in the Clinch or Tuscarora are the probable remains of worms. Two types of worm tubes are present and, depending upon whether the tubes are vertical or horizontal, they are named Scolithus and Arthrophyucus, respectively.

Age. - The age of the Clinch is considered to be Medinan and Clinton age (Cooper, 1961, p. 53). The Tuscarora is of Medinan age (Rodgers, 1953, p. 100).

#### Middle Silurian Series

##### Rose Hill Formation

Name. - C. K. Swartz (1923, pp. 27-28) named the Rose Hill Formation from outcrops near Cumberland, Maryland. As originally proposed, the formation excluded the Rochester Formation and its member - the Keefer Sandstone. Butts (1940, pp. 238-239) included the Rose Hill, Rochester, and Keefer in one unit that he and Ulrich (1923, pp. 245 and 266) termed the Clinton Formation. In the Burkes Garden Quadrangle which embraces approximately two miles along the strike of Big Walker Mountain, B. N. Cooper (1944, p. 114) applied the name Rose Hill Formation to the maroon and red sandstone-shale sequence that overlies the Tuscarora. Cooper also included some 100 feet of white sandstone that had formerly been included in the Keefer (Butts, 1940, pp. 237-250) as part of the upper Rose Hill for he believed that there was no proof of Keefer or Rochester equivalents in the area (Cooper, 1944, p. 114).

Distribution. - The Rose Hill Formation is present only on the southeast dip slope of Big Walker Mountain and the flanks of Long Spur which is an anticlinal warp on the Walker Mountain homocline (see Plate 6). The rocks of this formation form the conspicuous flat-irons which are well displayed on the dip slope of Walker Mountain. In this area there are no known places where the Rose Hill has been breached by erosion to expose the underlying Tuscarora in the form of an erosional inlier in any stream valley.

Good exposures of the Rose Hill Formation are present along U. S. Route 21-52 on the south slope of Big Walker Mountain. There are also easily accessible exposures on Pulaski County Road 738 south of Mechanicsburg. Other exposures are present along the old Bland-Wytheville highway (abandoned Wythe County Road 603) on the south slope of Big Walker Mountain 3.75 miles south of Bland.

Lithology. - The Rose Hill Formation is characterized by the presence of a high percentage of iron oxide in the lower half of the formation. As a result of the iron oxide, the most frequently encountered color of sandstone slabs forming a lag shingle on dip slopes on the lower half of the formation is dark purplish-maroon. Most of the formation consists of very hard and resistant fine- to medium-grained ferruginous sandstone. The shales which are present in the Rose Hill are rarely seen, except in fresh exposures such as road cuts, as they weather rapidly and are quickly covered by talus and soil. The shales are most commonly drab-brown to light greenish-gray and the shale sequences rarely exceed five feet in thickness because most of the shale occurs as thin intercalations between the more massive sandstone ledges. The sandstones crop out in either flaggy thin ledges or in relatively even-bedded 8 to 18 inch-thick ledges. A few pebbles of white quartz are scattered through some beds of the formation. Light greenish-gray to rusty-brown granule-size clay galls are abundant in many beds and commonly the dark-maroon ferruginous beds are marked by mottles of light greenish-gray spots which, for the sake of convenience, may be aptly termed "leopard-spotted" beds. The worm tube Scolithus is present in many beds of the Rose Hill and commonly the worm tubes appear to have been filled with light greenish-gray sand,

whereas the remainder of the rock, which probably contains iron in a somewhat different state of hydration, is dark-maroon to purple in color. This combination results in a mottled appearance on bedding surfaces and vertical stripes of alternating colors on sections which are perpendicular to the bedding.

There are at least two, four to six inch-thick beds of white-weathering shale present in the formation along U. S. Route 21-52. The white-weathering beds are quite soft and plastic clay where moist, but dry to hard, mud-cracked, small cobble-size masses.

There are no thick hematite-rich beds of economic importance in the Rose Hill Formation in this area. Float of hematite ore is present on the dip slope of the mountain, but no bedrock exposures were seen on either Big Walker Mountain or Long Spur.

Fossils, age, and correlation. - B. N. Cooper (1944, pp. 115-119)

correlated, on the basis of fossils, the Rose Hill Formation of the Burkes Garden area with the middle two-thirds of the Rose Hill Shale of the Comberland, Maryland, area. Neither the Rochester Shale nor the Keefer Sandstone were found to be present in the adjacent Burkes Garden area (Cooper, 1944). Cooper mapped the upper white sandstone sequence on Walker Mountain with the Rose Hill Formation because it was found that the top of the white sandstone succession was below beds that contain fossils typical of the Maryland upper Rose Hill Shale (Cooper, 1944, p. 119). There are very few identifiable fossils in the Rose Hill Formation in the area of this report and, consequently, correlation with the Maryland type section is quite difficult.

The white sandstone that overlies the typical red units of the Rose Hill Formation is approximately 50 feet thick on Big Walker Mountain and is thick enough to be mapped separately in many places. In order to delineate this distinctive sequence of white sandstones the upper sandstones are herein designated as the Upper White Member of the Rose Hill Formation and are shown on the map separate from the more typical Rose Hill lithology and included, for mapping purposes, with the overlying beds of the Rocky Gap and Oriskany formations. These three units are keyed to the symbol DorSk.

Upper White Member of the Rose Hill Formation (Sk). - The upper white sandstone member of the Rose Hill Formation is well exposed at three locations within the Walker Mountain belt. The best exposure is along U. S. Route 21-52 on the dip slope of Big Walker Mountain south of Big Walker Lookout. The other exposures, which are also on the dip slope of Big Walker Mountain, are located along the old Wytheville-Bland Road (the abandoned route of Bland County Road 603), and along Bland County Road 738 south of Mechanicsburg. The upper portion of the white sandstone member is well exposed in Spur Branch near the Kitts General Store (now closed) which is just west of Bland County Road 602 near the village of Long Spur.

The lithology of the upper white member of the Rose Hill Formation consists of about 50 feet of predominantly white to light yellowish-gray, fine- to coarse-grained orthoquartzite. There are a few interbeds of medium-grained, rusty-brown limonitic sandstone present intercalated within the member.

Devonian System

Oriskanian and Helderbergian Series

Rocky Gap Sandstone

Name. - The Rocky Gap Sandstone was named by F. M. Swartz (1929, p. 80) for exposures at Rocky Gap, Bland County, Virginia.

Lithology and thickness. - Approximately 30 feet of coarse-grained, light-brown, partially glauconitic, relatively clean sandstone is referable to the Rocky Gap Sandstone on Big Walker Mountain. There are no known beds of Rocky Gap Sandstone present in the Crockett Cove belt. In the bore holes drilled at the site of the Interstate Route 77 tunnel through Big Walker Mountain about 4.5 miles south of Bland, B. N. Cooper (1965, p. 17) reported from 25 to 30 feet of friable permeable sandstone in the Rocky Gap Formation.

The Rocky Gap is too thin to be mapped separately in the Big Walker Mountain-Crockett Cove area. Therefore, it is included on the map, Plate 1, as the middle part of the unit which is keyed to the symbol DorSk and includes the Upper Member of the Rose Hill Formation at the base and the Oriskany or Ridgeley Sandstone at the top.

Unidentified brachiopods in coarse-grained sandstone float probably from the Rocky Gap Formation are present in some places on the dip slope of Big Walker Mountain.

Oriskany Sandstone

Name. - The Oriskany Sandstone was named by James Hall (1839, p. 308) from Oriskany Falls, New York.

Lithology and thickness. - The Oriskany Sandstone is the same as the

Ridgeley Sandstone mapped by B. N. Cooper (1944, p. 130-131) on Walker Mountain in the Burkes Graden quadrangle.

The Oriskany consists of from less than 5 feet of coarse-grained, brown, friable sandstone mapped with the Clinch Formation on Cove Mountain to less than 20 feet of coarse-grained glauconitic sandstone and light-brown, relatively clean, sandstone on Big Walker Mountain and Long Spur where it was mapped as the uppermost part of the unit shown as DorSk on the Map (Plate 1). B. N. Cooper (1965, p. 17) reported seven feet of Oriskany Sandstone in the test boring for the Big Walker Mountain Interstate Route 77 tunnel. However, there is probably as much as 15 feet of Oriskany present just south of High Rock near the base of Big Walker Mountain.

Poorly preserved fossils are abundant, locally, in float of the Oriskany Sandstone in both belts of exposure.

#### Upper Ulterian Series

#### Huntersville Formation

Name.- The Huntersville Formation was named by P. H. Price (1929) from exposures of chert near the town of Huntersville, Pocahontas County, West Virginia. The formation is probably equivalent to the Onondaga Formation of Butts (1940, p. 295) according to B. N. Cooper (1944, pp. 132-133).

Distribution. - The Huntersville Formation is present near the base of the dip slopes both Big Walker and Cove mountains. However, the formation is not well exposed anywhere except in fresh road cuts. Commonly the position of the formation must be inferred from the presence of chert

float owing to the relatively rapid rate of physical breakdown of the fractured, brittle rock and the subsequent covering of the bedrock by colluvial and alluvial deposits from the sandstones and shales which crop out higher up the dip slope. Good exposures of the Huntersville are present in the fields and creek beds along Long Spur just off Bland County Road 602, along Pulaski County Road 738, and along Wythe County Road 603 beside St. Lukes Fork in Crockett Cove.

Lithology. - The Huntersville Formation is composed predominantly of chert which is generally medium to dark-gray where fresh and is quite hard and brittle. The formation also contains thin, irregularly bedded intercalations of drab gray siliceous shale which commonly occur as gnarled laminae within beds of chert. A few lenses of coarse-grained, greenish-gray, glauconitic sandstone occur within the formation on Big Walker Mountain. Essentially all of the formation is irregularly bedded and all of the exposed surfaces are quite rough and knobby in appearance. The thickness of the formation ranges from 50 to 70 feet.

Fossils, age, and correlation. - The principal fossils that occur in the Huntersville Formation in the area are mainly brachiopods. Most of the fossils seen in the formation in the Crockett Cove area are found loose pieces of coarse-grained sandstone float near the southeast base of Cove Mountain. The fossils are more abundant and easier to collect in places along the southeast base of Big Walker Mountain. The fossils occur as molds and casts mainly and, in most places, show poor detail.

The Huntersville Formation is of late Ulsterian age and it is equivalent to the Esopus and Schoharie formations of New York (G. A. Cooper and others, 1942, Chart 4). The "Onondaga" Chert of Butts (1940,

pp. 294-305) and the Saltville Chert of F. M. Swartz (1929, p. 80) are the terms which were formerly applied to beds of this age in the Appalachians of southwestern Virginia.

### Erian and Senecan Series

#### Millboro Shale

Name. - The Millboro Shale was named by Butts (1940, p. 308-309) from exposures at Millboro Springs, Bath County, Virginia.

Distribution. - Black shale of the Millboro Formation crops out at the southeastern bases of Big Walker Mountain and Cove Mountain and forms the northern side of the valley floors which lie north of Little Walker Mountain and Little Brushy Mountain respectively. The Millboro forms a continuous U-shaped outcrop belt around the flanks of the Long Spur anticline. In all places the formation is topographically expressed as a series of steep-sided low knobby hills which are characterized by a thin cover of soil and a predominance of scrub pines and scrub oak trees.

The best exposures of the Millboro Shale are located along Bland County Road 602 near Long Spur and along Bland County Roads 603 and 717 in the valley between Big Walker and Little Walker mountains. Near Crockett Cove the best exposure of the Millboro is along Wythe County Road 603 just south of the gap in Cove Mountain in a small quarry on the east side of the road.

Lithology. - The Millboro Shale is a black shale that commonly contains large ellipsoidal concretions. Most of the shale has a velvety luster and, where weathered, is a light-orange to pinkish-brown soft clay. Fresh, unweathered exposures are rare except for a few that are present along recently constructed road cuts. Beds near the top are generally

more silty and not quite so dark-colored as the lower beds. Near the trough of the Queens Knob syncline along Wythe County Road 603, the formation contains several light orangish-brown-weathering beds of conglomeratic black shale. The pebbles in these beds consist mainly of siltstone and shale and range from granule- to pebble-size. The Queens Knob area is the only known occurrence of these beds in the Millboro in the entire area of this report. The thickness of the Millboro Shale ranges from less than 350 to more than 500 feet in the Walker Mountain belt. In the Crockett Cove belt the thickness can not be accurately determined because the formation is locally complicated by folding and, in most instances, covered by Clinch- and Huntersville+ derived colluvium.

Fossils, age, and correlation. - The Millboro carries a fauna composed mainly of small brachiopods, pelecypods, cephalopods, and gastropods. Most of these fossils are imperfectly preserved and occur as impressions and molds or casts on bedding planes. The following fossils were collected and identified from various localities along the base of Big Walker Mountain:

Ambocoelia sp.

Leiorhynchus sp.

Lingula sp.

Lyriopecten sp.

Orbiculoidea sp.

Schizobolus sp.

Styliolina fissurella sp.

The age of the Millboro Shale is Erian and generally regarded by most geologists to be partially equivalent to the Marcellus Formation of New York (G. A. Cooper and others, 1942, Chart 4). The lack of well-preserved diagnostic fossils makes it difficult to assign an exact age to the formation in this area. However, B. N. Cooper (1939, p. 44; 1944, pp. 134-137) indicated that it contains both Marcellus and "Naples" equivalents. Butts (1940, p. 309) originally designated the Millboro as the equivalent to the Marcellus and Naples where the two are indistinguishable and can not be mapped separately. There may be a few feet of shale equivalent to the Needmore Shale of West Virginia and Pennsylvania present at the base of the Millboro in the Big Walker Mountain-Crockett Cove area. In Crockett Cove along Wythe County Road 603, 2.25 miles north of Wytheville, about four feet of siliceous olive-drab shale between the Huntersville and Millboro may represent the Needmore.

#### Brallier Formation

Name. - The Brallier was named by Charles Butts (1918, pp. 523-537) for exposures at Brallier Station, five miles northeast of Everett County, Pennsylvania.

Distribution. - The Brallier Formation crops out in the valleys between Big Walker and Little Walker mountains and between Cove and Little Brushy mountains. Very good exposures are present along the secondary roads which run through these valleys and along the southeast base of Little Walker Mountain. The topography formed by the formation is rugged and covered by vegetation. The soil cover is generally quite thin and easily eroded and, consequently, is characterized by extensively developed gullies

and steep-sided ravines. Exposures are generally poor and uncommon except along road cuts and in stream valleys.

Lithology. - The Brallier Formation is probably one of the most monotonous and least studied portions of the stratigraphic section that is present in the entire region of southwestern Virginia.

The Brallier is composed of mainly shale and siltstone at its base. These rocks grade upward into siltstones and sandstones at the top of the formation. The lower portion of the formation resembles the underlying Millboro Formation owing to the predominance of dark-gray colors and the soft, clayey character of the shales. However, the Brallier can usually be recognized by the presence of dark-gray, fine-grained, blocky-weathering sandstones interbedded within the lower beds of shale. Most of the lower sandstones seldom exceed three feet in thickness and are generally seen only in relatively fresh, unweathered stream or road cuts.

The siltstones and sandstones of the Brallier are generally drab olive-green to greenish-gray in color and are characterized by laminations that are commonly disrupted or deformed where viewed in cross section. The siltstones generally show dimpled and welted surfaces which are, in most instances, probably due to soft sediment deformation and, less commonly, worm trails (pictured by Butts as Pteridichnites biseriatus). None of the beds in the Brallier are noticeably calcareous. The upper beds in the formation are not so thin-bedded as the lower units and have less green and more brown colors. Most of the beds in the Brallier are highly micaceous. Fragments of plant fossils, though neither large nor well preserved enough to be positively identified,

are abundant in many beds.

The average thickness of the Brallier is 2500 feet in the valley between Little and Big Walker mountains. In the valley between Cove and Little Brushy Mountain the Brallier has an average thickness of 2000 feet.

Age, stratigraphic relations, and correlation. - The Brallier overlies the Millboro Shale with apparent conformity and it is probable that the basal beds of the Brallier represent a transitional interval of deposition between the two formations. The upper part of the Brallier is probably transitional with the overlying Broadford Formation. In most places it is difficult to distinguish the basal Broadford from the upper Brallier.

The age of the Brallier is Senecan (G. A. Cooper and others, 1942, Chart 4). It has been correlated with the "Portage" Formation and basal Jennings Formation of West Virginia and Maryland (G. A. Cooper and others, 1942) and Kimberling Shale of M. R. Campbell (Butts, 1940, p. 317).

#### Upper Devonian Series

##### Broadford Formation

Name. - The Broadford Sandstone was named by Reger (1927, p. 403) from exposures at Broadford Gap, Smyth County, Virginia.

Distribution. - Sandstones and shales of the Broadford Formation are present on the outcrop slopes of Little Walker and Little Brushy mountains. In several places on Little Walker Mountain the Broadford Formation caps and crops out on the dip slope of the ridge. The soil cover on the Broadford is rocky and thin. Most of the slopes underlain by the formation are heavily forested with dwarfed trees and brush. The upper

slopes of Griffith Knob and Browns Peak are underlain by the Broadford which in places is broken up and forms localized piles of slide rock. Good exposures of the Broadford sequence are located along U. S. Route 21-52 near Favonia and on Bland County Road 603 south of the crossroads at Carnot. Another good exposure is on Bland County Road 738 near the crest of Little Walker Mountain.

Lithology. - Sandstone and siltstone predominate in the Broadford of this area. The sandstones are, in most instances, calcareous and weather to a yellowish-brown punky residue that usually is quite porous as the result of the leaching of numerous calcite-filled molds and casts of fossils. Most of the sandstone in the formation is medium grained and greenish-gray to brown where fresh. The siltstones are generally dark greenish-gray to black. Shale in the Broadford is typically drab-brown to olive-drab and is less abundant than shale beds in the underlying Brallier. The sandstones in the Broadford are generally thicker bedded and more resistant than those in the Brallier. The more calcareous sandstones weather in concentric layers and in many places contain a brachiopod fossil hash. Many of the Broadford sandstones are lenticular in nature and, consequently, few of these beds can be traced along strike for any great distance. Near the top of the formation the sandstones are the predominant lithology. These upper sandstones are generally light brownish-maroon, fine to very fine grained, and flaggy. Cross-stratification is characteristic of some of the uppermost sandstone beds. Faint rusty-brown impressions of brachiopods and pelecypods are abundant on some bedding surfaces. Almost 100 feet of this flaggy-bedded, gray-weathering sandstone is present just below the summits of Browns Peak and

Griffiths Knob where the beds are almost flat-lying. Except for lack of a pleasing color, these beds could be successfully utilized as a source of flagstone and dimension stone. The thickness of the Broadford is approximately 600 feet in the Big Walker Mountain-Crockett Cove area. Fossils, age, correlation, and stratigraphic relations. - Fossils which are present in the deeply weathered residue of the Broadford include the following:

Camarotoechia sp.

Chonetes sp.

Cyrtospirifer sp.

Fenestrellina sp.

Spirifer sp.

The Broadford Formation is the same as the Chemung Formation of earlier reports. However, the Broadford of this area of Virginia is not the same age as the type Chemung of Pennsylvania. The type Chemung ranges from late Senecan to early Chautauquan, but the Broadford ranges into the latest Chautauquan and, therefore, is younger wherever a complete section is preserved (G. A. Cooper and others, 1942, Chart 4). Glover (1953), in his work on the Devonian-Mississippian systemic boundary of a portion of this area near Favonia, stated that the Chemung should be replaced by the Broadford as the name for this succession of strata in southwestern Virginia. B. N. Cooper (1963) used the name Broadford for sandstones and shales exposed along New River in Giles County, Virginia.

The contact between the Broadford and the underlying Brallier apparently is conformable. However, in the light of an incomplete and unimpressive amount of fossil material in the upper Brallier, it is possible that there may be a depositional break that is not represented by a marked unconformity. The upper beds of the Broadford are almost certainly transitional with the lowermost beds of the overlying Parrott Formation as there seems to be both a paleontological and lithologic continuity from one to the other. Glover (1953, pp. 14-16) could find no physical or paleontologic evidence of a marked break between the Broadford and the Parrott in this area or in any of the areas to the northeast or in Smyth County, Virginia, to the southwest. Indeed, it is difficult to ascertain where the Broadford stops and the Parrott starts except where there are excellent exposures and certain marker beds are well exposed.

#### Mississippian and Devonian Systems

##### Parrott Formation

Name. - The name Parrott was introduced by Glover (1953, p. 7) for exposures near the village of Parrott, Pulaski County, Virginia. B. N. Cooper (1963) was first to use the name formally.

Distribution. - The location of the Parrott Formation is limited to the crest and dip slopes of Little Walker and Little Brushy mountains. The type of soil and vegetation prevalent on the Parrott is essentially the same as that developed on the underlying Broadford. The crests of Griffith Knob and Browns Peak are capped by the basal portion of the Parrott Formation.

Lithology. - The sandstones that are prevalent in the Parrott Formation are typically flaggy, reddish-brown to maroon in color, and very fine to fine grained. Shale and siltstone interbeds are common, but are much less conspicuous than the flaggy sandstones and, in most instances, are concealed by sandstone float. The most common color of the finer clastics is brown to light-maroon.

Fossils, age, and correlation. - The most common fossils of the Parrott are Chonetes and Camarotoechia (Glover, 1953, pp. 14-16). These brachiopods are commonly found together on slabby ledges of sandstone and are generally distinguished by a bright rusty-yellow outline that tends to emphasize the fossil. These fossils were probably calcareous in fresh rock as some of the slabs show deep, differentially weathered shell molds and casts. The thickness of the Parrott Formation in the Griffith Knob is approximately 300 feet. Glover (1953, Plate 5, pp. 14-16) assigned the Parrott to the Lower and Middle Kinderhookian. The Parrott, which is marine in origin, is equivalent to the lower Price of Butts (1940, pp. 337-350) and the lower Price of Cooper (1944, pp. 145-151). The Parrott Formation is included at the base of the Price Formation of the geologic map (Plate 1) because of poor exposure and the inherent difficulty in locating the contact accurately in rugged, forested areas.

#### Price Formation

Name. - M. R. Campbell (1894, pp. 171, 177) named the Price Formation from Price Mountain in Montgomery County, Virginia.

Distribution. - The Price Formation crops out along the southeastern base of Little Walker Mountain and armors the dip slope of that mountain

in a belt that extends from the southwestern terminus of the area to the northeastern edge of the area. A second belt of Price is present along the southeastern base of Little Brushy Mountain and this belt extends from the southwestern end of the mountain northeastward across the area toward the town of Pulaski. The entire thickness of the formation is not seen in most of the area due to its concealment under the overthrust Cambrian carbonates along the Tract Fork and Pulaski faults.

Lithology. - There are two types of rock unique to the Price Formation. These two rocks are quartz-pebble conglomerate and coal. The quartz-pebble conglomerates are limited to the basal portions of the formation and are among the lowest beds included in the Price Formation. These quartz conglomerates were named the Cloyd Member of the Price Formation. Charles Butts (1940, p. 343) named the Cloyd from exposures of conglomerate at Cloyd Mountain, Pulaski County, Virginia. The type section of the Cloyd is just a few miles to the northeast of the area of this report and is an on-strike equivalent of Little Walker Mountain.

The coal beds in the Price Formation have long been the objects of intensive prospecting and hope for some of the residents in the area, but none of the coals has ever been successfully mined on a large scale because the beds dip below drainage relatively steeply and most of the coals are too thin and impure. They are not persistent enough to be mined along strike. In Montgomery County, at the village of Merrimac, the coals in the Price Formation were, once mined on a commercial scale, but modern methods of machine mining are not applicable to these coals and, consequently, the mining has practically ceased. Coal was also mined north

of Pulaski at the Langhorne and Empire mines and on the southeastern flank of Little Walker Mountain near Stony Fork of Reed Creek in the vicinity of Favonia. The two most prominent coal beds in the Price Formation have been named the Merrimac and Langhorne beds by Campbell (1925, p. 145) from the conspicuous development of these coals near Merrimac, Virginia, and on Cloyds Mountain at the old Empire Mine.

The lowest coal-bearing beds in the Price are about 300 feet above the base of the formation and are the probable equivalents of the Merrimac bed of Montgomery County. This interval is exposed in the Favonia area in several stream valleys, but is covered in most places by the allochthonous Cambrian dolomites that have been thrust over the formation along the Tract Fork and Pulaski faults. Residents of the Favonia area have reported that coal has been struck at depths of less than 50 feet in water wells and that as much as "nine feet of coal" was present in one of these wells near Leon's Motel on U. S. Route 21-52. However, if one considers the average dip of the bedrock in the area to be more than  $30^{\circ}$ , then the true thickness of the coal bed can not exceed 4.5 feet and this figure is probably higher than the true thickness because most of the coal in the area is highly crumpled and deformed because it has been folded and sheared as a result of its proximity to major faults. Most of the coal in the Price occurs in beds that are less than two inches thick and these are generally quite clayey and impure.

Quartz-pebble conglomerates occur in the basal beds of the Price Formation as lenses that are, in most places, less than 30 feet thick. The valley floor just north of Piney Mountain (see Plate 1) is littered with weathered-out quartz pebbles which were derived from the Price.

The maximum thickness of the conglomeratic part of the Price seen in the area is near the junction of Robinson Tract and Piney mountains at the head of Tract Fork Creek where the thick-bedded conglomerate is 90 feet thick. The conglomerate at this place consists of rounded fragments of white to light-gray vein quartz in pieces which are as large as 2 x 2 x 4 inches. The sandstones of the Price Formation are, in most places, relatively impure and range from arkoses and subgraywackes to proto-quartzites (see Pettijohn, 1957, pp. 316-321) in composition.

The thickness of the Price Formation is greatest on the dip slopes of Browns Peak and Griffith Knob where it is probably about 1,000 feet. The thickness is about 900 feet on Little Walker Mountain near the eastern border of Plate 1.

Age. - The age of the Price Formation is probably Osagean (B. N. Cooper, 1961, p. 61). Fossils of poorly preserved non-marine pelecypods and fragments of plants are present in some of the beds, but are of limited use for correlation of the formation.

#### Meramecian and Chesterian? Series

##### Stroubles Formation

Name. - B. N. Cooper (1961, p. 62) named the Stroubles Formation from exposures along Stroubles Creek near Blacksburg, Montgomery County, Virginia. The name was introduced to supplant the misuse of the name Maccrady Formation which was proposed by Stose (1913, p. 233). It includes predominantly red-bed successions of the same facies as the Maccrady, but ranges far higher stratigraphically than the Maccrady of the type area. Cooper (1961, p. 62) believes that the Stroubles must

range as high as Middle Chester due to the similarity of fossil bryozoans in the Stroubles and the Bluefield formations and the similarity of the Stroubles red-beds and the Mauch Chunk red-beds of Pennsylvania.

Distribution. - The Stroubles Formation is present in the Big Walker Mountain-Crockett Cove area as discontinuous patches along the Pulaski Thrust in the vicinity of Favonia and extends to the northeast and southwest for several miles along the fault trace. There are no Stroubles beds present in Crockett Cove proper northeast of the area at Fairview Church. In the area near the Robinson Tract Community in Pulaski County there is considerable Stroubles Formation exposed around the trace of the Pulaski and the Tract Mountain faults. Another belt of Stroubles is present just south of the mapped area near the southeastern base of Little Brushy Mountain.

Lithology. - The most distinguishing feature of the Stroubles Formation is the predominance of red, maroon, and green colors. The majority of the rocks consists of fine clastics in the clay- and silt-size range. A few beds of impure sandstone are present, but these comprise a minor percentage of the total thickness of the formation. In at least one instance there are beds of finely crystalline, medium-gray dolomitic limestone present in the Stroubles near the drainage divide between Sally Run and Laurel Run along Wythe County Road 600, 1.3 miles east of Favonia. The thickness of the dolomitic sequence is less than 10 feet. The total thickness of the Stroubles Formation exposed in the western portion of the area is from 50 to 600 feet. However, to the northeast in the Robinson Tract area the thickness may exceed 600 feet.

Age and correlation. - The age of the Stroubles Formation is thought to

be within the range of Meramec to Middle Chester (B. N. Cooper, 1961, p. 62). However, in the area of this study the thickness of exposed beds in the Stroubles is considerably less than the 1,600 feet of Stroubles reported by Cooper (1963, p. 22) in the Blacksburg synclinorium some 25 miles to the northeast. Therefore, it is quite possible that only a portion of the formation is present at the surface in the Crockett Cove and Robinson Tract areas.

The Stroubles is correlated with the entire group of formations that occupies the interval between the base of the Maccrady Formation of the Saltville, Virginia, area and the lower portion of the Bluefield Shale of the southwestern Virginia and the southern West Virginia area. The formations that make up this interval include, in ascending stratigraphic order, the Little Valley, Hillsdale, "Ste. Genevieve", and Glen Dean limestones (see Weller and others, 1948, Chart 5).

There are no units younger than the Stroubles in the area. The contact between the Stroubles and the underlying Price Formation is apparently conformable. The transition between the Price and the Stroubles is gradual and occurs within a stratigraphic thickness of several hundred feet of beds where the top of the Price becomes less coarse and more shaly upwards until the typically maroon and red claystones and shales of the Stroubles predominate.

## STRUCTURAL GEOLOGY

### Structural Setting

The Big Walker Mountain-Crockett Cove area is bounded on the northwest by the northwestern limb of the Greendale syncline which is one of the major structures of a large fault block bounded on the northwest by the Narrows fault and on the southeast by the Saltville fault. The trough and southeastern limb of the Greendale syncline have been overridden from the southeast by the Saltville fault block. The Saltville thrust is a low angle fault which dips to the southeast. The fault is the northern boundary of the Saltville block which extends southeast to the Pulaski thrust (see Plates 1, 6, and 8). The Saltville block is broken by the Tract Mountain fault which is roughly parallel to the Saltville fault. Plate 6 shows the location of the structural elements within the Big Walker Mountain-Crockett Cove area.

Two-thirds of the area lies north of the Tract Mountain fault and is made up of the Walker Mountain homocline. The Walker Mountain homocline represents most of the southeastern limb of the faulted anticline southeast of the Greendale syncline. William Moon (1961, Plate 1) named this fold the Poplar Hill anticline. In the western part of Walker Mountain homocline the beds have been locally deformed into two cross folds - the Stony Fork syncline and the Big Bend anticline. In the eastern part of the area there are subsidiary cross folds which, from north to south, are the Spur Branch syncline and the Long Spur anticline. There is one small fenster or window present in the northern part of the Walker Mountain homocline near Bland. The Piney Mountain syncline is the southernmost fold of the Walker Mountain homocline.

Structural features of the Tract Mountain block, which is bounded on the north by the Tract Mountain fault and on the south by the Pulaski thrust, are generally more complex than those of the northern block. The major structural elements of the Tract Mountain block are, from north to south, the Peak Creek anticline, the Round Mountain syncline, the Crockett Cove-Eddys Branch anticline, and the Queens Knob syncline. The Tract Mountain block is terminated in the vicinity of Favonia (see Plates 1 and 6) by the Pulaski block where it overlaps the trace of the Tract Mountain fault.

The Pulaski thrust limits the Pulaski block on the north. The structure of the Pulaski block consists of the Pine Ridge syncline in the area covered by Plate 1. The trace of the Pulaski thrust passes outside the southeastern boundary of the mapped area but, according to B. N. Cooper (1961, Plate 25), the trace continues to strike eastward for a distance of more than 10 miles to Draper Mountain in Pulaski County. At the eastern end of Draper Mountain the fault trace swings to the north past the end of Robinson Tract Mountain to the valley of Tract Fork Creek where the trace reappears as a U-shaped reentrant (see Plates 1 and 6).

#### Structural Blocks

Narrows block. - The footwall block of the Saltville fault is formed mostly by Mississippian and Devonian clastics which make up the northwest limb of the Greendale syncline. The Greendale syncline, which is one of the major structures in the Appalachians, plunges rather steeply to the southwest where, in Washington and Smyth counties, the Mississippian beds are thicker than anywhere else in Virginia.

Northeast of Crandon, north of Virginia Route 42, the rocks exposed on the footwall of the Saltville fault are mainly of Silurian and Ordovician age and there they form the overturned southeastern limb of the Brushy Mountain syncline of Moon (1961, Plate 1). The Brushy Mountain syncline is probably the on-strike equivalent of the Spruce Run syncline located in Giles County still farther to the northeast. The Brushy Mountain-Spruce Run syncline is probably the extension of the much larger Greendale syncline. Both synclines have a common northwest limb and are cut on the southwest by the Saltville fault; henceforth this syncline will be referred to merely as the Greendale syncline.

The trough of the Greendale syncline is located southeast of the trace of the Saltville fault. The exact location of the trough cannot be determined in the Big Walker Mountain-Crockett Cove area; but, in the Burkes Garden quadrangle just west of Effna, the trough of this asymmetrical, overturned syncline is within 2,000 feet of the fault (B. N. Cooper, 1944, Plate 1).

The abnormally thick sequence of Mississippian rocks that were deposited in the Greendale syncline in Smyth and Washington counties is believed by B. N. Cooper (1963, p. 94) to be evidence that this structure was experiencing contemporaneous subsidence and deposition. The thickest section of Devonian strata south of the James River is present in the Kimberling basin which is just north of Bland (B. N. Cooper, 1961, p. 108-109). This abnormal thickness must also be related to subsidence of the basin during deposition.

The large reentrant which is located just southwest of Bland may be related to the presence of the Stroubles Formation in the sub-surface

below the leading edge of the Saltville fault. Where the Stroubles is present along the footwall of the fault, it behaves as an incompetent material along which movement of the two blocks may be facilitated. Other more competent beds, such as the Parrott and Price formations, would tend to relatively retard movement.

Where the Stroubles is present farthest north under the sole of the Saltville fault, the advance of the hanging wall block, which is composed of Honaker Dolomite, should be greatest. Along the fault trace to the southwest and northeast of the reentrant, the Stroubles is probably located farther north than at the reentrant. The distribution of the Stroubles in such a pattern may be an indication of a syntectonic feature related to the subsidence of both the Kimberling basin and the Greendale syncline. The structure under this reentrant is probably an anticlinal cross fold that is adjacent to synclinal cross structures on both its southwest and northeast flanks.

Saltville thrust fault. - The Saltville thrust occurs in association with the northwestern limb of the Greendale syncline along its entire length of outcrop in the Big Walker Mountain-Crockett Cove area. The stratigraphic displacement along the fault decreases to zero to the northeast in the vicinity of Newcastle, Craig County, Virginia, where the break apparently dies out at the nose of the Sinking Creek anticline.

The stratigraphic displacement along the Saltville fault in the Saltville, Smyth County, Virginia, area is more than 8,000 feet as the Cambrian Honaker Dolomite is in fault contact above the Mississippian Maccrady Formation. In the southwestern two-thirds of the Big Walker Mountain belt (see Plates 1 and 6) the stratigraphic displacement is

approximately the same as that at Saltville. However, the stratigraphic displacement near the northeastern extent of the fault in this area is less than 4,000 feet as the Honaker Dolomite of the hanging wall block is in contact with limestones and shales of Middle Ordovician age which form the footwall block. The decrease in stratigraphic throw is due, for the most part, to the fact that older beds of the footwall block are encountered along the trace of the fault because it obliquely intersects the axis of the Greendale syncline.

The only good exposures of the Saltville thrust that can be studied in order to determine the dip of the fault surface are along artificial exposures such as road cuts. Such an exposure is located along the south side of Virginia Route 42, two miles southwest of the Giles-Bland County line at the Bland Correctional Farm near the northeastern corner of Plate 1. Plate 9 shows the exposure at that locality where the apparent dip of the fault surface is approximately 35 degrees to the southeast. The trace of the fault has sufficient sinuosity where it crosses topographic prominences to indicate that the dip of the fault plane is probably about 30 to 40 degrees to the southeast. B. N. Cooper (1944, Plate 1) shows the dip of the fault to be approximately 30 degrees. Another very important clue to the probable dip of the fault is found in the area south of Bland where a small fenster is present (see Plates 1, 6, and 7). According to the interpretation of the writer the dip of the fault near Bland must be between 20 and 25 degrees (see Plate 8).

There are at least five slices of Middle Ordovician strata exposed northwest of the trace of the Saltville fault in the northeastern part of the Big Walker Mountain-Crockett Cove area (see Plate 1). These slices

were originally part of the overturned southeastern limb of the Brushy Mountain syncline. The slices were carried to their present location north of the Saltville fault as they became detached from the overturned limb of the Greendale syncline and were moved up along the fault as the hanging wall block advanced up and to the north.

Walker Mountain homocline. - The beds which form the Walker Mountain homocline dip, in most places, toward the southeast at angles which range from 25 to 45 degrees. As previously noted the homocline constitutes the major part of the southeastern limb of the Poplar Hill anticline (Moon, 1961, Plate 1) or the northeastern limb of the Blacksburg synclinorium of B. N. Cooper (1961). In the Poplar Hill area, which is located about 10 miles northeast of the Giles-Bland County line, the crest and northwestern limb of the Poplar Hill anticline is present locally (Moon, 1961). The anticline which plunges to the southwest has Cambrian Honaker Dolomite exposed in the core. The axis and the northwestern limb of the anticline are cut off by the Saltville fault just northeast of the Big Walker Mountain-Crockett Cove area and, consequently, are no longer present at the surface in the area that is covered by Plate 1.

The oldest beds present in the Walker Mountain homocline are the Honaker Dolomite of Cambrian age. The youngest beds now present on the homocline are the Stroubles Formation of Mississippian age. The width of the structure ranges from a maximum of 8 miles near the western border of the area to less than 4.5 miles on the eastern border of the area. The thickness of the sequence of sedimentary rocks which comprise the homocline is about 10,000 feet. In general the thickness of the individual units decreases along strike toward the northeast.

There are two prominent cross folds in the Walker Mountain homocline. These folds, herein named the Stony Fork syncline and the Big Bend anticline (see Plate 6), are rather broad, open cross structures which plunge almost due south at an angle of about 15 degrees. The structures apparently die out down dip in Devonian shales at the southern base of Big Walker Mountain.

South of the Big Bend anticline and the Stony Fork syncline the dip values decrease toward Griffith Knob and Browns Peak where the beds dip less than 5 degrees to the south. South of these two peaks the dip values increase abruptly to more than 35 degrees (see Plate 1). The Price and Stroubles formations crop out south of the peaks and dip at angles greater than 50 degrees where they disappear beneath the Pulaski thrust block.

Long Spur, which is a spur on the southeast flank of Big Walker Mountain, is an anticlinal flexure on the Walker Mountain homocline (see Plate 1 and 6). The fold is slightly steeper on the northern limb and the plunge of the axis is approximately five degrees east. Bedrock exposures along the limbs and crest of the fold, which has not been completely breached by erosion, consist of the Tuscarora through Millboro formations. The topographic potency of the orthoquartzites that arch over on the anticline are responsible for the ridge that is known as Long Spur. The structure is here named the Long Spur anticline.

The rocks north of the Long Spur anticline have been folded into a small, eastward-plunging syncline which is here named the Spur Branch syncline after the stream that flows along the axis of the fold. The youngest beds present in this syncline are the Millboro and Brallier formations of Devonian age.

Both the Long Spur anticline and the Spur Branch syncline plunge and die out to the east at the southern base of Little Walker Mountain. The lowest elevation on the crest of Little Walker Mountain in this area coincides with a zone of highly fractured bedrock which is directly on strike with the axial trace of the Long Spur anticline. Other minor shifts along the ridge line of Little Walker Mountain southwest of the wind gap where Pulaski County Road 738 crosses the mountain are due to cross structures which are not persistent enough to be given geographic names. The Spur Branch syncline, Long Spur anticline, and the smaller associated folds apparently die out in the Blacksburg synclinorium to the southeast.

Bland window. - A unique feature in the Walker Mountain homocline occurs 1.5 miles south of the town of Bland (see Plates 1, 6, and 7). There an elliptical fenster of Middle Ordovician strata is surrounded by Cambrian and Ordovician dolomites, limestones, and cherts of the Saltville block. The contact between the beds within the window and the adjacent overlying strata is marked by a highly brecciated girdle of dolomite, chert, limestone, and shale which can be found in an unbroken state both farther within the fenster and adjacent to the fenster within the relatively allochthonous block. Allochthonous, in this case, is relative and refers to rocks within the fenster. The "zone" of breccia is of almost certain tectonic derivation as its character and features are remarkably like the tectonic breccias associated with other more prominent faults such as the Pulaski and Max Meadows faults. The angularity of the fragments and the relationship among the fragments, such as rotated and highly fractured pieces of a block which was apparently one larger fragment, demand a tectonic origin

for the breccia. The breccia seems to be better developed along the northern and eastern edges of the window. However, this apparently better development of breccia may be due to the lack of good exposure along the western and southern edges of the window.

The dip of the fault surface which surrounds and originally overlay the window is probably greater than 45 degrees at most places on the surface for there is no marked deviation of the fault trace where it crosses stream valleys or hills. The best exposure of the fault contact between Knox Dolomite of the hanging wall block and Middle Ordovician limestones of the footwall block is along the north bank of Walker Creek near the junction of Bland County Routes 617 and 603 just south of Bland (see Plates 1 and 7). Here, the fault plane dips out to the east toward the upthrown block at an angle of approximately 37 degrees.

The outcrop belts within the fenster describe a doubly plunging syncline which is broken by a series of probable reverse faults which strike nearly parallel to the axial trace of the syncline (see Plate 7). The youngest beds which are exposed within the fenster are shales and limestones of the Middle Ordovician Martinsburg Formation. The Moccasin Formation which normally underlies the Martinsburg Formation is present and is underlain with apparent conformity in most places by limestones which resemble, for the most part, the Chatham Hill Formation. The absence of any beds which can definitely be referred to as the Wassum or Witten may be due to either unrecognized faults or the presence in the window of a limestone facies which does not normally include lithologies which can be correlated with the Wassum-Witten.

The origin of the fenster is a problem which will probably be controversial for many years or at least until core drill data is available

for study. The Moccasin beds which are present within the window show more lithologic similarity to previously referred to slices of Moccasin brought up along the Saltville fault northeast of Bland (see Plate 1). The Moccasin Formation that is exposed in the allochthonous block is much more sandy and less calcareous than the Moccasin which is exposed within the window. Therefore, based on these considerations, the source of the beds within the window must be the same as the fault slices to the northeast - namely, the footwall block of the Saltville fault. In the case of the window, the source is probably the northwestern, normal limb or the trough portion of the Greendale syncline.

The northern edge of the fenster is about 8,000 feet south of the main trace or leading edge of the Saltville fault near Bland. As the strata north of the fault are of Mississippian age and dip less than 20 degrees to the south, the normal succession probably continues for some distance below the fault plane.

Structure section CC' in Plate 8 shows the interpretation of the Bland window as proposed by the writer. The Greendale syncline over which the Saltville block was thrust, must, according to this view, be a much broader and less tightly folded structure in the Bland area than it is in the vicinity of Crandon and Point Pleasant some eight miles to the northeast. Dip values north of the fault near Crandon and Point Pleasant support this thesis.

As previously noted, the dip of the Saltville thrust surface in the Bland area must be less than 20 to 25 degrees (see Plate 8, cross sections) in order to explain the reappearance of the same fault at the surface around the window. If the fault surface dips steeply, then the origin of

the beds exposed within the window must be explained by a process similar to the injection of a horst-like plug of sedimentary rocks through the overriding block.

If the dip becomes less in the subsurface, then the origin of the beds within the window may be explained as a detached slice of the homoclinally dipping beds below the Saltville thrust block. These beds which are exposed in the window were abutted by and plucked off by the overriding fault block and carried upward along the low-dipping fault surface to their present position.

The long-term effects of weathering and erosion have lowered the topographic surface developed on the once overlying bedrock enough to expose the fault and the beds inside the window. The apparent steepness of the fault surface is probably related to the steepening of the fault surface upward near the surface where the sedimentary cover was thinner.

Piney Mountain syncline. - The Piney Mountain syncline lies just north of the Tract Mountain fault. The syncline, which is essentially symmetrical, plunges between 10 and 15 degrees to the N.60°E. The dip of the limbs ranges from 20 to 30 degrees. The structure loses its identity as a fold just southwest of the salient in Little Walker Mountain. The Piney Mountain syncline is probably a minor flexure near the western nose of the much larger regional feature - the Blacksburg synclinorium. The beds that are folded and that appear at the surface consist of the upper Broadford, Parrott, and the lower Price formations. The axial portion of the syncline contains, on the surface, abundant quartz pebbles and cobbles that have been weathered from the Cloyd member of the Price Formation. Locally, on the southeastern limb near the trace of the Tract Mountain

fault, the dip of the beds is as much as 56 degrees to the north. The steep dips are probably due to drag folding of the beds adjacent to the Tract Mountain fault.

Tract Mountain fault. - The Tract Mountain fault is a major structural element of the southern part of the Saltville block. This fault, which essentially parallels the southern base of Little Walker Mountain (see Plates 1 and 6), passes under the Pulaski block in the area just southeast of the village of Favonia on U. S. Route 21-52. The fault trace passes out of the mapped area along the northern base of Robinson Tract Mountain at the eastern edge of the map (Plate 1). The Tract Mountain fault passes under the Pulaski block near the eastern end of Robinson Tract Mountain and according to B. N. Cooper, 1961, Plate 21, reappears at the surface again nearly 30 miles to the northeast next to the Pulaski thrust just north of Blacksburg, Montgomery County, Virginia.

The hanging wall of the Tract Mountain fault is composed of beds that range from the Cambrian Honaker Dolomite to the Mississippian Price Formation. The footwall block north of the fault trace is composed, at its southwestern terminus, of Upper Devonian to Lower Mississippian formations. The dip of the fault surface is toward the south at an angle which, in most places, is about 35 to 45 degrees. The basis for this estimate is mapping which reveals only one pronounced deviation that are related to topographic features. Locally, such as near the northeastern end of Crockett Cove proper, the dip of the fault surface is less than 25 degrees as the elevation of the fault trace decreases only 400 feet in a horizontal distance of 1,000 feet. At this place, the fault trace swings abruptly toward the north and forms a salient which is composed of overturned beds of relatively resistant Huntersville and Clinch formations.

Near Favonia (see Plate 1), the Cambrian carbonate rocks that comprise the beds on both sides of the Tract Mountain fault are highly brecciated and deformed. Tectonic breccia is well developed at this place because the Pulaski and Tract Mountain faults are in such close proximity. However, in most other localities there is no pronounced concentration of tectonic breccia along the trace of the Tract Mountain fault.

The stratigraphic displacement of the Tract Mountain fault near Favonia is approximately 8,000 feet as Upper Cambrian rocks are in fault contact with Lower Mississippian rocks. However, the amount of stratigraphic displacement decreases progressively toward the northeast where, at the juncture of Piney and Robinson Tract mountains, the displacement is probably less than 1,000 feet because Lower Mississippian rocks form both the footwall and hanging wall blocks. Therefore, the type of movement which characterizes the Tract Mountain fault in this area is scissors or oblique slip for the northeastern area acted as the point of least movement or rotation.

As the stratigraphic displacement decreases northeast along this fault, the difficulty in locating the fault increases. Unless the stratigraphic displacement of the fault increases eastward just outside the mapped area, the fault would have to die out either near the eastern end of Robinson Tract Mountain or just beneath the Pulaski block. The presumed persistence of this fault along strike to the northeast outside the mapped area would seem to be enhanced if the dip of the fault plane decreases in that direction.

Tract Mountain block. - The Tract Mountain block is composed of strata which range in age from Cambrian to Early Mississippian. These rocks have been folded into several northeast -trending and northeast-plunging anticlines and synclines which are relatively limited in areal extent. As the displacement of the Tract Mountain fault decreases to the northeast, the southwestern part of this block shows the most apparent northwestern movement. Conversely, the northeastern edge of this block lacks only a thousand feet of stratigraphic displacement of still being connected to the main part of the Saltville block.

In the eastern part of the Tract Mountain block the Peak Creek anticline and the Round Mountain syncline plunge northeast apparently into the Blacksburg synclinorium. The Crockett Cove-Eddys Branch anticline, although separated from the axis of the Blacksburg synclinorium by the Tract Mountain fault, also plunges toward the trough of the synclinorium.

Peak Creek anticline. - The Peak Creek anticline which trends and plunges toward the northeast is named for the main stream that drains the area in which it is present. Beds of the Brallier, Broadford, and Parrott-Price formations are folded to produce this structure which apparently dies out down plunge toward the Blacksburg synclinorium. The Tract Mountain fault parallels the northwestern limb of the fold for a distance of about 2.5 miles and cuts obliquely across the axis of the fold two miles east of the Pulaski-Wythe County line (see Plates 1 and 6).

Round Mountain syncline. - The northwestern limb of the Round Mountain syncline, which is named for the mountain located near the nose of the

structure, is also the southeastern limb of the adjacent Peak Creek anticline. The syncline plunges about 10 degrees to the N. 60°E. The trace of the Tract Fork fault cuts obliquely across and slightly offsets the axis of the fold near the headwaters of Tract Fork Creek (see Plate 1). All of the beds involved in this fold are Upper Devonian and Lower Mississippian sandstones and shales. The stratigraphic displacement along the Tract Mountain fault in the mapped area is at a minimum along the northwestern limb of the Round Mountain syncline; the hanging wall block consists of the Broadford and Parrott formations, whereas the footwall block is composed of mainly Price and Stroubles beds.

The Round Mountain syncline plunges under the Pulaski thrust sheet near the junction of Fortnerfield Branch and Tract Fork Creek (see Plates 1 and 6). The beds at the nose of the fold near the summit of Round Mountain are approximately horizontal; however, dip values of from 5 to 10 degrees to the northeast are common along the axis to the northeast. The northwestern limb of the fold generally has lower dips than the southeastern limb which has dips that range from nearly vertical to slightly overturned to the northwest.

Crockett Cove-Eddys Branch anticline. - The Eddys Branch anticline is named for the stream which breaches and flows parallel to the axis of the fold. The axis of the fold strikes northeast and plunges to the northeast. The structure lies just southeast of the axis of the Round Mountain syncline and apparently dies out eastward toward the trough of the Blacksburg synclorium toward the northeast across the trace of the Tract Fork fault. The axis of the Eddys Fork anticline is on strike with the Crockett Cove anticline which is located three miles to the west.

It is probable that these two anticlines are the same and that the principal difference between the trend of the two is caused by the flexures to the north, namely the Peak Creek anticline and the Round Mountain syncline. The presence of these two folds north of the Crockett Cove-Eddys Branch anticline apparently is responsible for the curvature of the axis in the area near Holston School on Route 712 in eastern Wythe County (see Plates 1 and 6).

The southern limb of the anticline is normal and has dips that range from 30 to 50 degrees to the south. However, the fold is asymmetrical because the beds on the northwest limb dip as much as 40 to 50 degrees or more toward the north. Beds of the Brallier Formation form the core of the structure, whereas the beds that form the limb of the fold are red sandstones and shales of the Stroubles Formation. Only the northwest limb of the fold with the Stroubles Formation is exposed in the mapped area. Little Brushy Mountain is formed by the southeastern limb of the fold and the base of Robinson Tract Mountain coincides with the northwestern limb which is cut by the Tract Mountain fault which trends subparallel to the trace of that limb. The nose of the Eddys Branch anticline is preserved at the juncture of Chestnut and Robinson Tract Mountain two miles northeast of Pulaski. The Pulaski thrust sheet, which forms a large reentrant at the nose of the anticline, covers the fold northeast of the nose. The anticline which is exposed in the Price Mountain window nearly 20 miles northeast may be an on-strike equivalent of the Crockett Cove-Eddys Branch anticline.

The western portion of the Crockett Cove-Eddys Branch anticline lies immediately south of the Tract Mountain fault and in the large strike

valley, Crockett Cove, which is underlain by the rocks that form part of this structure. This fold is here designated the Crockett Cove anticline.

Campbell (1925, p. 37) called this anticline the Crockett anticline. However, as there is no geographic location in this area named Crockett per se, the writer has added the word "Cove" to Campbell's term in order to more precisely relate the structure to the geography.

With the exception of a small area in the extreme northeastern portion of Crockett Cove, none of the northern limb of the anticline is exposed in this area. The southern limb of the fold is all that remains of what was probably, prior to faulting, a rather small, prominent anticline that plunges toward the northeast and loses its structural identity in the Pulaski (Empire syncline of Campbell, 1925, p. 82) synclinorium. However, as faulting has occurred and has been accompanied by erosion and breaching of the structure, only the southern limb of the anticline remains. The oldest beds exposed in the core of the anticline are the Honaker Dolomite. The plunge of the axis of this structure cannot be accurately measured at present. However, it is estimated that the plunge is approximately 15 to 20 degrees if values for adjacent structures are comparable. The plunge of the Piney Mountain syncline which is located two miles northeast of the nose of the Crockett Cove anticline is approximately 12 degrees. The plunge of both structures was probably less than 10 degrees prior to folding as the type of movement along the Tract Mountain fault apparently had significant horizontal and vertical components of movement and, consequently, the true plunge of the folds is greater now than it was initially. The plunge of the fold decreases to the northeast.

The values of dip along the southern flank of the Crockett Cove anticline decrease, in more or less regular fashion, from the structurally highest portions of the fold to the structurally lowest portions in the northeast. Beds at the southwest fault terminus of the fold have dips of from 50 to 70 degrees toward the south. However, beds near the structural nose of the fold dip from only 20 to 25 degrees to the south. The formations near the nose of the fold have been subjected to rather great deforming forces because of their proximity to the Tract Mountain fault. This stress combined with the relative resistance to deformation provided by the competent Clinch and Juniata formations near the nose of the anticline where the trend of the beds is nearly parallel to the direction of greatest stress during faulting resulted in the following features:

- 1) beds in the Rich Valley-Clinch stratigraphic interval typically have dips that are either nearly vertical or overturned. The beds are generally highly sheared and fractured near the trace of the Tract Mountain fault and the nose of the Crockett Cove anticline.
- 2) the relatively incompetent Martinsburg Formation is deformed into a large bulbous outcrop pattern in the area near the headwaters of Peak Creek. The Martinsburg was apparently folded into the area of low stress that was between the southern and the northern limbs of the anticline during faulting and folding. The competent Clinch orthoquartzite was sheared and overturned during this time, but did not experience as much deformation as the Martinsburg.

Queens Knob syncline. - The southernmost fold north of the Pulaski fault is the Queens Knob syncline which is here named for the topographic prominence located three miles north of the town of Wytheville. The Queens Knob syncline is an east-plunging fold that is asymmetrical because the dips of the beds on the normal northwestern limb of the fold range from 25 to 70 degrees and the southern limb shows dips that range from near vertical to overturned by as much as 20 degrees from the vertical. The lower values of dip are characteristic in the trough and northeastern portions of the structure. Higher dips are common in the southwestern portions of the fold near the Pulaski and Tract Mountain faults. The youngest beds known to have been deposited in the Queens Knob syncline belong to the Stroubles Formation. However, these beds are not exposed in the structure in the mapped area, but are present only 0.5 miles east of the extreme southeastern corner of the mapped area near the confluence of Coal Creek and Miller Creek. The upper part of the Price Formation is the youngest formation present in the map area and beds of this unit form the typical U-shaped outcrop pattern of a plunging syncline on Little Brushy Mountain. With the exceptions of portions near Little Brushy Mountain and the area near Queens Knob, the southern limb of the syncline is concealed beneath the Elbrook and Rome formations of the overriding Pulaski fault block.

M. R. Campbell (1925, pp. 81-82) named this syncline the Max Meadows syncline. However, the writer feels that this name is not as suitable as the Queens Knob syncline because the trough of the structure is located fully two miles north of Max Meadows, whereas Queens Knob is formed by the beds located on opposing limbs of the fold.

The features of the Queens Knob syncline are discernible for a distance of at least 20 miles northeast of the area, and to the southwest these features can be noted for a distance of more than 10 miles near Marion, Smyth County, Virginia, where the structure is highly faulted and loses its identity between the Pulaski and Hungry Mother faults. In the Dublin area the Pulaski synclinorium, of which the Queens Knob syncline is a subsidiary flexure, dies out and the predominant feature is the Blacksburg synclinorium (Cooper, 1961, Plate 33).

The Queens Knob syncline is the southwest extension of one of the component synclines of the Pulaski synclinorium (Cooper, 1963, Plate 2.1). The Pulaski synclinorium is south of and separated from the Blacksburg synclinorium by a gentle arch.

The overturned southeastern limb of the Queens Knob syncline is also the northwestern overturned limb of an anticline which must have at one time lay south of the present axis of the syncline. The elimination of the anticlinal structure south of the overturned limb is a problem that requires study of an area much larger than the Crockett Cove area in order to completely solve, if solution is possible. The Draper Mountain window which is about 15 miles northeast of the mapped area reveals an anticline which has its northwest limb overturned (B. N. Cooper, 1961, Plate 25). This anticline is located immediately south of the axis of the Pulaski synclinorium which is on strike with the Queens Knob syncline. A reverse fault of small stratigraphic displacement is present along the northwest limb of the Draper Mountain anticline (Cooper, 1961, Plate 25). If this fault continues along strike to the southwest into the mapped area and the displacement along the fault increases toward the southwest, then

the anticlinal crest and part of its southeastern limb may have been eliminated by movement along this fault which would lie somewhere below the Pulaski block. What must have been a major anticlinal slice probably was brought up along this fault and pushed along in front of the Pulaski block. Since it has been destroyed by erosion, any trace of the postulated fault is missing because of covering by the Pulaski block. The presence of fault slices along the southern flank of Queens Knob supports this interpretation.

Variations in thickness and stratigraphy of units within the Crockett Cove area support the theory of syntectonic sedimentation on the Crockett Cove anticline and the Queens Knob syncline (Webb and Cooper, 1963). The subject is treated more fully under the heading of Syntectonic Sedimentation, but briefly the main argument in support of this theory is based on stratigraphic studies in the Crockett Cove anticline and the Queens Knob syncline which form Crockett Cove (see Plate 1). Greater thicknesses of sediment near the trough of the Queens Knob syncline indicate more pronounced subsidence of the sea floor under the sites of synclines, whereas lesser thicknesses of the same stratigraphic units are present near the crest of the Crockett Cove anticline. The areas of less sediment accumulation are thought to coincide with areas of less profound subsidence. Lithologic variations between the two structures also tend to support differential movement of the sea floor during sedimentation.

Pulaski block. - The southernmost fault in the area is the Pulaski thrust fault which forms the northern limit of the Pulaski block. B. N. Cooper (1961, p. 86) gives a minimum horizontal displacement of 7 to 8 miles

from its root zone to the southeast. The rocks comprising the leading or northern edge of the fault block consist of the Rome or Elbrook formations in most places (Butts, 1940, p. 449). The Elbrook Formation comprises the bedrock on the overthrust edge of the Pulaski fault block in this area.

The northern edge of the allochthonous block commonly shows a well developed fault breccia which consists largely of angular fragments of dolomite, limestone, and shale in a matrix of finely crushed carbonate and shale fragments. The same type of material is common in the Elbrook and Rome along the entire length of the Pulaski fault in the Appalachians. The most extensive development of this tectonic breccia has been named the Max Meadows Breccia (B. N. Cooper, 1959, p. 4). The breccia is present between the Elbrook Formation and the Rome Formation where the Rome has been thrust upon the Elbrook in areas near the Pulaski fault. Although there is, in a strict sense, no true development of the Max Meadows Breccia in this area, the type of brecciation present along the trace of the Pulaski fault probably had the same genesis as the Max Meadows Breccia. The breccia was produced where movement of the overriding mass of Elbrook resulted in the generation of great crushing forces that crushed and rolled out fragments of bedrock from both the allochthonous and autochthonous blocks. Subsequently these macerated fragments were lithified and exposed by erosion and now mark the trace of the Pulaski fault zone. The best exposure of tectonic breccia in the Crockett Cove area is in the fields along Sally Run near the junction of Wythe County Roads 600 and 661. At this locality the Pulaski fault block has overridden both the Tract Mountain and Saltville fault blocks and the traces of the Pulaski and Tract Mountain faults intersect. The rocks that have been subjected to

crushing along the two faults are highly brecciated and the resultant tectonic breccia is quite similar to the Max Meadows Breccia of the type areas.

The tectonic breccia exposed along Sally Run is characterized by angular to subangular pebble- to boulder-size fragments of dolomite and light greenish-gray shaly dolomite which are enclosed in a matrix of light brownish-gray silty dolomite that is fine to medium grained. Much of the breccia is porous and the majority of the fragments comprising the rock seem to have no preferred direction of orientation.

The Pulaski fault surface dips at angles of from 20 to 30 degrees as far as can be ascertained from field studies and mapping the trace of the fault. The overridden rocks range from the Cambrian (Honaker Formation) to Mississippian (Stroubles Formation) in age. Near the trace of the fault the rocks comprising the autochthonous block are generally more highly fractured and relatively more steeply dipping than the rocks situated more than 250 to 500 feet north of the fault. In the vicinity of Queens Knob there are several detached slivers of the Tract Mountain fault block that have apparently been brought up from beneath the sole of the Pulaski fault plane and carried to the surface where they now rest against the relatively indigenous rocks of the Tract Mountain block. These fault slice blocks include overturned beds that range in age from Early Ordovician to Middle Ordovician and include portions of the Knox, Ciesler, and Chatham Hill or Rich Valley formations. These fault slices are best displayed in the area that lies at the southern base of Queens Knob between Wythe County Roads 661 and 659.

The overall structure of the Pulaski block is that of a syncline which, just southwest of the mapped area, is named the Pine Ridge syncline.

The axial trace of this syncline strikes northeast and is probably a southwestern continuation of one of the major synclines of the Pulaski block to the northeast.

#### Syntectonic Sedimentation

The conventional interpretation of the depositional history in the Appalachian geosyncline involves accumulation of sediments on the depositional floor which, somehow, was subsiding uniformly as the sediments accumulated. E. O. Ulrich (1911) advanced the idea that the Appalachian geosynclinal basin floor subsided at a more or less uniform rate and without any recognizable persistent framework of structure. In effect, the beds just accumulated. Therefore, each structural feature is interpreted as an attribute which was gained after the last bed was deposited.

Continuing along the lines of reasoning that had been established by Ulrich, Dennison (1961), Woodward (1958), Kay (1951), and others have evaluated thickness and facies variations in different parts of the Appalachian section on the basis of the same broad regional frames of reference which have been used to explain stratigraphic variations in the Central Interior region. Most of the areas of sediment source have commonly been conceived to lie if not wholly, then at least predominantly, outside the Appalachian geosyncline.

Notable exceptions to this prevalent concept include the suggestions made by Bailey Willis (1893, pp. 217-241) on the recycling of Paleozoic sediments in general; A. W. Grabau (1909, pp. 209-252) stated that derivation of the Bald Eagle or Oswego sediments was by the erosion and subsequent redeposition of the Lower Cambrian quartzites from the Blue

Ridge belts that were upraised during the Taconic orogeny; and P. D. Krynine (1951, p. 747) postulated the recycling of Paleozoic sediments, based on his work with heavy mineral suites of successive stratigraphic units.

The Big Walker Mountain-Crockett Cove area is of too limited extent to furnish much additional information on the source areas of the Appalachian Paleozoic sediments. However, it is large enough to illustrate how sediments derived from some source or sources were deposited. The Crockett Cove area contains one belt of outcrop which stretches in a broadly sigmoidal curve from the crest of the Crockett Cove anticline southwestward into the trough of the adjacent Queens Knob syncline.

The succession of beds that comprise the Honaker through the Knox Group in the Crockett Cove belt appears to be remarkably uniform in thickness from the trough of the Queens Knob syncline and on the crest of the Crockett Cove anticline. There is very little observable variation in the Honaker - Knox succession except possibly for a little greater thickness of Longview limestones in the St. Lukes Fork area near the trough of the Queens Knob syncline than along the axis of the Crockett Cove anticline. However, this variation may be merely a matter of facies change of part of the thicker Longview Limestone section in the Queens Knob syncline into dolomite on the crest of the anticline to the northeast. Because there are no well exposed sections of these Lower Ordovician limestones in the Big Walker Mountain belt to the north, no accurate comparison can be made between the northern and southern strike belts at present. Also the amount of quartz sand present in the Copper Ridge beds in the Crockett Cove belt is relatively uniform along strike. The

character of the medium- to coarse-grained sandstones of this formation also is relatively uniform along strike. However, comparison of the thickness of the Copper Ridge sandstones in the Big Walker Mountain belt shows that the sands thicken northwestwardly and in a fashion that is independent of existing structure. From all local indications in the area of consideration, the Paleozoic sediments ranging from the Honaker up to the top of the Knox Group were laid down on a floor that subsided more or less uniformly and with no decipherable patterns in the subsidence.

The depositional environment was one of shallow marine conditions during all of the time interval represented by the Honaker through Mascot units. Evidence of this is in the form of primary depositional features such as mud cracks, ripple marks, marine fossils, cross-stratification, scour-and-fill structures, and development of intraformational conglomerates and breccias. These features are especially evident in the Noli-chucky, "Chepultepec", and overlying Copper Ridge formations in an area 0.35 mile northwest of the junction of Wythe County Roads 600 and 659 in the southwestern end of Crockett Cove. In the Big Walker Mountain belt the Copper Ridge contains excellent examples of large-scale scouring where as much as twelve inches of beds have been eroded away within a horizontal distance of less than five feet (Plate 10). The Copper Ridge at the previously noted locality is exposed in a fresh cut along Bland County Road 608, 0.25 mile south of Point Pleasant. Here, the dark brownish-gray fine- to medium-grained dolomite is laminated. The beds exposed in this section, which extends for a distance of approximately 75 yards normal to the strike, not only show the effects of scouring but also exhibit what is probably the best example of soft sediment carbonate

deformation displayed in this part of the folded Appalachians. The contorted sequence occurs in a 7.5 feet thick interval which displays highly contorted bedding that indicates, by the direction of overturning soft-sediment slump down a southeast-sloping depositional surface. Where the beds have moved farthest and been contorted the most, squeezing, rotation, and partial dismemberment of the laminated beds within the axial portions of the nearly recumbent microfolds have taken place. Photographs shown in Plates 11-14 illustrate these features. The origin of the contorted, convolute beds may be the result of a small scale limited slide down a slope on the sea floor shortly after the time of deposition.

The topmost beds of the Knox Group in both strike belts have been eroded probably as a result of an eustatic lowering of sea level in late Canadian time. Evidence of this break has been widely recognized in the Appalachians. Beds deposited directly above the surface of unconformity consist of angular to subangular fragments of chert and dolomite probably from the upper Knox. These chert and dolomite clasts have been incorporated in the lowermost beds of the Blackford and Mosheim formations in both of the strike belts in the area. The best display of the basal breccia beds in either of the two strike belts is on the farm of M. H. Bowen, Jr., about two miles south of Bland in the Big Walker Mountain belt. The conglomerate and breccia are not so well developed toward the northeast along strike in this belt. The uppermost beds of the Knox Group exposed in the Crockett Cove area have also experienced erosion, but the development of the basal conglomeratic beds in the overlying Middle Ordovician is at best only slight.

Beginning with the Champlainian beds and continuing up stratigraphically at least as high as the top of the Silurian System, each successive stratigraphic subdivision shows a thinner section on the Crockett Cove anticline than in the Queens Knob syncline. The cumulative difference in aggregate thickness of beds deposited on the Crockett Cove anticline and the Queens Knob syncline is about 2,000 feet. The distance across strike from the synclinal trough to the anticlinal axis is less than 2.5 miles. Along strike the trough and crest are less than 8.5 miles apart. Thus, on the basis of much local knowledge of the thickness of each individual unit, it seems inescapable that the thickness of beds deposited was controlled by inception of differential downwarp along axes essentially identical to those of the Crockett Cove anticline and the Queens Knob syncline. This relation of existing structure to sedimentation has been pointed out by Webb and Cooper (1963).

The Giesler, Mosheim, and Fetzer limestones of the Crockett Cove belt are the oldest beds which show marked effect of the contemporaneous differential downwarp in the Queens Knob syncline and Crockett Cove anticline. The effect of the downwarp which started probably in early Champlainian time is manifest in these units in that their aggregate thickness decreases up structure from a maximum of 125 feet in the trough of the Queens Knob syncline to a minimum of less than 70 feet on the Crockett Cove anticline.

Additional stratigraphic evidence that supports the hypothesis of sedimentation and contemporaneous downwarp is found in the nature of the lithologies of these units as they are followed along strike from the trough of the syncline northeast to the Crockett Cove anticline. The

Giesler Limestone which is a dark-gray to nearly black, highly impure biosparite, has its thickest development in the trough of the syncline on the J. Kelley farm just south of Wythe County Road 600 along St. Lukes Fork. On the crest of the anticline less than 8.5 miles northeast, the Geisler unit is at most only 20 feet thick and is locally absent in many places. Nodular black chert in the form of irregularly shaped ellipsoidal masses is relatively abundant in the trough of the syncline in the Geisler, but none was seen in the anticlinal section. The decrease in the amount of silica probably indicates that downwarping along the axial portion of the synclinal trough caused trapping of the colloidal quartz and the greater thickness of sediment.

The Fetzer Limestone, which is overlain by the Rich Valley Formation, is even more impure than the Geisler Limestone in the Crockett Cove area. The Fetzer is rich in organic material, iron sulfide, silt, and clay. The silty black, medium- to fine-textured limestone is from 10 to 15 feet thicker in the trough of the syncline than on the Crockett Cove anticline where it is only 5 to 10 feet thick.

On the farm of Charles King near the northeastern end of the Cove, the normal sequence of Fetzer directly under the Rich Valley Formation is not present. Between the two there is a localized body of limestone which represents an indigenous reef situated nearly on the crest of Crockett Cove anticline. The confinement of the Effena reefy limestones to the crestal portion of the Crockett Cove anticline is more than fortuitous and probably reflects less rapid subsidence of part of the old sea floor. The shallow waters favored biohermal accumulation.

In the Crockett Cove area the Rich Valley Formation overlies the Fetzler or, where the Effna is present, overlies the latter. The thickness of the Rich Valley Formation ranges from a maximum of more than 600 feet in the Queens Knob syncline to less than 400 feet on the crest of the Crockett Cove anticline. The dark brownish-gray limestones which comprise most of the formation in this belt constitute more than 90 per cent of the formation in the northeastern end of the Cove on the crest of the anticline. In the Queens Knob syncline, however, less than 70 per cent of the formation is composed of that lithology. Calcareous graptolitic shales which are high in iron sulphide and weather a distinctive chocolate-brown are more abundant in the syncline. The predominance of clastic sediments in the Rich Valley Formation in the trough of the syncline is probably the result of flushing of more mobile material into the structural-topographic lows which were the troughs of growing synclines of deposition.

The Chatham Hill Formation consists mainly of dark-gray impure, sulfide-bearing intramicrites and biomicrites which are more or less abundantly fossiliferous. The formation contains abundant interbeds and partings of siltstone and fissle shale. The thickness of this formation ranges from a maximum of 300 feet in the Queens Knob syncline to a minimum of less than 160 feet near the crest of the Crockett Cove anticline. The lithologic change which is attendant with the change from syncline to anticline consists of a decrease in shale-clay content from former to latter. The color of the formation also is from dark-gray to black in the syncline, whereas it ranges from medium- and light-gray to reddish-gray near the anticlinal axis at the northeastern end of the Cove.

Although there are silicified fossils present in the Chatham Hill in this belt, there are no black chert nodules present as are present in the Big Walker Mountain strike belt.

The Wassum and Witten limestones thin up structure along strike from a maximum of 300 feet in the syncline to approximately 50 feet near the crest of the anticline. The basal portion of this formation contains yellowish-tan shale partings and interbeds which are more numerous in the syncline than on the anticline. Approximately 35 feet of calcareous lusterless yellow, light "sky-blue"-weathering shale which contains few fossils, is of rather local extent, and is apparently confined to the trough portion of the syncline because there is no similar lithology present in the more easterly area on the crest of the anticline.

The Bays Formation overlies the Wassum-Witten succession in the Cove with a "knife-edge" contact. Along St. Lukes Fork and just east of Wythe County Road 603 where Cove Creek flows across it, the abrupt change from deposition of relatively pure carbonates to coarse-grained, conglomeratic quartzose sandstone can be observed within a stratigraphic thickness of three inches. Detailed study of several exposures in the Queens Knob area reveals that no more than a few feet, if any, of the underlying beds have been removed or reworked by the scouring action of the currents which washed the coarse clastics into the area. As the supply of clastics, mainly vein quartz, became more abundant in late Witten-Wassum time, these clastics were transported to the northwest and dumped directly on top of the relatively pure limestones that had been deposited in the Queens Knob syncline and on the Crockett Cove anticline. A small amount of the clastics

was transported as far north as the northwestern limb of the Blacksburg, Pulaski synclinorium (i.e., Walker Mountain homocline) and incorporated in the Moccasin Formation (see Plate 23A). The Bays Formation in the Queens Knob syncline contrasts sharply with the thinner, much finer textured red beds in the Draper Mountain area (Cooper, 1961) and the Marion, Virginia, area; but is essentially like, though by no means as thick as, the Bays Formation in the Catawba or Salem syncline (Cooper, 1963). The pronounced coarseness and abnormally greater thickness of the Bays Formation in the trough portion of the Queens Knob syncline reflects relatively greater downwarp during sedimentation in the axial portion of the syncline.

If the thickness and lithology of the Bays were the only data available for study, then it might possibly be argued that the occurrence of a greater thickness and coarser, more impure section of Bays clastics in the Queens Knob syncline than on the Crockett Cove anticline might be related to either, or both, distance from source area and normal or reverse sedimentary by-passing (Krumbein and Sloss, 1956, p. 172). However, all other data for intra- as well as extrabasinal sediments point to greater thicknesses of sediment in the trough of the Queens Knob syncline than on the Crockett Cove anticline.

Because of poor exposures the Martinsburg Formation which overlies the Bays and Moccasin formations in this area offer little opportunity for detailed observation of any lithologic variations from the Crockett Cove anticline into the adjacent Queens Knob syncline. However, a major increase in the thickness of the Martinsburg from anticline to syncline is clearly indicated. More than 1800, possibly as much as 2,200, feet of beds make up the Martinsburg in the syncline, but there is certainly less than 900 feet of section that represents the Martinsburg on the crest

of the anticline. Although there is no single continuously exposed section of Martinsburg present in the area, most of the attitudes where available in areas where sections were measured were consistent and showed less variation than one normally finds in the Martinsburg Formation. In most places, the amount of limestone present in the Martinsburg is greater toward the crest of the anticline. There seems to be more shale, siltstone, and fine-grained calcareous sandstone present in the trough of the syncline.

The Juniata Formation consists of a series of maroon to reddish-brown sandstones, shales, siltstones, and mudstones of probable non-marine or very shallow marine origin. The thickness of the formation ranges from approximately 200 feet near the crest of the anticline to slightly more than 275 feet in the trough of the Queens Knob syncline. The Juniata contains coarser sand in the trough of the syncline than on the anticline.

The Clinch orthoquartzites are well exposed in the gap carved by Cove Creek in Cove Mountain along Wythe County Road 603. At this locality which is near the trough of the Queens Knob syncline, the thickness of the formation is 165 feet. Accurate measurement of the formation near the crest of the anticline is difficult and complicated by the fact that the rock is exposed on a steep dip slope, but in the northeastern end of the Cove it is about 100 feet. Thus, the Silurian sandstones also reflect structural control of their thickness.

In summary, the beds ranging from basal Champlainian to Upper Silurian, deposited over a period of perhaps more than 100 million years and having an aggregate thickness of about 4,400 feet reflect relatively greater subsidence along the axis of the Queens Knob syncline than on adjacent areas of the Crockett Cove anticline. There is too little of the Devonian

shales and the Mississippian clastics exposed in the area to indicate greater thicknesses of beds in the synclines than on the anticlines, but B. N. Cooper (1963) has shown structural control of thickness in these units in the Blacksburg-Pulaski synclinorium.

#### Origin of Structures

Mechanics of deformation. - The competence of the strata which are involved in the folds and faults in the Big Walker Mountain-Crockett Cove area extends over a relatively wide range. Relatively competent units such as the ridge-forming Tuscarora and Clinch orthoquartzites occur between sequences of incompetent beds such as the Devonian shales and the Martinsburg Formation.

Flexure or true folding in a strict sense is limited to include only bending of beds as a result of compressional forces in most instances. Bending of the strata is alone not sufficient to account for the structural features of the mapped area. Drag folds are present in parts of the Martinsburg, Brallier, Stroubles, and in limited places in the Chatham Hill and Rich Valley formations. Drag folds, according to classical interpretation, result from slippage along bedding planes of beds past each other. Therefore, flexure-slip folding in which any given upper bed moves away from synclinal axes upward in relation to an adjacent lower bed has occurred to some extent.

The structures in the mapped area show strong evidence of having been deformed by forces which were compressional and acted principally from the southeast. The folds are generally asymmetrical and have their axial planes tilted toward the northwest in all instances. The faults,

which developed after the folds had formed, all dip to the southeast at angles generally less than 45 degrees.

The facts that support syntectonic sedimentation for two of the folds in the area have been presented and interpreted in a previous part of this thesis. The case in favor of vertical movement of the basement and early inception of folding, that is in Middle Ordovician time, seems to be strong for at least the southern folds in the area. Other folds adjacent to and on strike with structures in the Big Walker Mountain-Crockett Cove area have been studied by B. N. Cooper (1961 and 1963) and found to show evidence in support of vertical differential movement of the basement.

Whether forces that produced the structures in the mapped area were entirely due to vertical movement of the basement or entirely due to lateral compressive forces cannot be stated definitely. However, there is evidence, previously stated, to strongly support syntectonic sedimentation and vertical forces acting through the basement. Lateral-directed compressional forces probably played an important role in the later stage (s) of deformation as the folded strata were broken by low angle thrust faults.

Folding of the salient of the Pulaski thrust block which is present in the eastern part of the area in Tract Fork valley seems to require that deformation occurred over an extended period of time rather than a single closing phase of relatively limited duration. Folding of the Pulaski fault block where it lies above the trough of a syncline has been demonstrated by B. N. Cooper (1961, p. 88; 1963, p. 31) for the Blacksburg synclinerium. The fault block salient in Tract Fork valley

apparently shows the same features and, therefore, would indicate the continuation of subsidence even after faulting began.

Time of deformation. - The area studied by the writer is of too limited extent to provide a basis for establishing the exact nature and duration of the so-called Appalachian orogeny. However, the area does provide information on the date of inception of two adjacent and related folds - the Queens Knob syncline and the Crockett Cove anticline. As previously indicated (Webb and Cooper, 1963) these folds began to take form even while the Middle Ordovician and younger strata were being deposited. They signify basement control of not only deposition, but of folding.

Whether there was a late Paleozoic orogeny is not clearly demonstrated in the Big Walker Mountain-Crockett Cove area. The Pulaski and Tract Mountain faults cut beds as young as the Stroubles Formation, hence are at least late Mississippian (Cooper, 1963, p. 32). Cooper (1963) has discussed the probable nature of the Pulaski thrust in the type area and has suggested that it is very likely a gravity-induced overriding of a great indigenous syncline.

At least, it can be said that the folds in the area studied by the writer are closely involved with sedimentation and were basement controlled. Lateral compression, possibly generated by subsidence, has been a dominant tectonic feature since early in Paleozoic time. Very little more can be said without repeating either old traditional ideas and concepts of Appalachian folding or repeating some of the controversial conclusions of Cooper (1963) which are based upon a much wider knowledge of Appalachian geology than the writer possesses.

## GEOMORPHOLOGY

The relative resistance to erosion of the various sedimentary rocks plays the most important role in the geomorphic differentiation of an area. In addition to the relative resistance of the rocks, the areal distribution and location of structural features such as folds, faults, joints, and fractures, have a profound effect on the size, magnitude, and distribution of the geomorphic elements which comprise the topography of an area.

The Valley ridges portion of the folded Appalachians is characterized by ridges and valleys that are essentially parallel to the strike of the beds which form them. The relative relief of these features is related to the relative resistant or non-resistant nature of the rocks which hold up the mountains or underlie the valleys. The ortho- and protoquartzites and quartz-rich conglomerates are the most prominent ridge makers. Secondary ridges at lower elevations are formed by relatively impure sandstones, interbedded fine-grained clastics and sandstones, and more or less pure chert-bearing limestones and dolomites. The valley floors are underlain in most cases by shales, impure limestones and dolomites, mudstones, as well as calcareous and non-calcareous black shales.

The thickness of a resistant bed is an important factor in determining the relative elevation of the geomorphic feature which it forms. In most instances the thicker sections of a given formation coincide with the highest elevations on a ridge held up by the formation. This relationship is particularly well shown by the row of low knobs upheld by the Bays Formation and the relatively pure Witten Limestone in

Crockett Cove. These two units show a progressive decrease in thickness from the southwest to the northeast. This thickness change is reflected by a decrease in both the elevation of the knobs and the local relief of the knobs in relation to the adjacent topographic features.

The attitude of a ridge-forming unit is a very important factor in determination of the height of the ridge. N. M. Fenneman (1936, p. 183) was first to recognize the importance of the thickness and the attitude of a bed in relation to topographic potency. Generally, the more a unit has been tilted from the horizontal during the process of folding and structural evolution, the greater the number and development of fracture and joint systems in the unit. Where the beds are nearly horizontal, the height of the ridge held up by the beds will be greater than where the same beds are tilted more if all other factors are the same. Cooper (1944) in his study of the Burkes Garden Quadrangle presented one of the first cases for the control of ridge elevations by variations in dip angle and stratigraphic thickness of the beds which hold up the ridges.

Two striking examples of topographic highs that are underlain by nearly flat-lying or gently dipping beds are present in the Big Walker Mountain-Crockett Cove area. In the Griffith Knob area west of U. S. Route 21-52 the elevation of the ridge which is capped by the Parrott Formation ranges from 3450 to 3600 feet, whereas the beds of the same formation on Little Walker Mountain just a few miles to the northeast hold up a ridge that ranges in elevation from 2800 to 3200 feet. The essential difference in this instance is that the beds at Griffith Knob dip less than 10 degrees, whereas the beds along the crest of Little

Walker Mountain dip more than 25 degrees.

The maximum elevation of Big Walker Mountain is 3984 feet near Big Bend which coincides with an anticlinal cross fold in the ridge-forming Tuscarora Orthoquartzite. At Big Bend, the Tuscarora dips at an angle of approximately 20 degrees toward the southeast. Other elevations along the crest of this mountain are lower but are capped by beds of the same formation which dip at angles greater than 25 degrees in most places. It is generally the rule, rather than the exception, that all along Big Walker Mountain where the beds are gently dipping the elevations are greater.

The gap cut in Cove Mountain by Peak Creek is located where the combination of the thinnest section of Clinch Sandstone and the maximum elevations on this mountain are located where the beds are most gently dipping. The elevations at these points are in excess of 3400 feet, whereas the more steeply dipping Clinch along strike to the southwest holds up a ridge that does not exceed 3200 feet elevation.

The lowest elevations on Little Walker Mountain are located in an area where the rocks are highly jointed and fractured. This area, 3 miles southeast of the village of Longspur, shows a slight bend in the strike of the ridge crest which coincides with the axis of a minor cross fold.

One of the lower elevations on the crest of Big Walker Mountain coincides with a fracture-joint system that cuts the Tuscarora near the Big Walker Lookout. The other low summit elevation of Big Walker Mountain occurs where the ridge-forming strata are steeply dipping on the Route 738 which leads south from Mechanicsburg.

The ridge crest profiles in the entire area are the antithesis of the classic concept of peneplaned surfaces as proposed by earlier workers in the Appalachians such as Butts (1940) and Campbell (1896). Both Little Walker and Cove mountains are striking examples of uneven-crested mountains that, where viewed from most vantage points, appear as storm-tossed waters which have irregular wave lengths and amplitudes. The headward-cutting obsequent streams which flow down the outcrop slopes of these ridges are almost surely the agents responsible for the irregular nature of the crests.

Warping or tilting of supposed "peneplains" cannot be invoked to explain the variations in elevation of the ridges in this area mainly because the process would, by the very nature of the irregularities, entail much extremely localized tilting and warping. If one but examines the longitudinal profiles of these crests, the credibility of the peneplain concept must surely be questioned seriously.

The majority of longitudinal and cross sectional profiles that are presented to show the "even-crested" nature of ridges in the Appalachians are plotted on a scale of one inch per mile or less. Such scales are not realistic because the magnitude of relief is not effectively shown where dealing with supposed peneplains that were within one thousand feet or less of the same general elevations. If one carries the scale a bit further and backs off to the moon and examines the Earth and its relief from there, the whole planet could be classed as having a flat, "peneplaned" surface.

In order to obtain the proper respect for the non-even-crested nature of Appalachian ridges, one has but to walk a distance of several miles

along the summit of a ridge such as Cove Mountain or Little Walker Mountain. Where these ridge profiles are plotted to a scale of 1000 or 500 feet to the inch, the irregularities are more impressive.

#### Drainage

The entire area lies within the drainage basin of New River and its tributaries. The Tennessee - Ohio watershed divide is located approximately one mile west of Effna which is in the extreme northwestern corner of Plate 1.

The area that lies north of Big Walker Mountain is drained by the northeast-flowing Walker Creek which discharges its waters into the main course of New River at Pembroke, 15 miles to the northeast in Giles County. The average gradient of the stream is 35 feet per mile in the mapped area. The stream's course is entrenched as much as 200 feet in the area between Bland and the Giles County-Bland County line. The effect of entrenchment is hardly noticeable near the headwaters of the stream.

The valley between Big Walker and Little Walker mountains is underlain by Devonian shales and is drained by two main streams. The portion of the valley that lies within Wythe County is drained by Stony Creek and its East Fork, both of which are tributary to Reed Creek. These streams flow at an average gradient of from 65 to 75 feet per mile. In the gap between Little Walker Mountain and Griffith Knob just north of Favonia the steepness of the stream bed may represent evidence for the entrenchment of the stream as it cut the gap by headward erosion through the Devonian and Mississippian rocks which cap the two mountains. Laurel

Run and Sally Run which flow into Stony Fork south of Favonia drain areas that are underlain by the Elbrook Dolomite and Price-Stroubles formations between Favonia and Fairview.

The area between Little and Big Walker mountains which lies in Bland and Pulaski Counties is drained by Little Walker Creek. The divide that separates East Fork-Stony Fork drainage from Little Walker Creek drainage is only 50 feet in height. The stream gradient is approximately 5 feet per mile (10 per cent) greater on the western side of the divide. The greater gradient will probably contribute to the ultimate shift of the divide to the east and to the pirating of the headwaters of Little Walker Creek by Stony Fork. The confluence of Little Walker Creek and Walker Creek is at Poplar Hill, Giles County, 8 miles east of the eastern boundary of Plate 1.

Crockett Cove is drained by Cove Creek and Peak Creek. At present, Cove Creek has the greater drainage area, but this is probably due to the relatively more recent extension of the headwaters of Peak Creek across the trend of Cove Mountain. The gradient of Peak Creek is almost 100 feet per mile, whereas the gradient of Cove Creek is approximately 55 feet per mile. The gradient advantage of Peak Creek should ultimately result in the capture of most of the drainage of this valley by Peak Creek as the divide shifts to the west. There may already be some "lost" flow of Cove Creek drainage into Peak Creek via underground solution openings in the Knox Dolomite and Middle Ordovician limestones which form the divide at present.

The southwestern portion of the Cove is drained by two streams - St. Lukes Fork, which is tributary to Cove Creek; and Sally Branch, which

is tributary to Stony Fork-Reed Creek. Cambrian and Ordovician carbonates form a low ridge of from 50 to 100 feet relief that is the divide between these two streams. There is probably already some mixing of the waters of these two drainage nets by underground connection in carbonate solution-cavity systems.

The gap cut in Cove Mountain isolates Queens Knob from the main mass of the ridge and may be located where it is at present rather than to the southwest on carbonate bedrock due to any one or combination of several possible factors. These are outlined as follows:

- 1) The location of the gap is due to a joint or fracture system that contributed to the localization of relatively rapid downcutting at this locality.
- 2) The gap is superimposed on its present course due to the area's at one time being overlain by the leading edge of brecciated and highly fractured Elbrook Dolomite along the trace of the Pulaski Thrust. As the stream eroded downward to its present course, the dolomite was slowly removed and eroded to its present limits just a few thousand feet to the south.
- 3) The stream established a course through the gap due to headward erosion.

The most probable cause of the location of the gap is probably a combination of all three of these factors. The second and third factors were probably incipient causes and the first probably contributed later.

The area lying to the east and northeast of Piney and Round mountains, and to the south of Little Walker Mountain near the eastern boundary of

Plate 1 is drained by Tract Fork which flows into Peak Creek at Pulaski some four miles to the east. Fortnerfield Branch and Tract Fork flow almost entirely along the main trace of the Pulaski Thrust. The location of these stream courses is structurally significant because the rocks which comprise the overthrust sheet are highly brecciated, especially near the edges of the sheet, and are, therefore, more easily eroded and more likely to be sites of stream valleys.

West Fork Creek and Mudlick Branch drain the valley which is between Cove Mountain and Little Brushy Mountain. Both of these streams empty into Reed Creek, but Mudlick Branch has a 30 per cent steeper grade. It is likely that the gap incised by Mudlick Branch is more recent than the West Fork-Miller Creek gap because the gradient of the former is greater. If the streams were of the same age, then the gradients should be about the same if all other factors were equal. However, the rocks through which Mudlick flows are nearer the trace of the major fault and, consequently, are more brecciated and less resistant to erosion. Also, Miller Creek gap cuts across the general strike of the beds and this factor, when compared to the fact that Mudlick flows more or less parallel to the strike of the beds, should result in the establishment of a gap at the more eastern locality. But, as the gap is to the west (and all the factors combine to make this the least likely spot for a gap) and the gradient is steeper, it is concluded that Mudlick Fork is younger and is gradually pirating West Fork drainage.

The largest stream which drains the area is Reed Creek which has a mean annual discharge of 260 cubic feet per second at Grahams Forge which is about three miles southeast of Max Meadows (U. S. Geological

Survey, 1960, Water-Supply Paper 1725, p. 208). Reed Creek has a gradient of less than 15 feet per mile which is 60 per cent less than any of the other streams in this area. Southeast of Max Meadows and in the vicinity of Wytheville the stream is entrenched as much as 250 to 300 feet. As is the case with all of the entrenched streams in the area, only the lower reaches of the stream are noticeably entrenched. This is probably due to the relative slowness of the headward migration of increased downward cutting by the stream in response to rejuvenation of its course. The increased gradient is probably due to the effective shortening of the course of the New River-Kanawha drainage system during the Pleistocene by ice damming and subsequent establishment of a new, shorter course to the sea. The point where Reed Creek discharges its waters into New River is located seven miles southeast of Max Meadows at Barren Springs.

## UNDERGROUND WATER

### General Statement

Most of the water utilized for domestic consumption in this area is obtained from natural springs, impoundments, or wells. The water obtained from drilled wells usually occurs in rocks that have secondary porosity and permeability owing to the fact that they have been fractured. Essentially all of the rocks of this area are either devoid of primary porosity and permeability or have very low percentages of open, connected pore space as they are tightly cemented. The almost closed nature of the sediments is probably due to a large extent to the post-diagenetic cementing of the constituent rock fragments in response to the heavy

load of material deposited on them.

### Fractures

The most favorable sites for finding suitable supplies of underground water in this area will be where the rocks have well distributed, more or less extensive fracture and joint systems. The most favorable water well locations will be near the faults where the rocks on both sides of the fault have been most extensively broken and fractured. Water also tends to circulate along fault surfaces and thereby promote recharge. The entire succession of strata in this area has been fractured and broken to some extent, but only where the fractures are connected and closely spaced is there much quantity of water available from bedrock.

### Solution Cavities

Underground solution openings that develop in carbonate rocks provide passageways for the movement of much water underground. However, the openings are generally large and have a direct connection with the surface. For this reason the water moves quite rapidly and undergoes little or no effective filtration. Consequently, this water may, more often than not, be impure and not suited for domestic consumption.

### Unconsolidated Deposits

Good supplies of water may be obtained from wells located in alluvial- or colluvial-filled valleys and near the lower slopes of some ridges. These alluvial-colluvial deposits are composed mainly of poorly sorted boulder-sized blocks of weathered ridge-forming sandstone, chert, and minor amounts of softer material derived from the disintegration of

carbonates and finer clastics. In most instances these colluvial-alluvial deposits are quite porous and permeable and receive an adequate supply of recharge from streams which flow over or drain into them. Consequently, water effectively soaks into and recharges the material. These deposits are usually quite effective filters in the removal of turbidity and contaminants from the water and, as a result, provide potable water.

#### Springs and Underground Drainage

Natural springs of this area occur in several diverse geologic settings. One of the common types consists of water which issues from underground at some point near the edge of alluvial-colluvial deposits. This type of spring is common on the slopes of the large colluvial-covered slopes of Big Walker Mountain. Another type of spring is the more or less typical limestone or dolomite spring which consists essentially of water which issues forth from solution openings that have developed in the bedrock. The occurrence of springs along the trace of faults is common. One such spring of this variety is located in the Honaker Dolomite which is brecciated and partially crushed along the trace of the Tract Fork fault. Approximately one-half mile northwest of Mt. View Church in Crockett Cove the Honaker contains several of these springs which have yielded, according to residents of the area, a dependable supply of apparently potable water for as much as 30 years.

Several springs are located near the crest of Long Spur. These springs provide small supplies of good water and flow throughout most of the year. The water flows between bedding planes of the Silurian and Devonian sandstones which cap this anticlinal ridge and issues from rock

ledges at several points near the crest of the ridge. Recharge is probably through fractures and joints that penetrate the rock in a vertical direction and circulation horizontally is probably along bedding planes in a direction more or less parallel to the plunge of the fold.

The greatest development of subsurface drainage is in areas that are underlain by the Cambrian and Ordovician carbonates in Crockett Cove, in the valley north of Big Walker Mountain, and south of the trace of the Pulaski Thrust. Karst topography is well displayed in these three areas and "sinking", "dry", and "lost" creeks are numerous. One has but to look at the size of the area drained by the major streams and notice the size of the stream discharge in order to be impressed by the quantity of apparent underground stream flow.

## ECONOMIC GEOLOGY

### General Statement

The economic resources of the area consist almost entirely of sedimentary rocks and minerals of a non-metallic nature. The most abundant industrial rock is limestone. Sandstone occurs in relatively great quantities, but most of it is too impure to warrant further consideration as an economic resource. Where the sandstones are pure, the rock is generally too hard and tough to be economically utilized. Hematite occurs in the Rose Hill Formation, but most of the deposits of this mineral are low grade and too thin to work on an economical basis under the present system of mining and beneficiation. Coal beds are present in the Price Formation, but the beds are generally less than

3 feet thick and dip too steeply to be mined on a large scale at present. M. R. Campbell (1925) studied and evaluated the coal reserves of this area and the interested reader is referred to his work for it is quite thorough and, despite its age, rather up-to-date as little exploration has been done since the 1920's.

The mineral and rock dolomite occurs in rocks of Cambrian and Ordovician age, but, so far as is known, the only deposits that might be potentially valuable occur in the Honaker Dolomite. Shale that could be used as a source of lightweight aggregate occurs in the Millboro Formation, but whether the material will bloat or not has not been determined. Colluvial and alluvial deposits which consist of gravels and boulders are rather extensive along the bases of most of the larger mountains in the area. These deposits might provide a source of fill material or loose aggregate for construction purposes.

Galena and sphalerite have been reported by residents of the area near the junction of U. S. Route 52-21 and Virginia 42 southwest of Bland. These minerals, if indigenous to the area, are probably concentrated due to the result of hydrothermal activity or ground-water movement through the fractured host rock which was probably Honaker Dolomite.

The mineral barite has been reported by several of the natives of the Fairview area in the southwest part of Crockett Cove. However, none of this mineral was seen by the writer. If the mineral barite is actually present, it is probably confined to the carbonate rocks which have been fractured and broken along the Pulaski Fault and concentrated as vein and replacement deposits.

Limonitic iron ore has been extensively prospected along the south-east or dip slope of Cove Mountain. The material occurs as the cementing or matrix substance of a collapse breccia that occurs between the top of the Clinch Sandstone and the Millboro Formation where relatively high carbonate material has been dissolved away by the action of percolating ground water and the limonitic material has been deposited in the interstices between angular fragments of shale, sandstones, and chert.

The Stroubles Formation in this area contains no gypsum or halite so far as is known. However, there is at least one bed of dolomite in the formation along Route 600 near Sally Run at the southwest end of Crockett Cove. The presence of dolomite may be an indication of more favorable conditions for the deposition of gypsum or rock salt or both in the Stroubles Formation either down dip or along strike in the subsurface as a highly saline depositional environment is generally inferred for dolomite.

The presence or absence of any one or all of these mineral deposits must be proved by core drilling and detailed mapping of each area of interest on a scale of less than an inch per 1000 feet. In most places the development of the deposits may not be economically feasible for many years. However, in some instances, especially for those minerals and rocks that are present in great amounts, are easily extractable, and have high place value, development may take place in the near future.

#### Limestone

Limestone is the material which shows the greatest promise of being utilized in the immediate future. The uses of limestone in industry are

numerous and have a wide range. The rock is the main source of lime (CaO) which is widely used in the chemical industry, the cement industry, and in agriculture. The rock is used as crushed stone and in this role it is important in the construction industry.

The best rock for use as crushed stone in the Crockett Cove area is either the Longview Limestone or the Mosheim Limestone. Both of these units contain a relatively low amount of chert and both should be rather easily broken in an impact or jaw crusher. The Longview is the thicker of the two formations and is generally located in the more favorable topographic site.

In either outcrop belt most of the limestones and dolomites that are more or less chert-free could be used as agrock. The Effna and Wassum-Witten limestones might be low enough in silica content for use as mine dust. Portland cement, which is essentially a mixture of shale and limestone in a one to three ratio, could be made from a mixture of Effna Limestone and the gray shales of the Middle Ordovician succession. However, detailed core drilling, sampling, and chemical analyses would have to precede any serious attempt to develop such an industry in this area. It must also be noted that a market for the material would have to be located before development.

Lack of a railroad and modern, high-speed highways has previously limited utilization of limestone and dolomite in the Big Walker Mountain belt. However, the soon-to-be constructed Interstate Highway 77 may provide the impetus necessary to promote some industrial utilization of these materials. There are numerous favorable quarry and cement plant sites within less than two miles of the highway right-of-way and any

quarry or cement plant operator would be at a distinct economic advantage if he were to utilize this modern, high-speed, all-weather route for north-south transportation by truck to points of sale or distribution.

Plate No. 9

Looking northeast at the fault contact between the Honaker Dolomite and the Moccasin Formation along Highway 42 near the Bland-Giles County line. The beds to the left of the creek in the right-hand one-third of the photograph are the southeast dipping Honaker Dolomite. Beds in foreground are in Moccasin Formation which are part of a fault slice caught between the Saltville fault and the Brushy Mountain syncline.

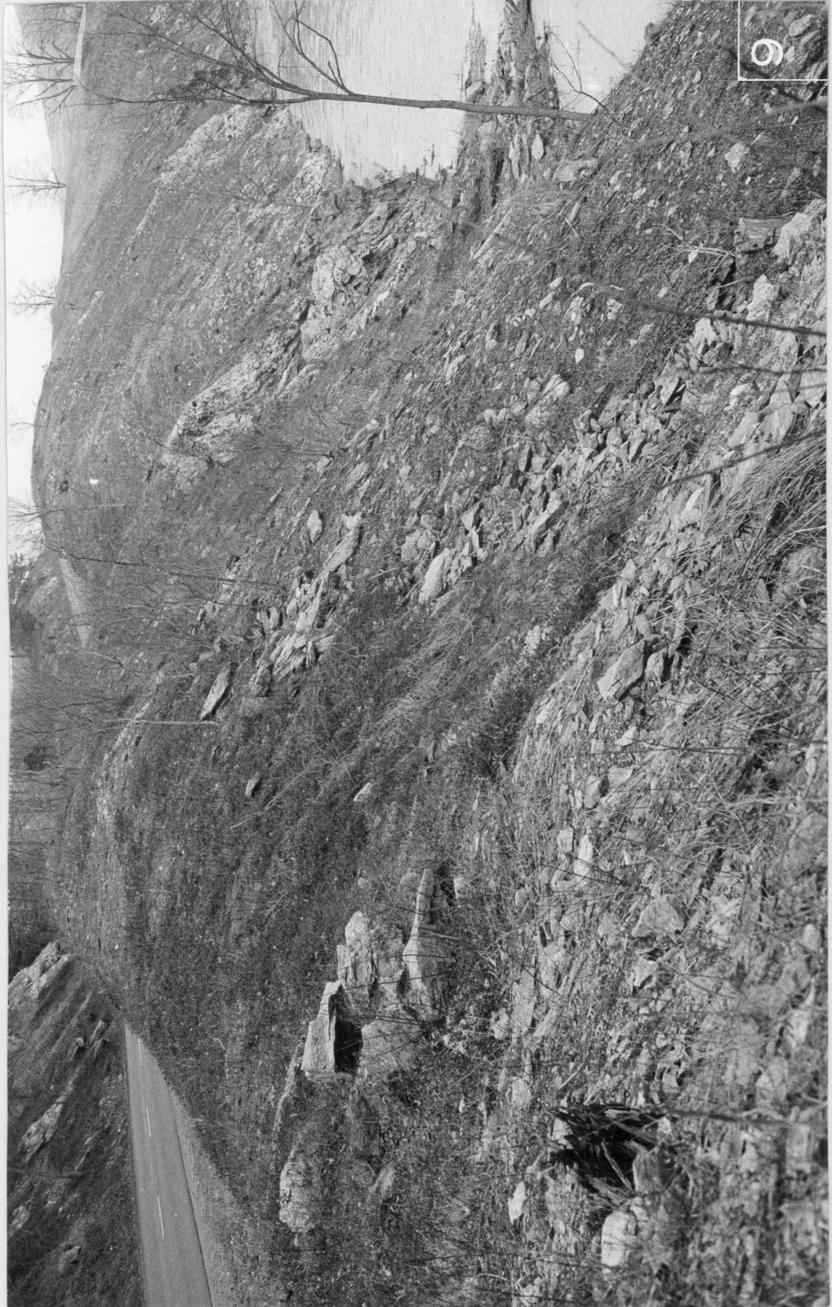


Plate No. 10

Small disconformity in Copper Ridge Dolomite along Road 608 just south of Point Pleasant in Bland County. The bed on which the hammer is lying was partially removed by erosion prior to the deposition of the bed just above the hammer. Note the irregularity of the bedding surface between the two beds. There is considerable quartz sand in this interval. The thickness range of the scoured bed is between 12 and 36 inches. The scouring bed ranges from 3 to 24 inches in thickness.



Plate No. 11

Slump structures and convolute bedding, which are well displayed near the center of the photo, in dolomites of the Copper Ridge Formation. Southeast is to the right of the photograph. The soft, unconsolidated sediment is thought to have slid down the primary depositional surface toward the right prior to lithification. This dolomite is finely crystalline, medium to dark gray, laminated, and contains a few isolated grains of quartz sand. Located along northeast side of Bland County Road 608, 0.35 miles south of Point Pleasant.



Plate No. 12

Partial dismemberment and rotation of dark-gray, crinkly laminated dolomite near the "crest" of a slump-induced convolute fold in the Copper Ridge Formation. Location and orientation is same as in Plate 11. Photo covers area just above and to the right of 6-inch scale in Plate 11.

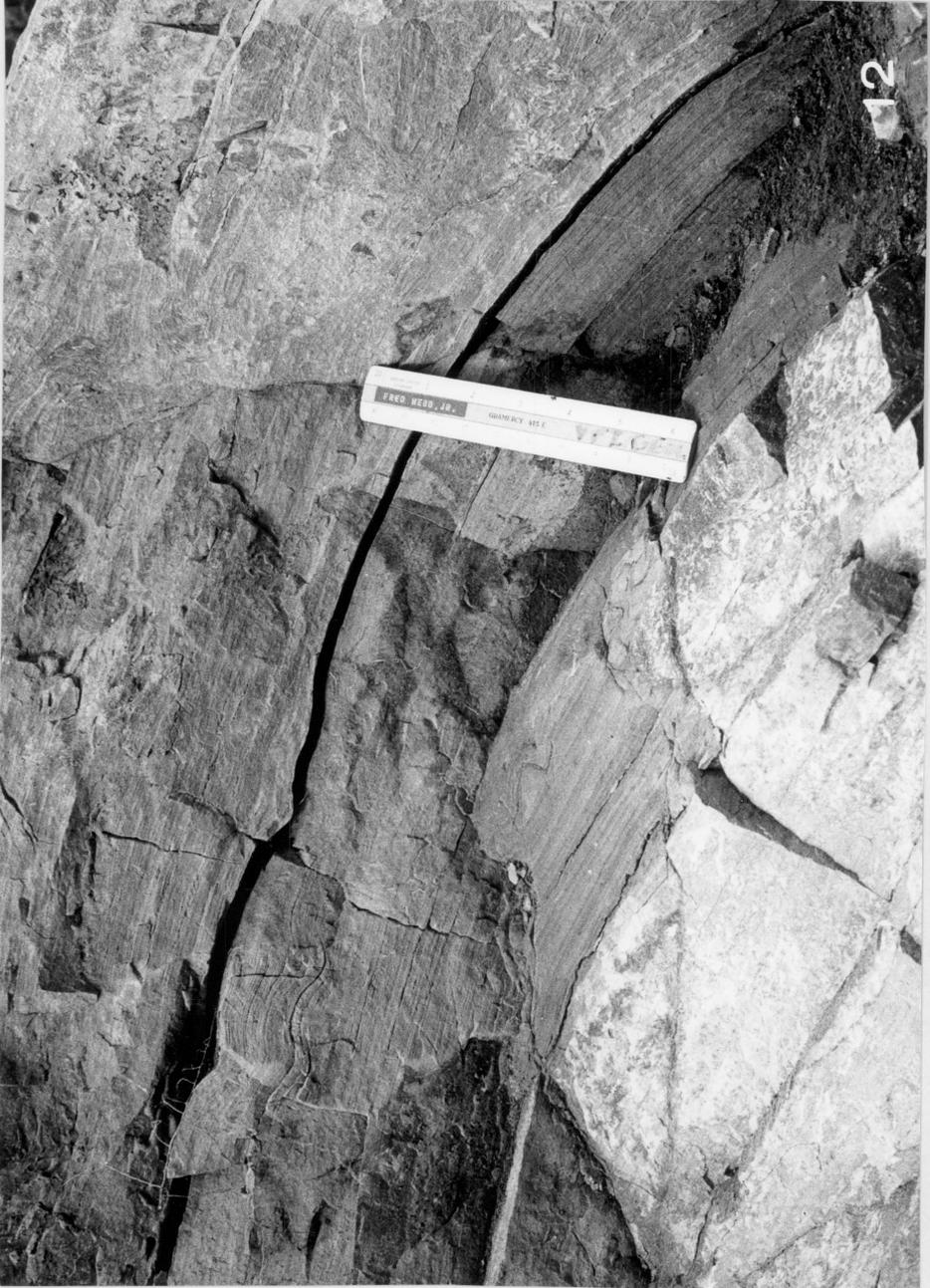


Plate No. 13

Close-up view of convolute bedding and advanced stage in the development of intraformational conglomerate by means of soft-sediment deformation in dolomite of the Copper Ridge. This photograph covers an area just above and to the right of upper end of 6-inch scale shown in Plate 12. Location is same as Plate 12.



Plate No. 14

Steeply dipping laminated Copper Ridge dolomites on the southeast "limb" of a large convolution produced by soft-sediment deformation. Near right-hand base of outcrop the same beds bend up sharply to form an asymmetrical syncline which has its axial plane overturned toward the southeast. Photo covers an area just below and to the right of 6-inch scale in Plate 11. Location is same as Plate 11.



Plate No. 15

"Cauliflower" chert in "Chepultepec" Formation which consists of laminated calcitic dolomite at this outcrop. Photo was taken along Road 640, two miles northeast of its junction with Road 738, just south of Mechanicsburg, Bland County.



15

Plate No. 16

Crinkly bedded and ripple-marked medium crystalline dolomite in "Chapultepec" Formation. Note light-colored incomplete chert nodules in thicker bedded dolomite at bottom of photograph. Location is same as Plate 15.



Plate No. 17

Weathered exposure of calcitic dolomite in the "Chepultepec" Formation. Note the honeycombed network of dolomite ridges that enclose the smaller, light-colored patches of dolomitic limestone. The wavy bedding surfaces and interruption of bedding suggest ripple marks and slump structures. Hobbs (1957, p. 105) suggests that similar beds in Montgomery County, Virginia, resulted from the circulation of Mg-bearing sea water through a poorly coherent sediment at the salt-water sediment interface. Location is along Road 640, two miles northeast of its junction with Road 738 near Mechanicsburg, Bland County.



Plate No. 18

A. Knox-Blackford contact. Hammerhead and lower left corner of photograph are in Knox. Handle of hammer is on Blackford dolomitic limestone. One-fifth mile south of Road 617, 1.4 miles south of its junction with U. S. Route 21-52 in Bland County.

B. Cherty Lincolnshire Limestone. Location same as Plate 19B.



Plate No. 19

A. Slabby-weathering, impure Lincolnshire Limestone on farm of M. H. Bowen, Jr., 1.75 miles southeast of Bland. Note fragments of silicified brachiopods.

B. Effna Limestone, 0.2 mile south of Road 617, 1.4 miles south of its junction with U. S. Route 21-52, Bland County. Note the irregular darker laminae which are probably algal structures in the white reefy limestone.



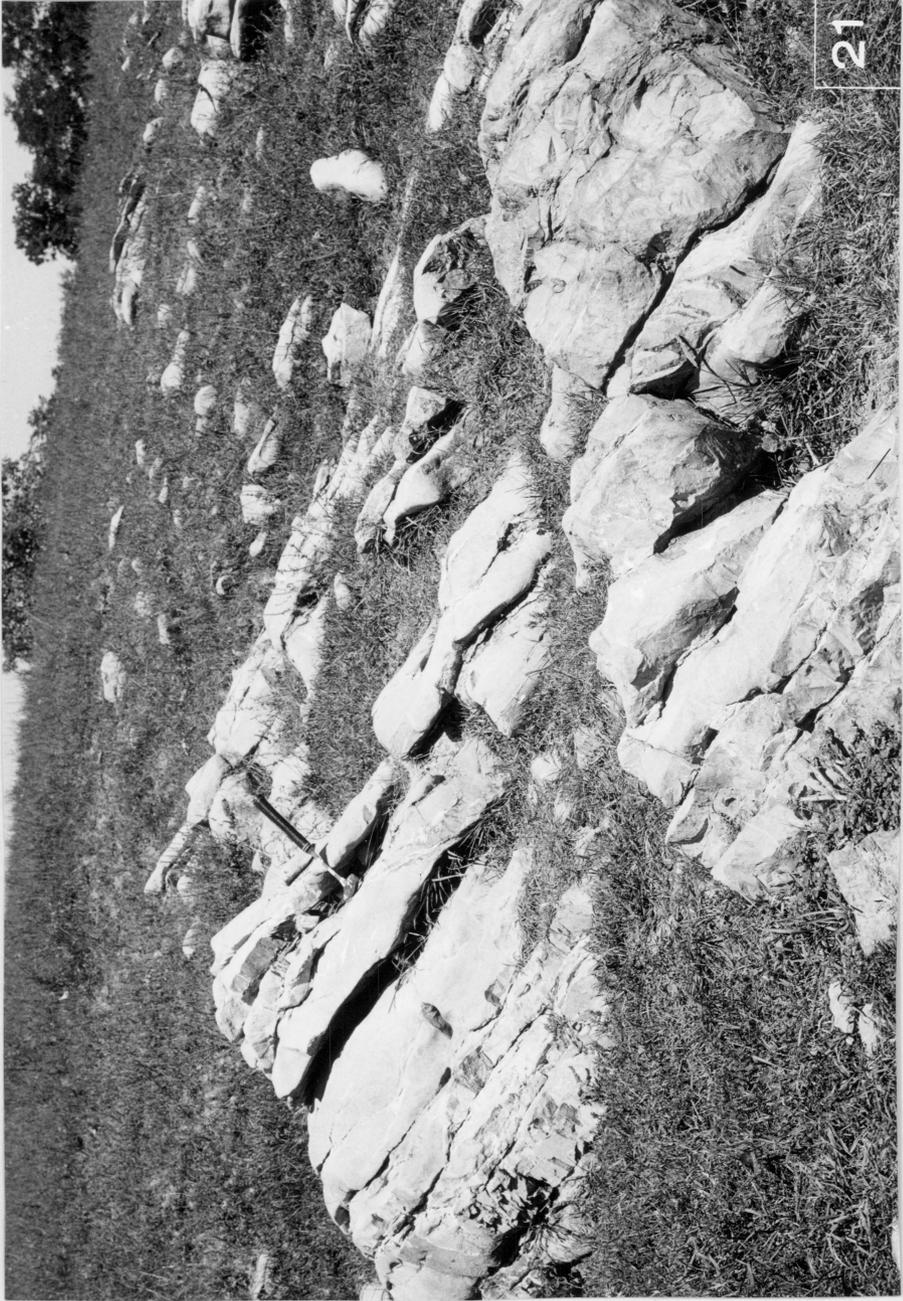
Plate No. 20

Irregularly bedded to cross-bedded Effna Limestone. Location same as Plate 19B.



Plate No. 21

Upper cherty limestones in Rich Valley Formation, on J. S. Penley farm, three miles southwest of Mechanicsburg on Road 608, Bland County.



21

Plate No. 22

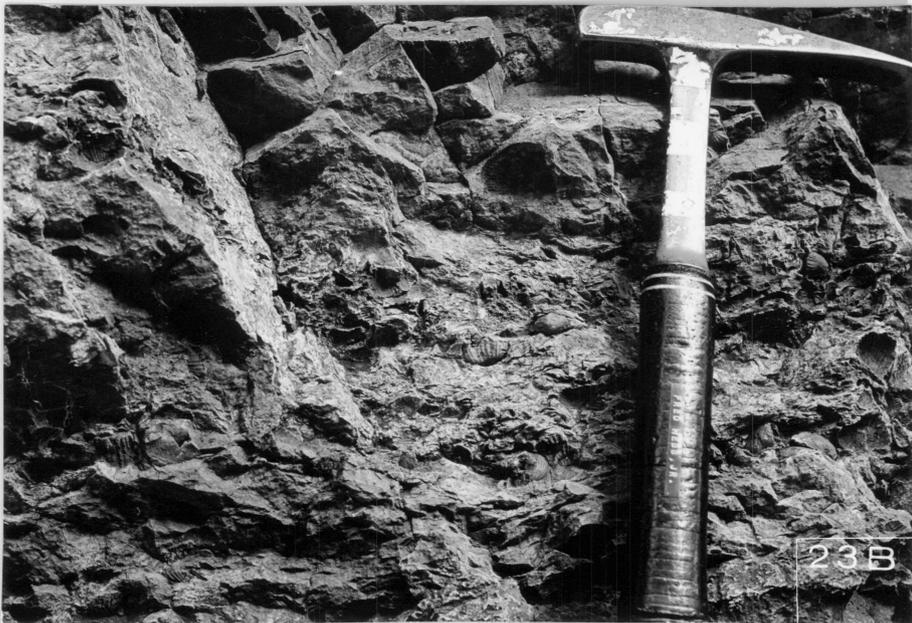
Fossiliferous Chatham Hill Limestone, just south of junction Roads 738 and 670 in Bland County, 2.5 miles southeast of Mechanicsburg. The rock is a wavy-bedded biomicrite with algae, brachiopods, gastropods, and bryozoans.

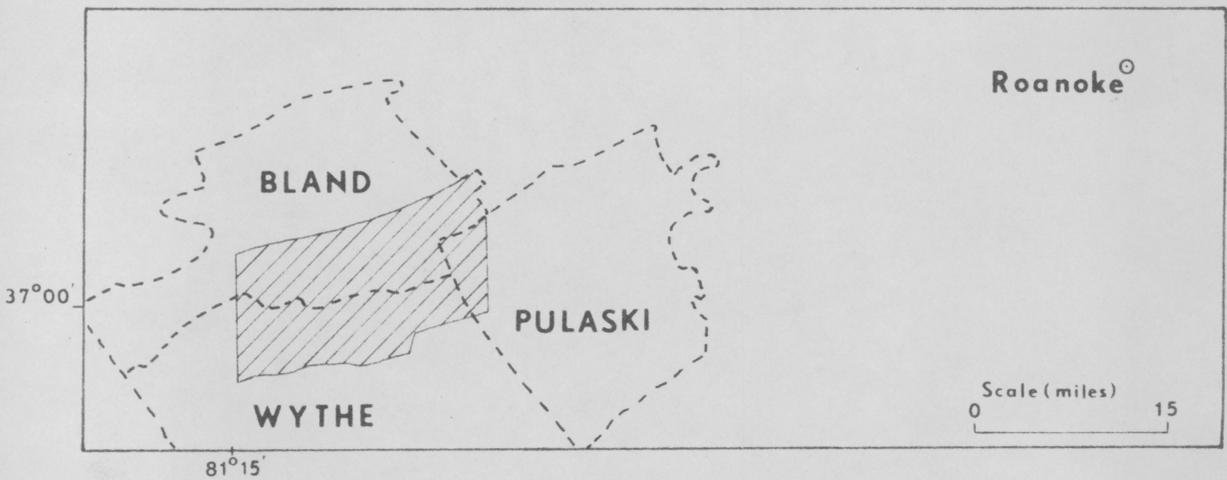
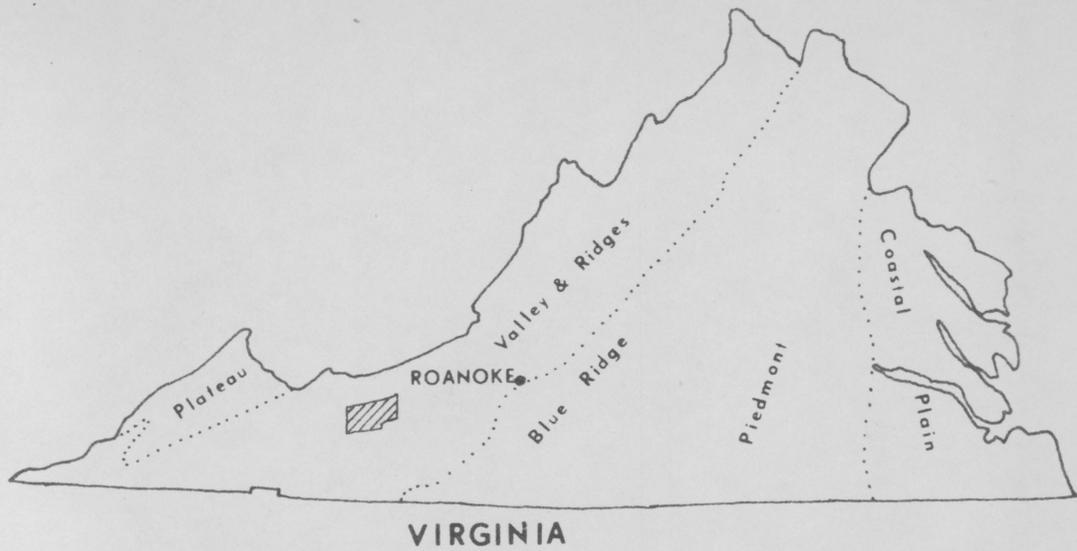


Plate No. 23

A. Blocky weathering, impure sandstones in lower Moccasin Formation. Located on Road 603 at base of Big Walker Mountain, 2.5 miles south of Bland.

B. Orthorhynchula-rich sandstones and siltstones of the upper Martinsburg Formation along Road 621, 0.2 miles northwest of the summit of Big Walker Mountain, Bland County.





Index Map of the Walker Mountain-Crockett Cove Area,  
Bland, Pulaski, and Wythe Counties,  
Virginia

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## Abstract

The Big Walker Mountain-Crockett Cove area lies in the Valley and Ridge province of southwestern Virginia and is made up of Middle Cambrian-Lower Mississippian strata which are exposed in two separate northeast-trending strike belts. The area is bounded on the northwest by the northwestern limb of the Greendale syncline which has been overridden from the southeast by rocks of the Saltville block. The northeast-trending Saltville thrust probably dips less than  $25^{\circ}$  in the area near Bland, Virginia, where Middle Ordovician rocks are exposed in a fenster. The rocks exposed in the fenster are probably part of the northwest limb or near-trough portion of the Greendale syncline.

The major structure of the Saltville block is the Walker Mountain homocline which has subsidiary folds that plunge eastward into a much larger structure - the Blacksburg synclinorium - which is located just east of the area studied.

The Saltville block is broken at its southern limit in most of the area by the Tract Mountain reverse fault which essentially parallels the trace of the Saltville fault. Stratigraphic displacement along the Tract Mountain fault decreases from a maximum of about 8,000 feet near its southwestern terminus where the Pulaski block overrides it from the south, to less than 1,000 feet nearly 18 miles away at the eastern border of the area studied. The Tract Mountain block, which is bounded on the northwest by the Tract Mountain fault, is made up of a series of northeast-trending folds which plunge eastward toward the Blacksburg synclinorium.

Mapping of the Tract Mountain block and stratigraphic studies of two of its larger folds, the Crockett Cove anticline and the adjacent Queens

Knob syncline, show that there is no appreciable thickness or lithologic change in Middle Cambrian-Lower Ordovician rocks between syncline and anticline. However, the basal Champlainian Series in the more southern fold, the Queens Knob syncline, has an aggregate thickness of about 4,400 feet, whereas the same interval near the crest of the Crockett Cove anticline is less than 2,000 feet thick. Most of the beds present near the trough of the syncline are markedly more clastic and less pure than the corresponding beds on the crest of the adjacent anticline which is less than 2.5 miles up structure to the north. Based on this evidence, it is concluded that the present structural axes are identical to axes of maximum and minimum differential subsidence of the sea floor during Middle Ordovician-Late Silurian time. The synclinal trough was the site of maximum subsidence and the anticlinal axis was the site of minimum subsidence. The date of inception of these two folds must correspond to the beginning of pronounced vertical movement of the sea floor which started in early Champlainian time.

The anticline which must have at one time lay adjacent to and southeast of the Queens Knob syncline was probably eliminated as a large fault slice during movement along the Pulaski fault that strikes obliquely across the axis of the Queens Knob syncline, which is the southernmost structural element of the Tract Mountain block. The leading edge of the Pulaski block forms the southern border of the Big Walker Mountain-Crockett Cove area which contains approximately 160 square miles that was mapped on a scale of 2 inches to the mile.