STRUCTURAL GEOLOGY OF THE MACKS MOUNTAIN AREA

VIRGINIA

by

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CONTENTS

ILLUSTRATIONS

INTRODUCTION

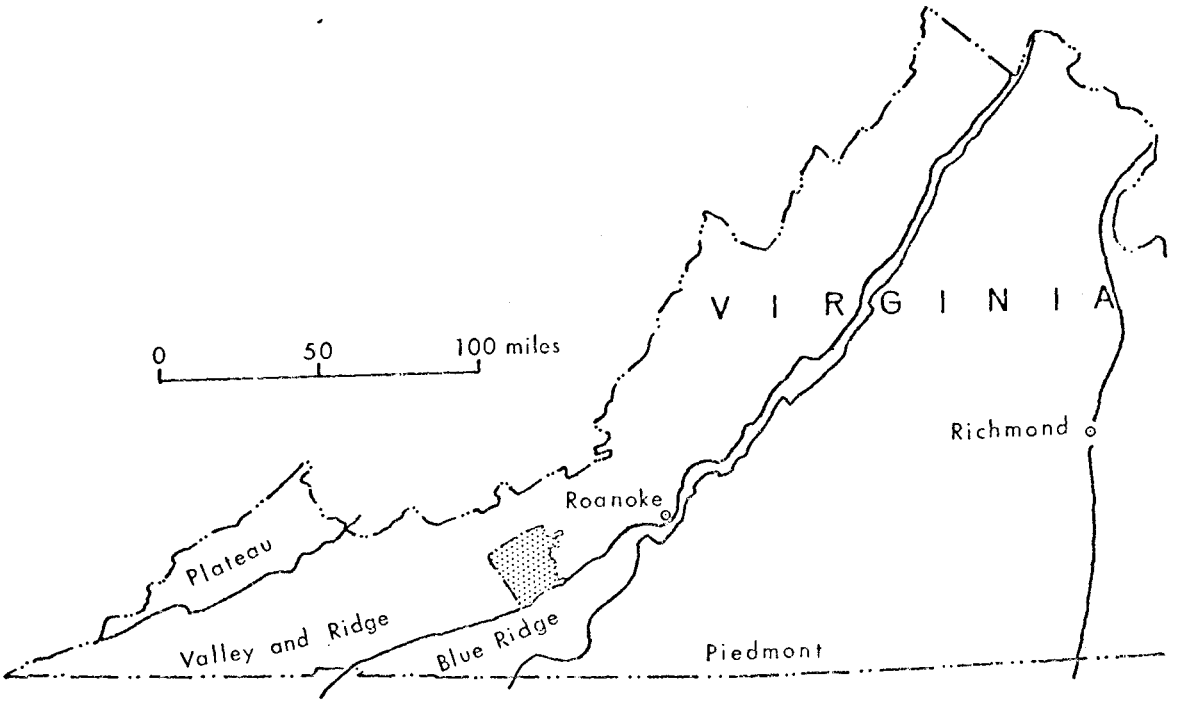
Purpose and Scope

This investigation is an attempt to determine the structure and the nature of deformation of an area between highly deformed crystalline rocks of the Blue Ridge structural province and much less deformed sedimentary rocks of the Valley and Ridge structural province. This interval, consisting of Lower Cambrian and Precambrian rocks, has been investigated in some detail throughout almost its entire length in Virginia and Tennessee, with the main exception of the Macks Mountain area.

The stratigraphy of the area was studied as a basis for detailed mapping of the structures, and for comparison with adjoining areas. Bedrock geology of the area was mapped.

Area of Study

The Macks Mountain area is located in the southern part of Pulaski County, Virginia, and includes small portions of adjacent Montgomery, Floyd, Carroll, and Wythe counties (Fig. 1). The area lies just south of Claytor Lake, which is impounded by a dam on the New River a few miles south of Radford, Virginia. Macks Mountain is bounded by two tributaries to the New River: Little River on the northeast and Big Reed Island Creek on the southwest. Southeast of the area lies the Blue Ridge upland of Floyd and Carroll Counties.



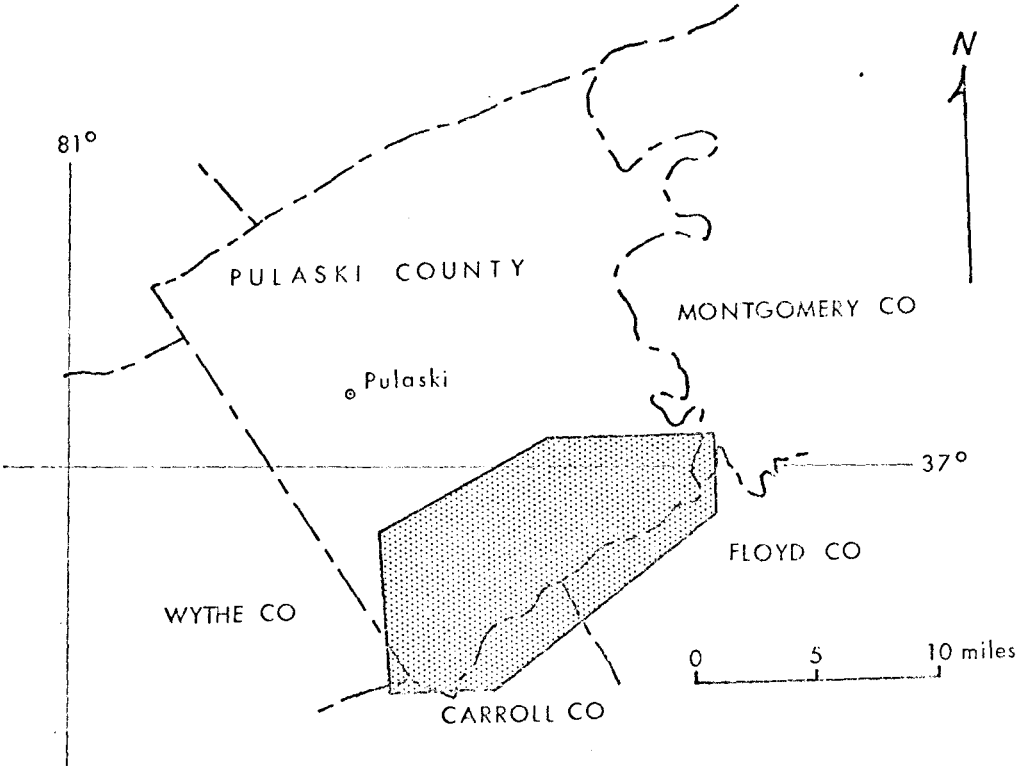


Figure 1.– Location of the Macks Mountain Area

The area under study is relatively inaccessible. County Road 693 skirts the northern and western margins, and County Road 787 passes along the eastern end. Several dirt roads, some of which are impassable for most vehicles, traverse the upland to the southeast. No county roads cross the area, but a fire trail passes through it near the center and a logging road crosses the northeastern end along Laurel Creek. Several dirt roads penetrate parts of the area. Service roads reach into Boy Scout Camps Powhatan and Ottari; a fire trail leads from Camp Powhatan to the saddle between Mack Peak and Dead Pine Mountain.

The geographic name "Macks Mountain" has commonly been used to designate the entire group of ridges and peaks lying between the Blue Ridge upland of Floyd and Carroll Counties and the New River Valley of Pulaski County, and extending from Big Reed Island Creek northeastward to Little River and Big Indian Creek. This usage encompasses most of the area considered herein. A more specific, but less common, use of the term is for the southeasternmost ridge of mountainous area, although some of the higher peaks of this ridge have individual names. Many of the other ridges and peaks in the area also have separate names, but many do not. Three names have been added by the writer to those found on the Macks Mountain Quadrangle map (1956), which was used as a base

map for this report. These names are added to simplify reference to specific localities within the area, and where possible agree with local usage. They include Flinchum Mountain, Line Ridge, and High Point (see Plate 1). In this report "Macks Mountain" is used in the more specific sense, and the term "Macks Mountain area" refers to the entire group of mountains ("mountainous interior") and the directly adjacent lowlands and uplands.

The highest elevation in the Macks Mountain area, the knob southeast of Dead Pine Mountain herein called "High Point", is about 3,500 feet. Claytor Lake, with a "normal pool elevation" of 1,846 feet, is the lowest point; the maximum relief of the area is thus about 1,650 feet. Local relief, measured from crest to base of individual peaks and ridges, is generally rather strong. Bear Knob has a relief of about 1,200 feet, and peaks with a relief of over 1,000 feet include High Knoll Mountain, Line Ridge, Brannon Knob, Chestnut Knob, and the peaks in the Dead Pine Mountain area.

The topography of the area is rugged. Only along the larger streams that bound the area are there areas of low relief. Of these streams only the Little and New Rivers have flood plains of any consequence, and most of those of the latter are now inundated. The mountainous interior consists of northeasterly-trending ridges characterized by knobs and spurs that subdue their linear aspect.

The Macks Mountain area is well drained. All surface water ultimately enters New River or its reservoir just north of the area, Claytor Lake. Surface drainage of the area can be divided into three categories: 1) directly into New River (or Claytor Lake), 2) into New River via Big Reed Island Creek, 3) into New River via Little River. Drainage patterns are shown in Figure 2.

Regional Geologic Setting

The Macks Mountain area is located in the northwestern margin of the Blue Ridge physiographic province, which is about ten miles wide in this region, and includes a narrow strip of the southwestern margin of the Valley and Ridge physiographic province (Fig. 3). The boundary between these provinces coincides approximately in many areas with a major fault or fault zone in which Lower Cambrian and Precambrian sedimentary and crystalline rocks have been thrust northwestward over younger Cambrian rocks of the Valley and Ridge province. This border fault, named the Blue Ridge overthrust by Woodward (1932, p. 80), has been considered by many geologists to be more or less continuous throughout the length of the Blue Ridge province in Virginia (e.g. Stose and others, 1919, p. 28-30; Butts, 1940, p. 440-443) and beyond. The name "Blue Ridge" was used for thrusts in North Carolina (Rankin, 1967) and Alabama (Burchfiel and Livingston, 1967, p. 249).

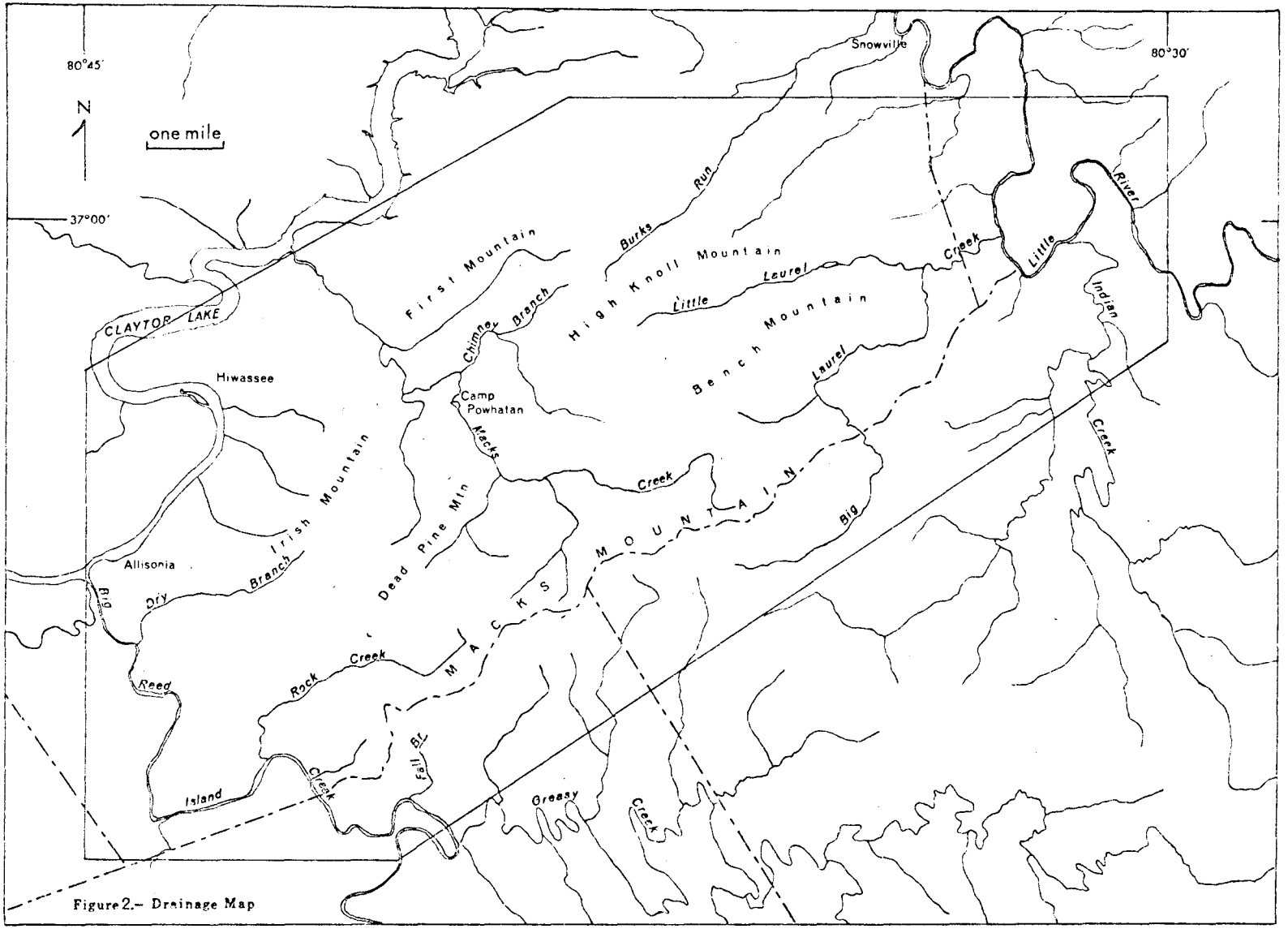


Figure 2.– Drainage Map

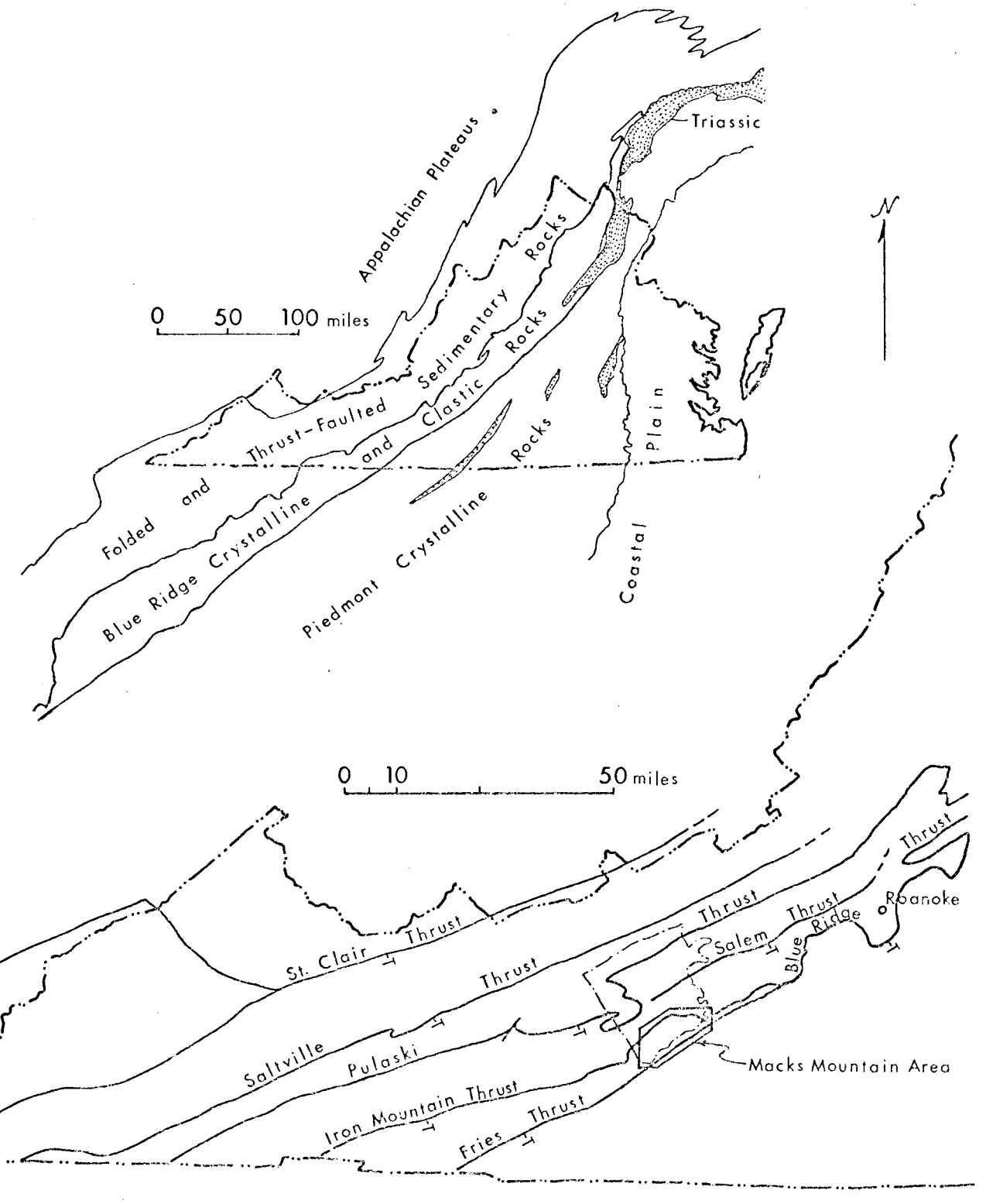


Figure 3.— Regional Geologic Setting

Top: after Eardley, 1951, Fig. 22
Bottom: after Cooper, 1964, Fig. 5

King (1950, p. 47-50), however, concluded that this fault probably does not exist in part of the Elkton area in Northern Virginia.

To the northwest of the Blue Ridge province lies the Valley and Ridge province, composed of Paleozoic sedimentary rocks which generally are in open, asymmetric folds, locally cut by southeastward dipping thrust faults. These structures indicate the deformational forces to have been directed northwestward. Lower and Middle Cambrian rocks are exposed adjacent to the Blue Ridge province and, in general, successively younger rocks are exposed across the strike to the northwest.

Rocks of the Blue Ridge province range more in age and lithology, and are more complexly deformed, than those of the Valley and Ridge province. They can be generalized as metamorphic and igneous rocks of Precambrian age and volcanic and clastic sedimentary rocks of Late Pre-cambrian and Early Cambrian age. The latter are found along the northwestern margin of the province, the former along the southeastern. The contact between the two in many places shows the crystallines to have been thrust over the younger rocks.

Roanoke, Virginia, 40 miles northeast of the Macks Mountain area, has been considered by many geologists to be the location of a fundamental structural and stratigraphic break between the southern and central Appalachians.

The city is situated on a recess between two structural salients that culminate in Pennsylvania on the one hand and in Tennessee on the other (Fig. 3). North of Roanoke, folds predominate over thrust faults in the northwestern part of the physiographic province and the Blue Ridge physiographic province is relatively narrow, nowhere exceeding about 15 miles in width. South of Roanoke thrust faults prevail and the Blue Ridge province broadens, attaining a width of 75 miles in North Carolina. Roanoke has also been used as a break point in stratigraphic nomenclature, with one set of names applicable to the southwest and another to the northeast for equivalent beds.

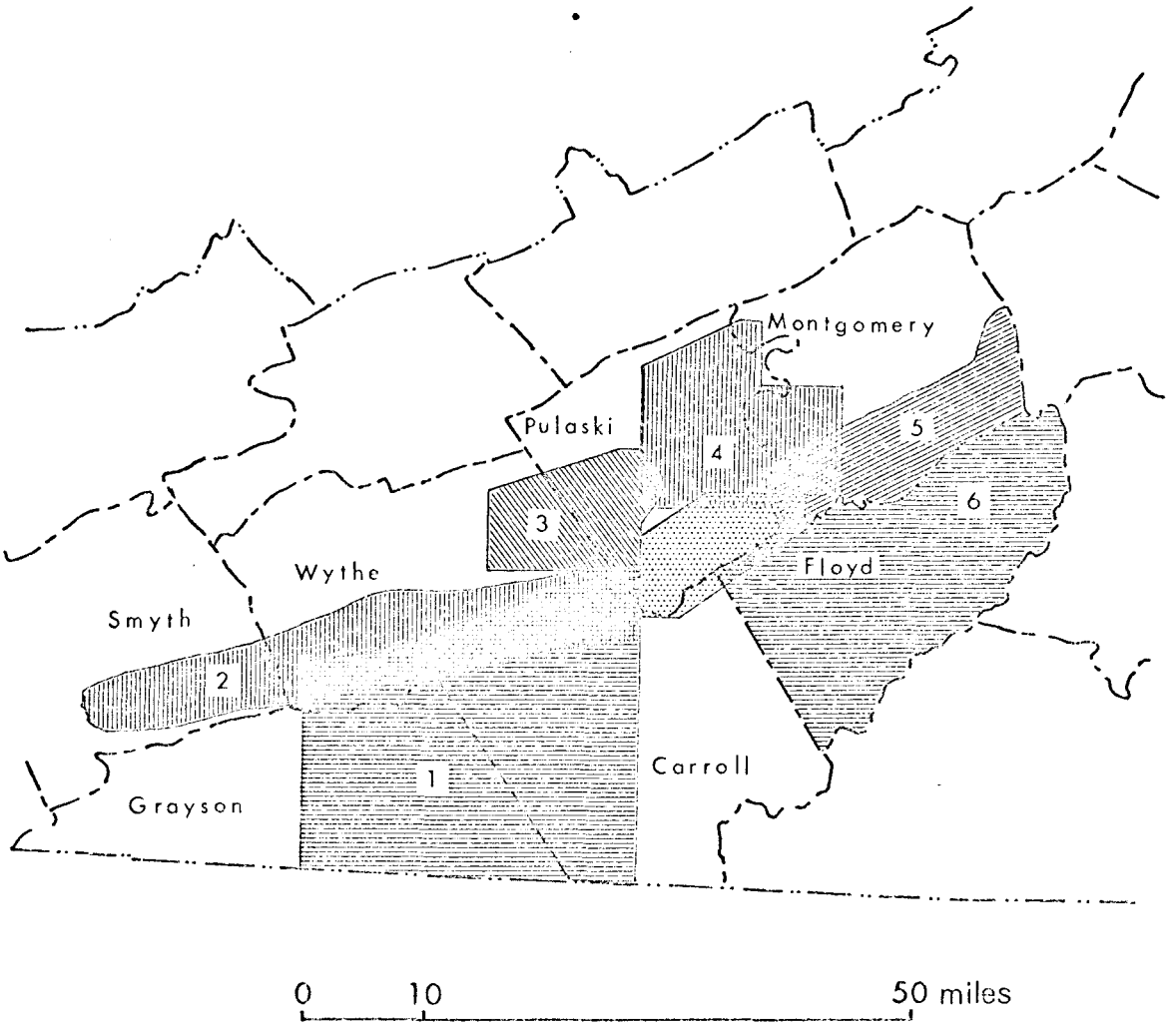
Previous Work

The earliest published reference to the Macks Mountain area was made in 1838 by W. B. Rogers (1884, p. 134) concerning the iron ore deposits extending from "Mack's Run...to the Iron Mountains", which he suggested were perhaps the best available in the "great limestone valley, either in Pennsylvania or Virginia". The following year (1839) his report alluded to "the almost inaccessible ridges of Mack's Mountain" (ibid., p. 206), a sentiment occasionally encountered still.

The Macks Mountain area has never been mapped in detail. McCreath and d'Invilliers (1887) published a very general map, using "Rogers numbers", of the New River - Cripple Creek mineral region. It covers the southwestern

end of the Macks Mountain area, and is apparently the earliest geologic map of any part of the area. Campbell (1894, p. 171) later produced a map of the area directly north of the Macks Mountain area notable for its designation of what is now called the Rome Formation as the "Graysonton Formation" for exposures at Graysonton, near Snowville. The first modern geologic map of Virginia (Stose, 1928) gives a crude approximation of the geologic relations in the area. The last mapping effort was made by Butts (1933). His map, at a scale of 1 to 250,000, is a reconnaissance of the Appalachian Valley in Virginia; he made no attempt to differentiate units within the Chilhowee group in the Macks Mountain area. Although it contains several fundamental errors, his map represented the most accurate picture of the area prior to this report, and his version of the Macks Mountain area was reproduced without change on the latest geological map of Virginia (Calver, 1964).

The areas adjacent to Macks Mountain have all been mapped in more or less detail in recent years (Fig. 4). The area to the southwest has been mapped by Currier (1935) and by Stose and Stose (1957). Cooper (1939) mapped to the west, and Hergenroder (1957) to the north of Macks Mountain. The bedrock east and south of the area has been mapped in reconnaissance by Dietrich (1954, 1959). Weinberg (1963) described an area five miles to the southwest.



1. Stose and Stose, 1957
2. Currier, 1935
3. Cooper, 1939
4. Hergenroder, 1957
5. Dietrich, 1954
6. Dietrich, 1959

Stippled: Macks Mountain Area

Figure 4.— Geologic Maps of Adjacent Areas

A number of references, particularly in the early literature, can be found concerning the iron, lead, and zinc deposits in the southwestern end of the area. The first was the above mentioned comment by Rogers (1884, p. 164) in 1838. Boyd (1881, p. 35) described the Shady Dolomite section at what is now Allisonia, indicating it to be a potential zinc and lead producer. McCreath and d'Invilliers (1887, p. 26-27) discussed the occurrence of "upper mountain (iron) ore" along the flank of Macks Mountain above Big Reed Island Creek. Zinc mining in the Allisonia-Delton area was noted by Watson (1905, p. 75; 1907, p. 531), who also described "mountain brown (iron) ores" in the area (1909, p. 30; 1911, p. 17). Holden (1906, p. 193; 1907, p. 448-449) described the iron industry in the area. More recently, Johnson (1964, p. 1-5) detailed the current pigment industry at Hiwassee.

Minor manganese operations in the northeastern corner of the area have been mentioned by Watson (1907, p. 254), Harder (1910, p. 72), and Stose and others (1919, p. 125). Clay deposit localities in the Rome formation at Macks Creek and in the Shady Dolomite southwest of Hiwassee were discussed by Ries and Sommers (1920, p. 36-38). Johnson, Denny, and Ie Van (1965, p. 68) analyzed a clay sample from a road cut near Hiwassee.

Methods of Study

Field mapping was done with the Brunton compass on 15 minute topographic quadrangle maps (Macks Mountain, Va. and Radford, Va.) enlarged to a scale of 1:31,250. Aerial photographs of the entire area at a scale of 1:20,000 were studied stereographically to determine both field locations and topographic trends. A steel tape was used with the Brunton compass for traverses in measuring sections.

Laboratory work consisted of thin section examination by petrographic microscope complemented by mineral identification by means of x-ray diffractometer.

Field work was begun in July, 1964. Most of the mapping was done during the summers of 1964 and 1965 and the winters of 1965 and 1966. Laboratory investigations were conducted during the summer of 1966.

Acknowledgments

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Grateful acknowledgment is made to members of the writer's graduate committee who gave help and advice. Special thanks are due to Dr. R. V. Dietrich, who suggested the area of study and guided the work to completion; to Dr. W. D. Lowry, who contributed valuable criticism of the structual analysis; and to Dr. B. N. Cooper, who provided assistance essential to the writer's understanding of the

stratigraphy and structure. Dr. G. C. Grender painstakingly reviewed the manuscript, and Dr. C. E. Sears made available his special knowledge of parts of the area.

Several graduate students in the Department of Geological Sciences provided helpful discussion of the work in progress, both in the field and in the laboratory. J. D. Hergenroder, W. H. Hazlett, and D. A. Aronson each spent a day in the field with the writer. Keith Robinson analyzed stylolite specimens on the electron microprobe.

Linda Steel McDowell, the writer's wife, contributed greatly to the work by assisting in the preparation of the plates, and by her encouragement and forebearance during the investigation.

STRATIGRAPHY

Introductory Statement

The Macks Mountain area is underlain by Precambrian metamorphic rocks and by five sedimentary formations of Late Precambrian (Unicoi Formation) and Early Cambrian (Rome Formation) age. The metamorphic rocks represent crystalline "basement" upon which Paleozoic or older sedimentary rocks were deposited in the Appalachian geosyncline; the depositional contact, however, is not exposed within this area. The complete Lower Cambrian succession cannot be seen in the area, but at least 6,000 feet of sedimentary beds are exposed.

No fossils have been found within the area except for the enigmatic trace fossil Scolithus, other cylindrical features of unknown affinities, and possible algal forms and archeocyathids, so stratigraphic analysis is necessarily physical. Monotony of lithology in the lower half of the section, combined with pervasive folding and faulting, make local correlations difficult so some of the conclusions reached as a result of this study may be considered tentative.

The sedimentary rocks include the Chilhowee Group, Shady Dolomite, and Rome Formation. In southwestern Virginia the Chilhowee Group comprises, in ascending order, the Unicoi Formation, the Hampton Formation, and the Erwin Formation. These formations are composed of diverse

clastic lithologies and total several thousand feet in thickness, although the base of the group is not exposed in the Macks Mountain area. Most of the area is underlain by rocks of the Chilhowee Group, which is composed mainly of quartzites, sandstones, siltstones, and shales. The upper Erwin beds are of definite Early Cambrian age, but the age of older Chilhowee rocks is uncertain.

The Chilhowee Group grades upward into the Shady Dolomite, a carbonate unit containing mostly dolomite, some limestone, and very few terrigenous components or chert. The Shady is conformably overlain by clastic and carbonate beds of the Rome Formation, the upper boundary of which is not exposed in the area. The Rome and Shady formations are both probably Early Cambrian in age in the Macks Mountain area, although the Rome Formation is reported to extend into the Middle Cambrian elsewhere (Butts, 1940, p. 66).

The provenance of the sedimentary succession is not well known. Rodgers (1956b, p. 410) suggests an easterly source for the Chilhowee clastic rocks because of their absence to the west, although the specific source is unknown. Carrington (1968) found evidence for a southeasterly source area of Lower Unicoi clastics in southwestern Virginia. King and Ferguson (1960, p. 51) suggest a southeasterly shoreline in Shady time but Rodgers (1956a, p. 357-377) has cited evidence that the Rome Formation was

derived from the northwest. It seems likely to the present writer that the Shady and Rome, because of certain lithological similarities, have a common source area.

Most of the rocks of the Macks Mountain area lie in fault blocks contained entirely within the area, and the formations cannot be traced along strike into adjoining regions. Only that fraction of the Rome Formation in the Pulaski fault block, along the northwest margin of the Macks Mountain area, is continuous for some distance beyond the area. The Rome extends in a belt that is continuous from Damascus, near the Tennessee border, to the Goose Creek Window northeast of Roanoke.

Precambrian Metamorphic Rocks

Metamorphic rocks of Precambrian age form the hanging wall of the Fries thrust along the southeastern margin of the Macks Mountain area. K-Ar and Rb-Sr age determinations of these rocks, recently reported by Dietrich et al. (1967), yield ages of 687±12 m.y. and 1300±100 m.y. respectively.

Several different lithologies occur in the metamorphic belt along the Fries fault. At the bridge over Big Reed Island Creek on Road 693 a weathered granitic gneiss is well exposed. At Rustin Hollow green mylonite grades to the south into a dark gray phyllite with a

distinctive, wavy foliation. Between Big Reed Island Creek and Big Indian Creek phyllites are poorly exposed.

The granitic gneiss at County Road 693 is a light-brown coarse-grained, limonite-stained rock with patches of dark biotite and hornblende giving rise to an indistinct foliation. The approximate mode of the rock, indicated by point count in thin section, is as follows:

Quartz	37 percent
Plagioclase	35 percent
Microcline	20 percent
Biotite	5 percent
Hornblende	1 percent
Magnetite	1 percent
Apatite	trace
Zircon	trace
Rutile	trace

The quartz grains are highly strained. Plagioclase is turbid with sericite inclusions except for locally unaltered rims; microcline is clear. The biotite, partially altered to chlorite, has associated magnetite and abundant included rutile needles in apparent trigonal orientation parallel to cleavage. Hornblende appears to be in the last stage of alteration to biotite and chlorite. The rock is probably the same as a "pink and green augen gneiss" which Stose and Stose (1957, p. 46-47) described from Sylvatus, three miles to the southwest, and which they suggested to be deformed Grayson Granodiorite Gneiss.

The green mylonite of Rustin Hollow may be the mylonitized equivalent of the granitic gneiss. In hand specimen, it appears to be a greenish-gray phyllite with

numerous small "eyes" of quartz and feldspar. Thin section study gave an approximate mode of:

Quartz	24 percent
Plagioclase	40 percent
Sericite	20 percent
Biotite	15 percent
Ilmenite (?)	1 percent

The texture is cataclastic with quartz and feldspar grains broken, crushed, and bent. Feldspars have undulatory extinction. The rock is apparently the "granite mylonite" of Stose and Stose (1957, p. 45-46). It may also be a fine-grained equivalent of the Little River Gneiss mapped by Dietrich (1959, p. 58-69) to the northeast.

The gray crenulated phyllite south of Rustin Hollow and along Big Reed Island Creek and the poorly exposed phyllites to the northeast may be equivalent to mica schist reported by Stose and Stose (1957, p. 69-70) along the Gossan Lead thrust or to the Alum Phyllite of Floyd County to the northeast (Dietrich, 1959, p. 75-83). Possibly all are equivalent.

The mineralogical associations noted in these rocks, particularly the chloritization of biotite and hornblende and the seritization of feldspar, may reflect retrograde metamorphism along the sole of the Fries thrust.

Cambrian System

Chilhowee Group

Safford (1856, p. 152-153) proposed the name "Chilhowee Sandstone" for a thick clastic sequence of "basal Paleozoic" beds at Chilhowee Mountain, Sevier and Blount Counties, eastern Tennessee. The term "Chilhowee Group" is now widely used for clastic rocks of Early Cambrian age or older which overlie Precambrian metamorphic and volcanic rocks, and are limited above by the earliest Paleozoic carbonate rocks of the Appalachian miogeosyncline. The unit is nearly continuous along the eastern side of the Appalachian Valley from Alabama to Pennsylvania, and it is as much as 7,500 feet thick along the Iron Mountains of southwestern Virginia (King and Ferguson, 1960, p. 33). It has been subdivided nearly everywhere into three or more components. In southwestern Virginia three formations have been distinguished: the Unicoi, Hampton, and Erwin. The Hampton and Erwin formations were identified in part of the Macks Mountain area on the basis of lithology, structural position, stratigraphic relationships, and the presence of Scolithus. In most of the mapped area, where neither the top nor the base of the Chilhowee Group is exposed, formational boundaries could not be identified with any degree of assurance, and the succession is divided into three arbitrary units which may correspond

in general to the formations of the Chilhowee Group. Mapping was done by tracing ridge-making quartzites along strike. Certain of these quartzites were arbitrarily designated as unit boundaries.

The Chilhowee Group includes a wide variety of clastic rocks succeeding various Precambrian units. The contact, not exposed in the Macks Mountain area, is reported to be conformable in southwestern Virginia and northeastern Tennessee where basal Unicoi overlies the Precambrian Mount Rogers Volcanic Group (Rankin, 1967). Elsewhere the contact is a well marked unconformity between the Chilhowee Group and older rocks, which include the Ocoee Series of sediments and metasediments in eastern Tennessee, and the various crystalline rocks in Virginia (King and Ferguson, 1960, p. 34; Rogers, 1956b, p. 410).

The subdivisions of the Chilhowee Group in Tennessee and Virginia are given in Table 1. These subdivisions have previously been supposed to distinguish widespread units of rather uniform lithology. Thus Stose and Stose (1957, p. 78-79) characterize the Unicoi Formation as composed of arkose, shale, conglomerate, and medial basalt flows; the Hampton Formation as a dark gray shale with thin quartzose beds; and the Erwin Formation as hard, white quartzite and banded argillaceous quartzite. Such categorization has been shown to be misleading in that

Table 1. Stratigraphic Terminology of the Shady Dolomite and Chilhowee Group Virginia and Tennessee

Age		Eastern Tennessee	Northeastern Tenn., Southwesternmost Va. (King and Ferguson, 1960)		Southwestern Virginia (Stose and Stose, 1957)		Southwestern Virginia This report		Virginia, Northeast of Roanoke (Butts, 1940)
Lower Cambrian		Shady Dolomite	Shady Dolomite	Upper Blue Member Upper White Member Middle Blue Member Ribboned Member Lower Blue Member	Shady Dolomite	Saccharoidal Member Patterson Member	Shady Dolomite	Laminated gray dolomite Upper Ribboned dolomite "White" crystalline dolomite Blue Ribboned limestone Lower Ribboned dolomite Basal "warty" dolomite	Tomstown Limestone
Lower Cambrian	Chilhowee Group	Hesse Sandstone	Erwin Formation	Helenmode Member Hesse Quartzite Member	Erwin Formation	Upper Member Middle Member	Erwin Formation	Transition beds	
Lower Cambrian or Precambrian	Chilhowee Group	Murray Shale Nebo Sandstone	Erwin Formation	Murray Shale Member Nebo Quartzite Member	Erwin Formation	Ridge-making Member Lower Member	Erwin Formation	Middle Member Massive Quartzite Member	Antietam Quartzite
	Chilhowee Group	Nichols Shale	Hampton Formation		Hampton Formation		Hampton Formation		Harpers Shale
	Chilhowee Group	Cochran Formation	Unicoi Formation		Unicoi Formation		Unicoi Formation		Weverton Quartzite Loudon Formation
		Ocoee Series	Mount Rogers Volcanic Group		Precambrian rocks		Precambrian basement rocks		Catoctin Greenstone

"lithologic boundaries are at greatly different levels from place to place, and....different rock types are so interbedded that none of the formations consists dominantly of a single sort of rock" (King and Ferguson, 1960, p. 32). According to Cooper (1961, p. 20-21) it is "unrealistic" to regard any of the Chilhowee units as "lithologically homogeneous" and the succession is "poorly understood at best". Because it was "not yet possible to distinguish units within the Chilhowee group with certainty" thoughout most of the area of outcrop in Virginia, because of facies changes and structural complications (Butts, 1940, p. 27), the group is undifferentiated on the "Geologic Map of the Appalachian Valley of Virginia" (Butts, 1933). Nevertheless, a general change can be observed from coarse conglomerates and arkosic beds in the Unicoi through a more argillaceous sequence above into an upper series of more quartzose beds, including several pure, massive quartzites near the top. Stratigraphic difficulties arise, however, in distinguishing the formations. Where the entire sequence is well-exposed the formational boundaries are commonly difficult to determine. In limited exposures precise stratigraphic position is generally impossible to demonstrate, and even assignment to a given formation is commonly uncertain. The Chilhowee succession is too readily separable into mappable lithologic units and the succession clearly is

too thick to remain unsubdivided. The approach of King and others (1944, p. 28) was to redefine the formations (Unicoi, Hampton, and Erwin) on the basis of certain widely traceable key beds. The problem then is in identifying these beds in areas (such as Macks Mountain) not continuous with those having boundaries established. Needless to say this cannot everywhere be done. The present writer suggests detailed stratigraphic study and subdivision in different localities, without emphasis on precise correlation of units between different areas until sufficient data are available for regional synthesis.

The nearest exposures of the complete (or nearly complete) Chilhowee sequence occur 20 miles to the northeast on Poor Mountain (Dietrich, 1954; Shufflebarger, 1953) and 15 miles to the southwest along the New River north of Fries (Stose and Stose, 1957). Probably as much as 1,000 feet of beds at the base of the Chilhowee section are not exposed in the mapped area, as indicated by the lack of exposures of Unicoi basalt. The uppermost beds, including the zone of transition into the overlying Shady Dolomite, are exposed in several localities.

Some controversy exists regarding the age of the Chilhowee Group. The problem lies in defining the base of the Cambrian System in the Appalachians. This question has been considered by Resser (1938, p. 20), Resser and Howell (1938, p. 206), King (1949), Rodgers (1956b),

Neuman and Palmer (1956), and Dietrich (1961). Howell and others (1944) placed the Erwin Formation at the base of the Cambrian System.

This report follows the long-established usage of "Lower Cambrian" for the entire Chilhowee Group with the following qualifications: 1) only the upper Erwin is definitely Lower Cambrian, as indicated by fossils; 2) the "base of the Cambrian" may lie anywhere within the Chilhowee Group below the lowermost fossil horizon, depending on one's definition of the term; and 3) the base of the Chilhowee Group may be locally gradational, and may be non-synchronous.

Unicoi Formation

Definition.-- The Unicoi Formation was named by Campbell (1899, p. 3) for exposures along the Nolichucky River in Unicoi County, Tennessee. King and Ferguson (1960, p. 36) redesignated as the type locality a well-displayed section south of Unaka Springs. In Virginia, the Unicoi Formation unconformably overlies metamorphic or igneous rocks except in the southwesternmost exposures where it is reported to be conformable over the Mount Rogers Volcanic Group (Rankin, 1967; Dietrich, 1961). The formation is overlain by the Hampton Formation in southwestern Virginia. The basal contact is not exposed in the Macks Mountain area. In Virginia, the Unicoi ranges in thickness from less than 1,000 feet to about

2,600 feet at Konnarack (Butts, 1940, p. 36).

Lithologies of the Unicoi in the type area include sandstone, vitreous orthoquartzite, conglomerate, arkose, shale, and siltstone; amygdaloidal basalt flows and rhyolitic tuffs occur locally in the lower half. As a whole, the unit is distinguished from the overlying formations by coarser grain size, poorer sorting, more feldspar, and by the presence of volcanic rocks.

No fossils have been found in the Unicoi Formation. It has been tentatively correlated with the Cochran Conglomerate of Tennessee (Keith, 1903, p. 4-5) and with the Weverton and Loudon formations north of Roanoke, Virginia (Butts, 1940, p. 26).

Distribution and Lithology.-- No beds within the Macks Mountain area were mapped as Unicoi, but the lowermost Chilhowee unit of the Powhatan block is suggested to be equivalent at least in part to the Unicoi. The base of this unit is not exposed, nor are basalts, characteristic of middle Unicoi, found in the area. The upper boundary of this unit was placed at the top of the uppermost ridge-making feldspathic quartzite in the Chilhowee succession. The unit also contains siltstone, shale, arkose, and a lower ridge-making feldspathic quartzite which was mapped separately (see Pl. 1). The maximum thickness of the unit is about 1,000 feet, exposed along Macks Creek.

The ridge-making quartzites are fine grained, light gray, generally well sorted, and locally show cross-bedding and scour-and-fill. Quartz veins are common.

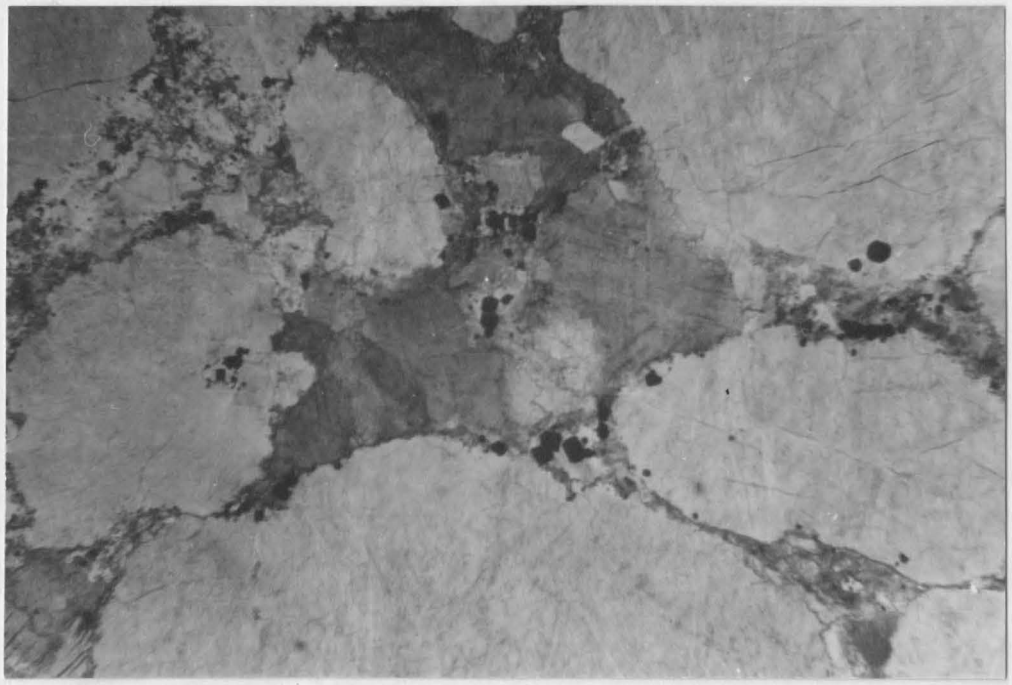
A common lithology in this unit is a laminated siltstone or fine-grained sandstone in which alternating dark and light-gray laminae are generally conspicuously convolute. This feature resembles the "load deformation" of Potter and Pettijohn (1963, p. 155) but such deformation features have alternatively been ascribed by Dzulynski and Walton (1965, p. 186-187, Fig. 119) to current movement over ripple marks. Amplitude of the individual convolutions is usually on the order of half an inch or less but folds up to 18 inches in height are exposed in the bed of Macks Creek about half a mile upstream from Camp Powhatan.

An excellent exposure of beds assigned to this unit occurs at Fall Branch. Here the sequence is overturned and dips steeply southward. Lithologies include quartzite, siltstone, and shale. The lower part of the section is dark gray highly sheared siltstone and shale with abundant slickensides on bedding surfaces. These beds are locally drag-folded (Pl. 22) and contain a distinctive granule conglomerate bed ranging in thickness from about 3 to 8 inches, locally with included siltstone lenses up to 6 inches thick and several feet long. A thin section of the bed showed about 5 percent interstitial calcite and abundant well-formed pyrite cubes (Pl. 3).

Plate 3

Photomicrograph of a calcitic granule conglomerate at Fall Branch. Quartz grains (light gray) are interpenetrating, and are deeply corroded by interstitial calcite (dark gray). Opaque grains are euhedral pyrite crystals. Plane light, x25.

Plate 3



The siltstone and shale beds are succeeded by a sequence of quartzites which are vitreous, generally massive, and commonly coarse grained. The lower quartzites are chiefly light gray to buff, and coarse grained; the upper are dark gray, green, or buff, and finer grained. Graded bedding and cross-bedding are rare and generally indistinct. Near the center of the quartzite succession, along the bed of Fall Branch, is an unusual conglomerate bed ranging in thickness from a few inches to about 20 inches. The conglomerate contains tabular clasts of siltstone up to 1 inch thick and 8 inches across, arranged parallel to bedding. Fresh surfaces of the conglomerate are gray, but the matrix weathers to a rusty brown. The bed is overlain by cross-bedded quartzite with scour-and-fill structures.

The vitreous quartzites are extremely resistant to weathering and form prominent falls in Big Reed Island Creek and ledges on either side. The unit is succeeded to the southeast by well exposed phyllites, and to the northwest by poorly exposed siltstones, and quartzites; both contacts are interpreted as faults.

Hampton Formation

Definition.-- The Hampton "Shale" was named by Campbell (1899, p. 3) for exposures near the town of Hampton in Carter County, Tennessee. King and Ferguson

(1960, p. 33) designated the best exposure of this unit, in the gorge of the nearby Doe River northwest of Hampton, as the type locality. The formation there comprises argillaceous shale, siltstone, arkosic sandstone, and vitreous quartzite. It is distinguished from the underlying Unicoi by fewer arkosic beds and generally finer grain size, from the overlying Erwin by few quartzites, and from both by more abundant argillaceous shale. The exact boundaries are difficult to place. The thickness in Virginia probably ranges from 1,500 to 2,000 feet.

The Hampton Formation is unfossiliferous except for the occurrence of the problematic Scolithus in northeastern Tennessee (King and Ferguson, 1960, p. 41). The formation has been correlated with the Nichols Shale of eastern Tennessee and the Harpers Shale north of Roanoke, Virginia (Table 1).

Distribution and Lithology.-- Black, very fissile, argillaceous shale in the Camp Powhatan - Camp Ottari area of the Hiwassee thrust block is mapped as Hampton because of its stratigraphic position below massive quartzite considered to be basal Erwin. Possibly as much as 1,500 feet of these beds are exposed in the outcrop area. The beds constitute High Knoll Mountain anticline and the locally overturned southeastern limb of Chimney syncline. The section grades upward from the black shale into a gray, buff-weathering, quartzose shale

and siltstone near the Erwin contact, which is placed at the base of the lowest massive vitreous quartzite in the clastic sequence. The base of the Hampton Formation is apparently not exposed in the Hiwassee block.

A thick sequence of buff-weathering shales and siltstones differentiated on the geologic map (Pl. 1) in the middle of the Chilhowee sequence in the Powhatan thrust block may be equivalent, at least in part, to the Hampton Formation. The thickness of this unit is about 800 to 1,000 feet.

Quartzites, siltstones, and shales of the Pilot-Mountain-Fishers View block were mapped as Hampton by Dietrich (1954).

Erwin Formation

Definition.-- Keith (1903, p. 5) named the Erwin "Quartzite" for outcrops near the town of Erwin in Unicoi County, Tennessee. A well exposed section in the gorge of the Nolichucky River south of Unaka Springs was designated the type locality by King and Ferguson (1960, p. 33), the same locality they suggested for the Unicoi Formation. The Erwin Formation constitutes the uppermost component of the Chilhowee Group and includes mainly siltstones, sandstones, and silty shales, with fewer but better exposed beds of vitreous quartzite and ferruginous sandstone. It is the prominence of the latter beds, as well as the absence of extensive arkosic or argillaceous

beds, that distinguish the Erwin from the older Hampton and Unicoi. The base of the formation is designated to be the base of the lowermost prominent vitreous quartzite. The Erwin grades upward through a transition zone into the Shady Dolomite.

Age and Correlation.-- No fossils other than Scolithus and other cylindrical forms were found in the Macks Mountain area, but elsewhere the Erwin Formation has yielded a sparse but significant fauna. These fossils, which are generally found in the uppermost few feet of the formation, include species of Olenellus, Hyolithes, and Obolella (Resser, 1938, p. 5). Laurence and Palmer (1953, p. 53-54) reported the rediscovery of the Murray Gap (Blount County, Tennessee) fossil locality, which yielded well-preserved specimens of the ostracode Indiana tennesseensis (Resser) from a bed in the Murray Shale Member, well below the top of the formation. All of these forms represent the earliest known life in the Appalachians and indicate a definite Early Cambrian age for most of the Erwin Formation.

Scolithus represents an unknown entity. Most workers agree on an organic origin for these long, tube-like features (Pl. 4), and most consider them some sort of worm boring. Resser (1938, p. 5) referred to them as "Scolithus borings"; Stose and Stose (1957, p. 114) considered them to be "burrows of sea worms"; King and

Plate 4

Scolithus tubes in ridge-making quartzite at the mouth of Rock Creek.

Plate 4

Ferguson (1960, p. 42) suggested burrowing worms and noted that in many places the tubes "depress" the bedding planes they penetrate, as if bored downward in unconsolidated material. This effect was found in the Macks Mountain area along Laurel Creek in relatively pure, fine-grained, cross-bedded vitreous quartzite. Almost all of the tubes are perfectly straight and essentially normal to bedding. An exception was found at the mouth of Rock Creek, where a single tube some eight inches long was curved about an inch away from plumb at its base. Lowry (1965) has given a synthesis of data pertaining to Scolithus tubes, but they are as yet of no value for correlation purposes, except insofar as they are apparently restricted in the Chilhowee of Virginia to Erwin quartzites. As previously mentioned, King and Ferguson (1960, p. 30) reported Scolithus from Hampton beds in Tennessee.

The Erwin Formation is correlated with the Antietam Sandstone north of Roanoke, Virginia.

Thickness.— The thickness of the Erwin is variable. Butts (1940, p. 40) suggested a maximum thickness in Virginia of at least 1,500 feet, measured at Whites Gap in Rockbridge County, near Buena Vista. Currier (1935, p. 12) estimated 500 to 800 feet for the thickness in the area southwest of Macks Mountain; Stose and Stose (1957, p. 101-114) obtained measurements of about 400 to 500 feet in the same area. Miller (1944, p. 15) reported thicknesses

from 1,500 to 2,000 feet in the Glade Mountain area; Stead and Stose (1943, p. 5) found only about 500 feet on Lick Mountain. As defined in this report, the Erwin Formation contains about 780 feet of beds in the Hiwassee block and possibly as much as 1,000 feet in the Powhatan block to the southeast (see Geologic Sections 1 and 3, appendix).

Distribution and Lithology.-- Most of the ridges peripheral to the Macks Mountain area are underlain by the Erwin Formation or its presumed equivalent. In the Powhatan thrust block the uppermost Chilhowee unit, designated as the beds above the base of a widely traceable vitreous scolithus-bearing quartzite, are probably equivalent to the Erwin Formation.

Presumed Erwin beds form Dry Pond Mountain, southwest of Big Reed Island Creek. This area, mapped by Stose and Stose (1957), was not examined in detail for this report.

Good exposures of the formation can be seen along Big Reed Island Creek and Laurel Creek, and along County Road 692 eastward or the railroad grade southward from the Hiwassee pigment plant. Locally the vitreous quartzite beds are well-exposed along ridge crests, but commonly, even though they "hold up" these ridges, they are covered by residuum.

Stose and Stose (1957, p. 101-102) defined four members, "each with a characteristic lithology," within the Erwin Formation of the area directly to the southwest of the Macks Mountain area:

Upper Member

Thin-bedded quartzite with pebbly layers, fossiliferous rusty-weathering beds at the top.

Middle Member

Laminated argillaceous quartzite, poorly exposed, and thin white quartzite beds.

Ridge-making Member

Massive white quartzite with conglomeratic beds at the base.

Lower Member

Thin-bedded, dark-banded quartzite, rusty-weathering, and interbedded black shale.

King and Ferguson (1960, p. 43) also recognized four members in northeastermost Tennessee:

Helenmode Member (King and other, 1944, p. 31)
Transition beds: shady, arkosic or calcareous sandstones.

Hesse Quartzite Member
Ledge-making vitreous quartzite beds with intercalated silstones.

Murray Shale Member
Sandy shale and siltstone, ferruginous quartzite.

Nebo Quartzite Member
White, vitreous quartzite, abundant <u>Scolithus</u>, intercalated shale.

Of these, the description of King and Ferguson is more like that of the Macks Mountain area. Geologic Section 1

(Spencer Branch), appended to this report, suggests a generalized description as follows (see also Fig. 5):

	Approx. thickness, feet
Helenmode member Gray, coarse-grained, dolomite-cemented sandstone, interbedded with thin granule conglomerate, siltstone, and shale.	30
Middle member Interbedded quartzite, siltstone, and shale; a few ledge-forming quartzites, locally with *Scolithus*.	700
Massive quartzite member Two or three light gray, coarse-grained, massive vitreous quartzite beds, 15 to 45 feet thick, separated by siltstone and shale.	60

The massive quartzites form prominent ledges (Pl. 5A) and produce many of the high ridges in the area. The beds are commonly so indurated that individual grains cannot be distinguished in hand specimen, and no indication of bedding can be found within the unit. Elsewhere, bedding is indicated by thin black laminae that can be identified in thin section as stylolitic. These laminae, generally not persistent over many feet, locally show cross-bedding and sour-and-fill.

A prominent iron-oxide-stained breccia (Pl. 5B) occurs within the massive quartzites where they form the hanging wall of the Hiwassee thrust. Thin section study shows a chalcedonic cement with hematite (largely altered to limonite) coatings (Pl. 6). Such breccia has been found in other occurrences of the Erwin Formation

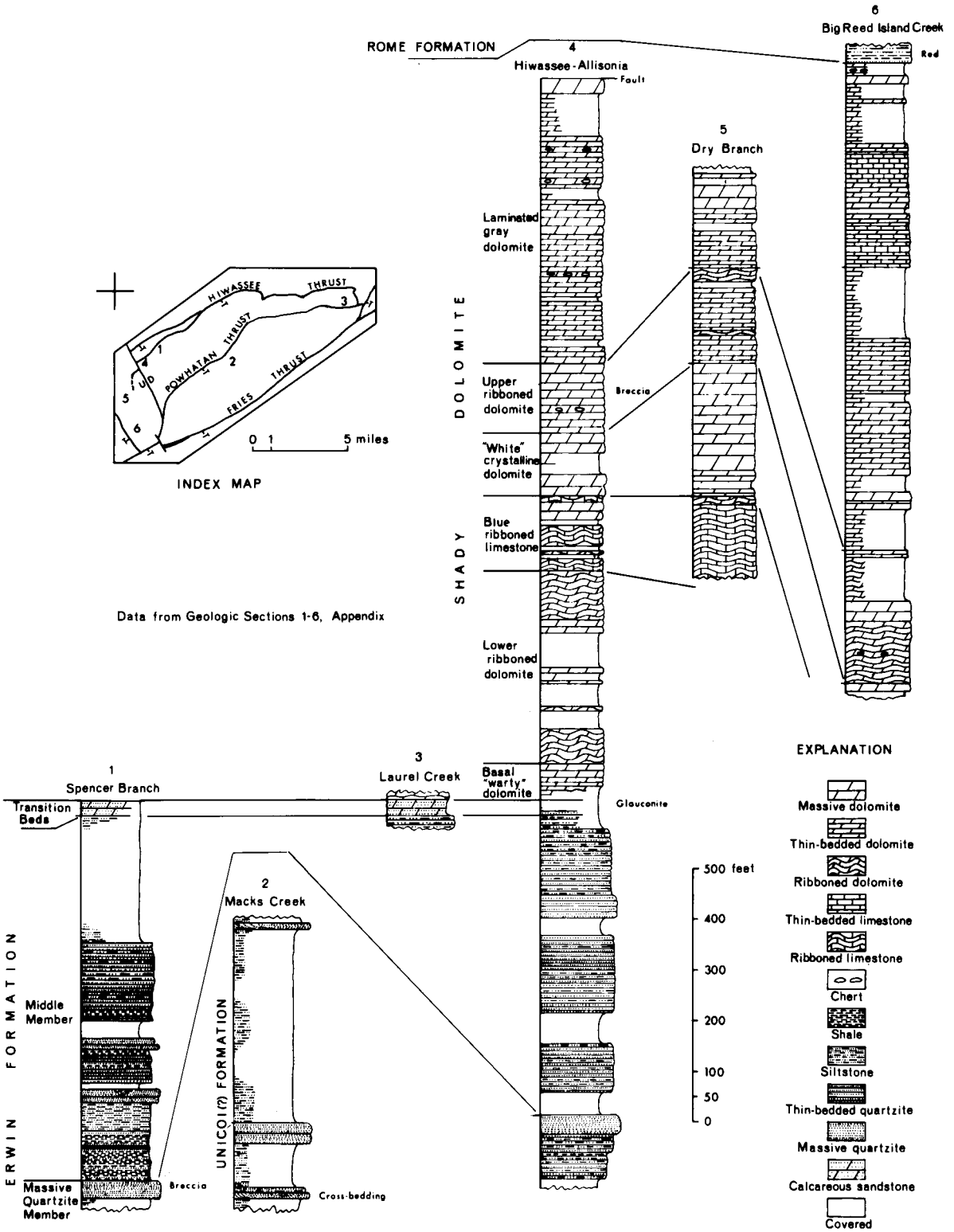


Figure 5.– Columnar Sections of Erwin Formation and Shady Dolomite (Lower Cambrian), Macks Mountain Area

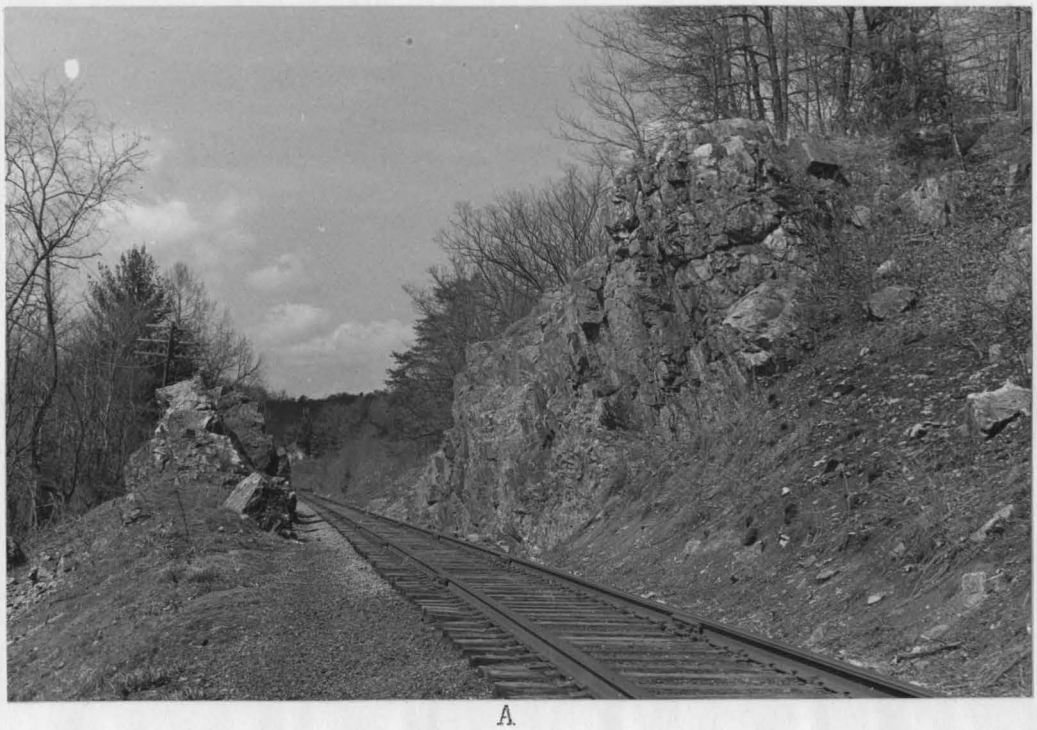
Plate 5

Massive quartzite of the Erwin Formation.

A. Outcrop one half mile south of Hiwassee. Nearly flat-lying bed.

B. Hematite-stained quartzite breccia near center of outcrop above. Compare Plate 4A, Stead and Stose (1943).

Plate 5



A

B

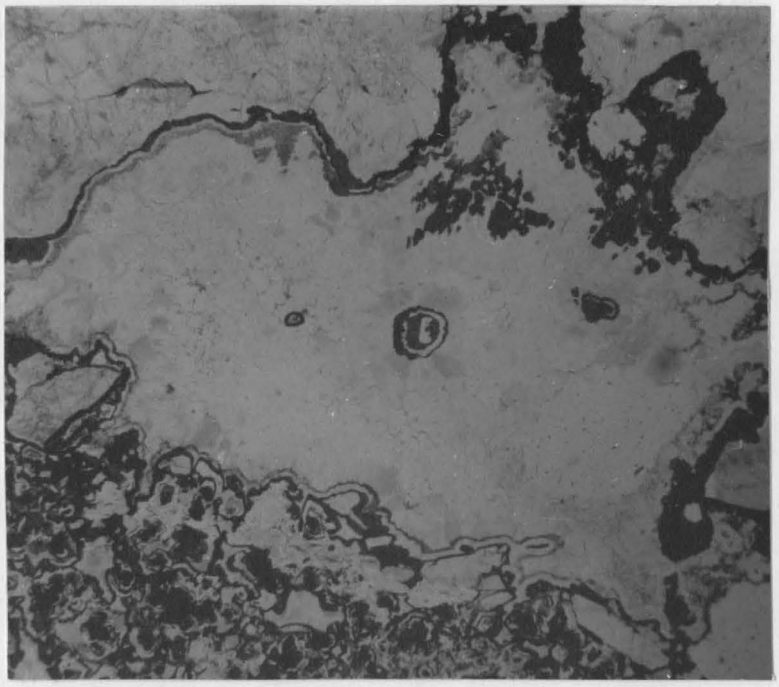
Plate 6

Photomicrographs of quartzite breccia shown in plate 5B.

A. Chalcedonic cement (light gray) with coatings of hematite (black). Plane light, x25.

B. Same as above, crossed nicols. Note axes of radial aggregate extinction.

Plate 6



A

B

and is generally associated with manganese oxides. Stead and Stose (1943, p. 7, Pl. 4) reported it from the Lick Mountains of Wythe County, and W. D. Lowry (oral communication, 1965) found it in the hanging wall of the Blue Ridge thrust at the Kelly Bank manganese deposit in Augusta County. The breccia is probably of tectonic origin.

Most of the massive quartzite ledges are relatively pure and extremely hard. Outcrop of the quartzite is lacking in many areas apparently because of the pervasive fracturing of the brittle beds, which promotes disaggregation of the ledges in the zone of weathering into the blocky "float" so characteristic of western Blue Ridge slopes.

The middle member, constituting the bulk of the formation, is an association of thin silicic beds including silty shale, siltstone, sandstone, and quartzite. Distinctive beds are few and non-persistent. Ferruginous sandstone and conglomerate crop out on Flinchum Mountain, and occur in float on Bench Mountain and in the saddle between High Point and Dead Pine Mountain. A "clay-gall conglomerate" crops out between Cove Branch and Puncheoncamp Branch and on Flinchum Mountain. Most of the member is a rather uniform and monotonous succession that weathers into thin, hard flags, locally with ripple-marks. Thin, vitreous, Scolithus-bearing quartzite ledges,

5 to 10 feet thick, form some ridges in the Hiwassee block, but these beds tend to "lens out" abruptly. Small-scale lenses of quartzite which give the appearance of megaripples can be seen along Road 692 at Spencer Branch.

There is a suggestion of cyclic bedding at the base of the middle member in Geologic Section 1 (appendix). Units 3 through 16 apparently represent a symmetrical repetition of thin massive quartzite units, dark micaceous shale, and irregularly bedded platy shale.

Ferruginous sandstone and conglomerate, absent in the measured sections, has its maximum development several hundred feet stratigraphically below the transition beds on Flinchum Mountain. Two ferruginous ledges trend eastward across the ridge crest but are concealed on the lower slopes. These lithologies should not be confused with ferruginous breccia float, probably of secondary origin, associated with the Shady-Erwin contact. The sandstone contains rounded, clear or milky white (or rarely blue) quartz grains, which range in size from about a millimeter up to 2 or 3 centimeters (Pl. 7A). The breccia consists of angular fragments, some of which are chert, and is generally quite porous.

The Helenmode member between the clastic Erwin and the carbonate Shady, is poorly exposed in the Macks Mountain area, as elsewhere in the Appalachians. A

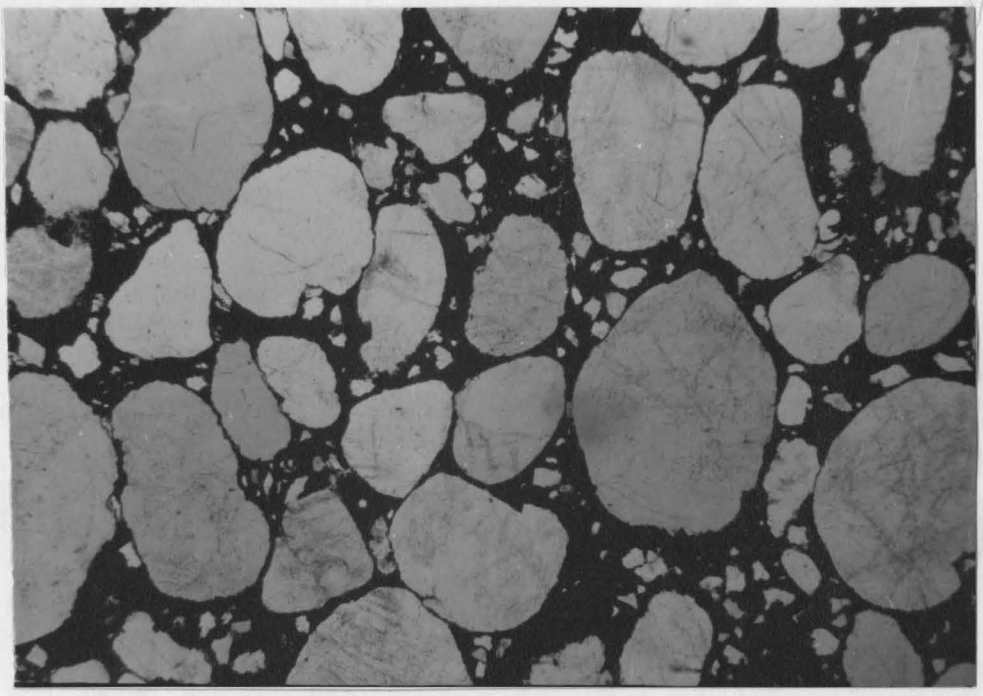
Plate 7

Photomicrographs of sandstones, Erwin Formation

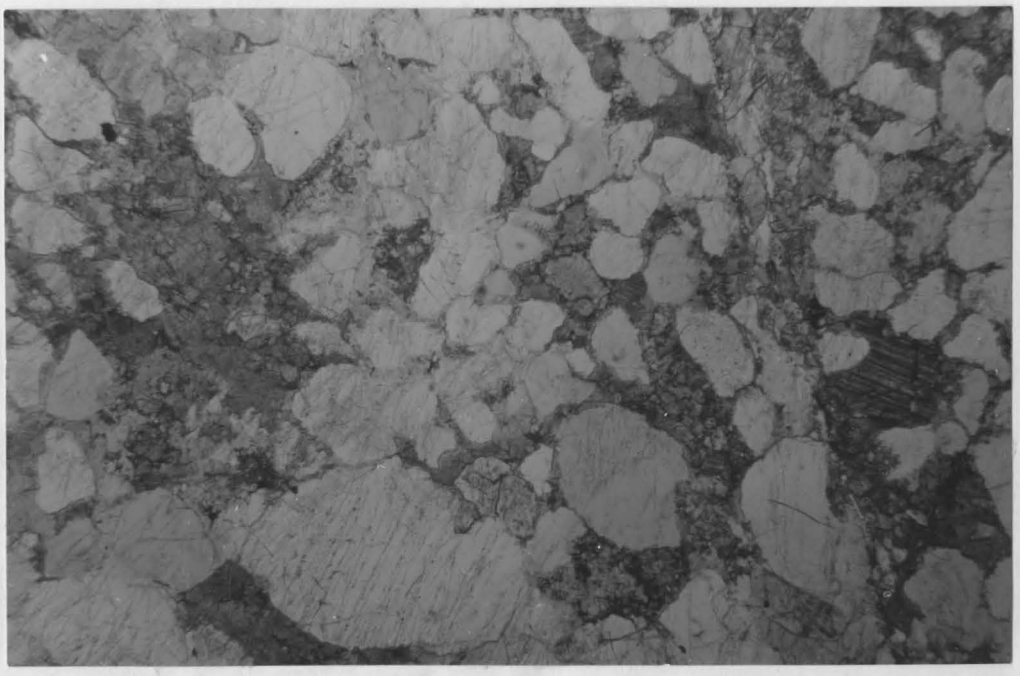
A. Hematite-cemented sandstone, Flinchum Mountain. Note corrosion and interpenetration of quartz grains. Plane light, x25.

B. Dolomite-cemented sandstone of the transition beds along Laurel Creek. Quartz grains (light gray) have tangential to sutured contacts. Calcite (dark gray) fills interstices in the grain-supported matrix, and has deeply corroded the quartz. Note plagioclase grain at right. Plane light, x25.

Plate 7



A



B

complete exposure of this succession, however, is found along Laurel Creek at the Montgomery-Pulaski county line (Geologic Section 3). It includes a cross-bedded, dolomite-cemented sandstone (Pl. 7B) with interbedded shales and a thin, non-persistent granule conglomerate. The sandstone is grain-supported; elsewhere it has lost the carbonate cement and is soft, friable, very porous, and commonly stained brown or maroon. The sequence produces a distinctive dark red soil which generally contains nodules of iron or manganese oxides. Between Hiwassee and Allisonia most of the Helenmode beds have been removed by erosion, but the lowermost more siliceous beds are exposed in some of the open pit iron-ore workings along the zone. These beds locally have conspicuous glauconite-rich layers.

The beds later designated "Helenmode" were divided between the Shady Dolomite and the Erwin Formation by Currier (1935, p. 14, section 1) at the boundary between dolomite-bearing beds and the glauconitic beds. King and Ferguson (1960, p. 44) included in the Erwin as the Helenmode Member all beds of the transition zone with a significant amount of clastic components. The sequence is probably 25 to 30 feet thick in the Macks Mountain area.

The Erwin Formation is thinner and more quartzose to the west. Scour, cross-bedding, and ripple marks suggest a shallow-water environment.

Petrology of the Quartzites

The non-ferruginous Erwin quartzites are typically composed of well-sutured grains of well-rounded quartz with some overgrowths and little cement. The grains range from 0.1 to 3.0mm in size and are commonly highly strained. Additional minerals, together accounting for only a small percentage of the rock, include zircon, tourmaline, plagioclase, microcline, muscovite(?), pyrite, magnetite, and clay. A few grains of chert have been found.

Three non-ferruginous quartzite lithologies can be identified: a "clay-gall conglomerate", a laminated quartzite, and a massive quartzite. The first is distinctive, but the latter two probably grade into each other and into laminated siltstone. The "clay-gall conglomerate" occurs on the southeast slopes of the ridge east of High Point and on Flinchum Mountain. The massive quartzite is the main ledge-former of the Hiwassee block, and is well-exposed in the vicinity of the pigment plant at Hiwassee. Laminated quartzite is an important ledge-former of the Powhatan block, and is prominently exposed at the mouth of Rocky Branch and along Laurel Creek. The quartzite ledges were taken as the base of the uppermost Chilhowee unit in the Powhatan block.

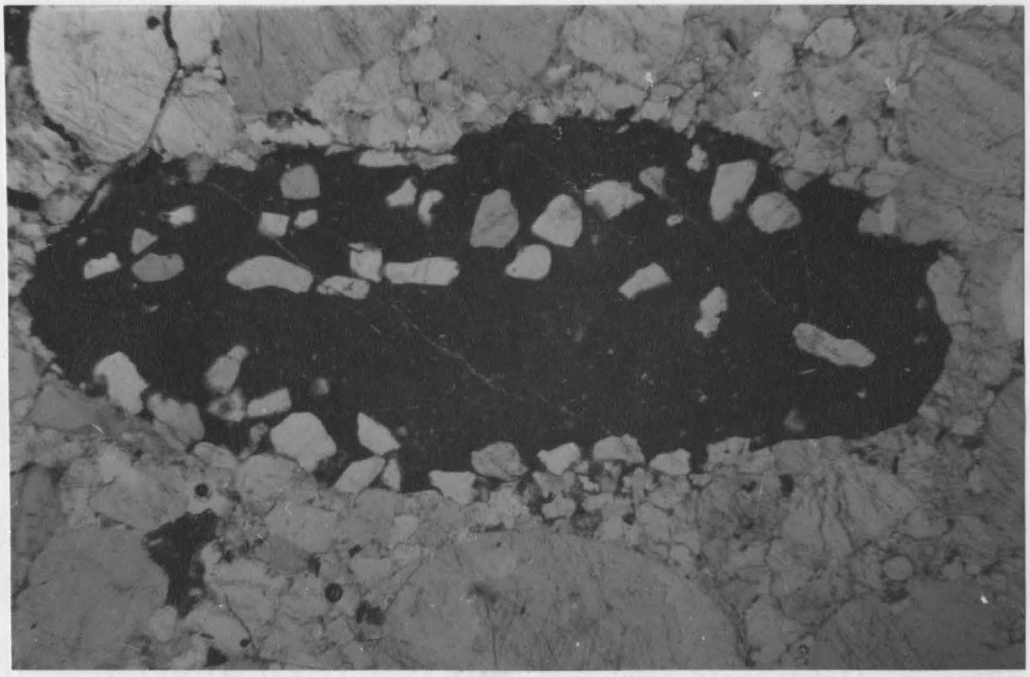
The "clay-gall conglomerate" is a medium-gray conglomeratic quartzite containing coarse, poorly sorted, well-rounded quartz grains with an interlocking texture, and coarser, oblate, rounded clasts ranging in size from 2 to 3 mm to about 1 cm across. The clasts are composed of clay and iron oxides in various porportions, and contain floating subrounded quartz grains (Pl. 8) and a trace of carbonate. The clasts are quite susceptible to weathering, so hand specimens commonly have a pitted appearance. The unit also contains a tubular structure that resembles Scolithus except that it occurs in short segments parallel to bedding. Recently similar features have been found at the base of the upper ridge-forming unit of the Erwin some 50 miles to the southwest by Aiken (1967, p. 7-9), who suggested an origin as either a reed-like plant or a primitive echinoderm. In the Macks Mountain area the bed apparently lies nearer the middle of the formation.

The massive quartzites and laminated quartzites may represent different facies of equivalent units, which are "cleaner" and coarser grained to the west, and more laminated to the east. A characteristic common to both types is interlocking fabric. In recent years, sandstone fabric has received considerable attention, and rather extensive terminology has sprung up. The more useful terms, illustrated in Fig. 6, are from a

Plate 8

Photomicrograph of clay gall in "clay-gall conglomerate". Some quartz grains included within the clay gall have penetrated grains of the surrounding quartzite. Plane light, x25.

Plate 8



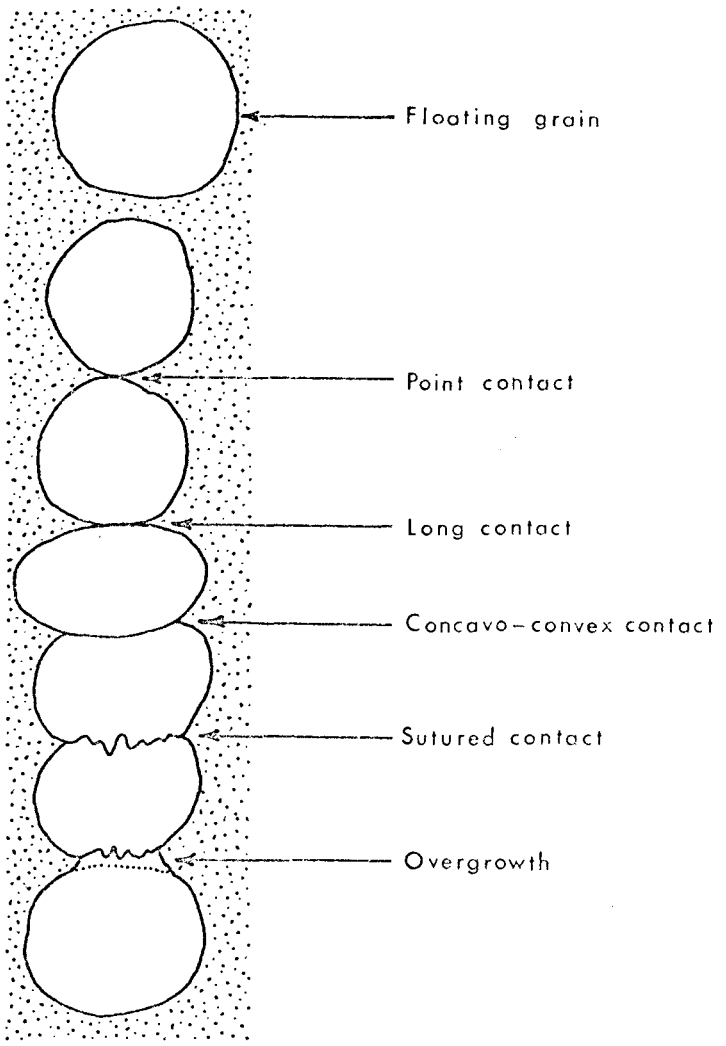


Figure 6.— Grain Contact Nomenclature in thin section

Quartz grains (white) in matrix (stippled)

classification of grain contacts in thin section by Taylor (1950, p. 707) modified by Siever (1959, p. 64):

Grain contact	Agency of development	Degree of interpenetration
Floating (no contact)	Packing	None
Tangential (point)	Packing	None
Long (= straight)	Packing, pressure	
Concavo-convex	Packing, pressure, solid flow, solution	Increasing degree
Sutured	Solution	

Allen (1962, p. 678) called grain contacts "fixed margins", as opposed to "free margins", leading to the terms "fixed grains" and "free grains" depending on which type of margin predominates.

Interpenetration of grains is now considered to be largely a pressure solution phenomenon and an important mechanism of sandstone cementation during diagenesis. Hatch, Rastall, and Black (1938, p. 103) were among the first to recognize this process, which they called "welding". Waldschmidt (1941, p. 1859, 1863) also cited the principle (known as the "Riecke principle") to account for sandstone cementation, in which silica is dissolved from quartz grains under pressure (and in the presence of solutions) at points of contact, where pressure is greatest, and is reprecipitated in the interstices between grains as overgrowths or microcrystalline cement. Lowry (1956, p. 490) gave pressure solution as the

mechanism of cementation for certain Appalachian quartzites (including the Antietam). Heald (1956, p. 22) found the effect in unstrained quartz grains from sandstones of the continental interior. He also found a consistent relationship between clay content (up to five percent) and silica cement, and concluded that "clay must in some way promote pressure solution" in the "pressolved" beds, although it is not necessary for the process to operate (ibid., p. 22-25). Thomson (1959, p. 105-106) suggested cation exchange in illite as the catalytic mechanism. Potassium, replaced by calcium or magnesium, forms potassium carbonate, creating a zone of high pH in which the solubility of silica is increased. Krauskopf (1959, p. 9), however, subsequently showed that silica solubility is essentially independent of pH for values below 9. Too much clay, on the other hand, may have an opposite effect. Heald (1956, p. 18-19) found that clay films on quartz grains had been replaced by quartz during overgrowth, but that thick clay coatings prevented overgrowth. Siever (1959, p. 71) found little interpenetration (or none at all) in clay-rich Pennsylvanian sandstones, possibly due to a cushioning effect. Recent experimental studies have supported the concept of pressure solution in quartz (Siever, 1962, p. 130-136; Ernst and Blatt, 1964).

In a study of 13 thin sections from 9 specimens of quartzites in the Erwin Formation of the Macks Mountain

area, the effects of much pressure solution are evident (Pl. 9). There are no free grains, sutured contacts are common, and porosity and cement are rare, although overgrowths are common. This might suggest strong (compressional) deformational forces. A study of 400 thin sections led Siever (1959, p. 71) to conclude that "the effects of structural deformation are more pronounced than weight of overburden" in causing interpenetration. Thomson (1959, p. 109) stated that depth of burial is not the major controlling factor.

Deformation of quartzite beds must entail a net loss of silica and loss of volume in the beds proportional to the degree of pressure solution, as indicated by extensive interpenetration but little cement. This may have facilitated the locally rather tight flexuring of the quartzite units.

Locally abundant, nearly parallel, hairline inclusion trails are problematic microscopic features of the quartz grains in the quartzites. Although present in most of the thin sections, they are most evident in the specimens shown in Plates 10A and 7B (the latter is from the transition zone). The trails commonly transect grain boundaries. Superficially they resemble Boehm lamellae, but they are apparently not controlled by crystallographic orientation. They may, however, indicate cataclasis during deformation and, if so, might be useful in determining stress orientation in the manner of joint sets.

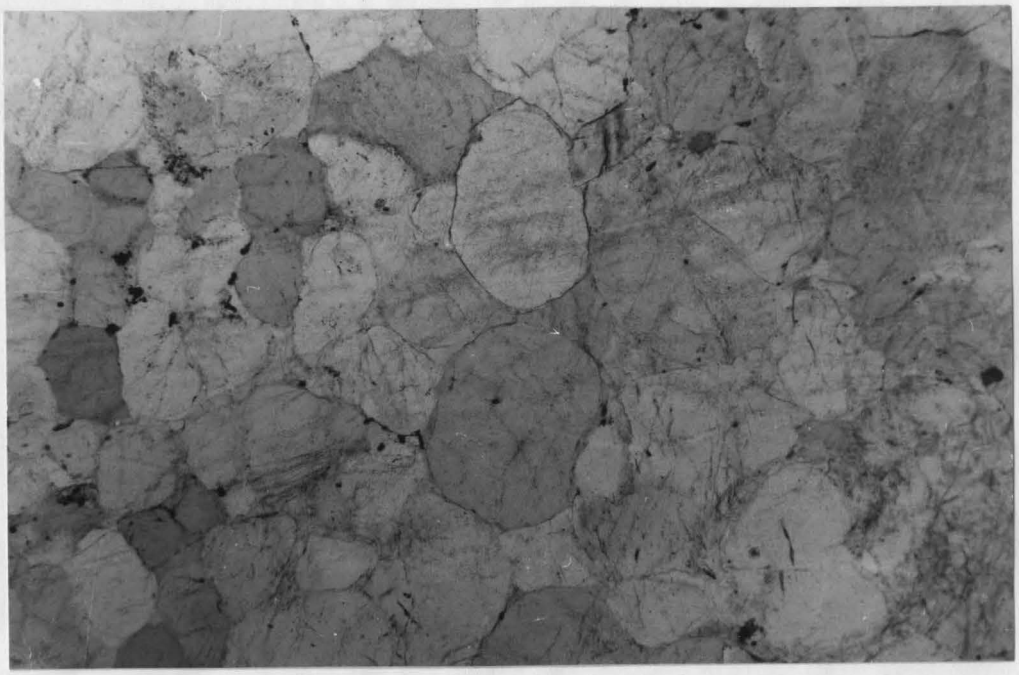
Plate 9

Photomicrographs of quartzite showing interpenetration of quartz grains.

A. Plane light, x25. Note overgrowths, such as at the upper end of the large grain just above center.

B. Crossed nicols, x25. Note overgrowths, highly sutured contacts, and undulatory extinction.

Plate 9



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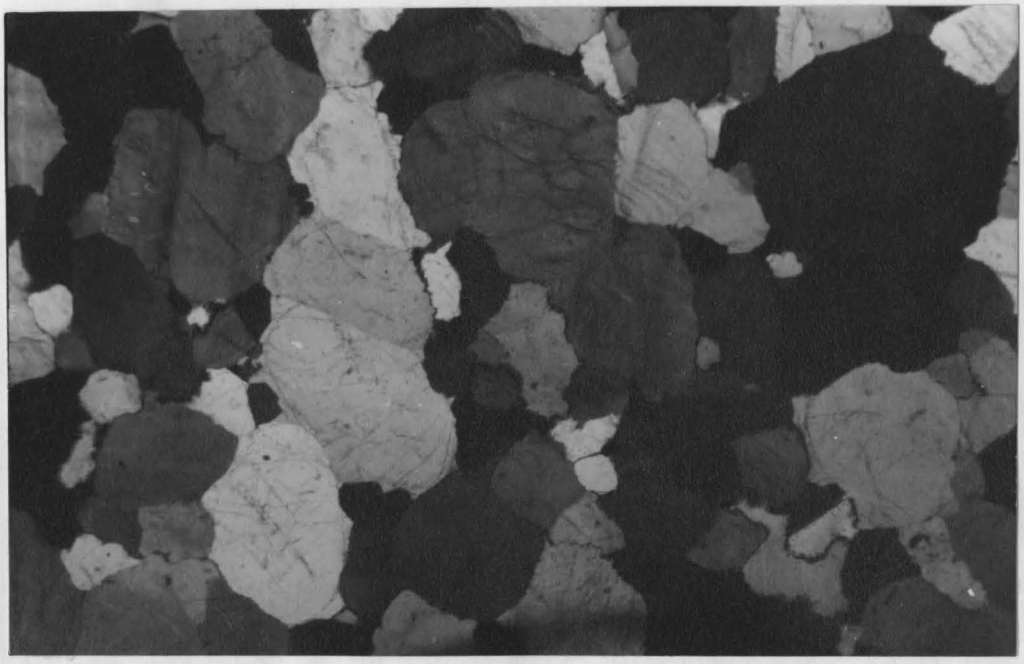


B

Another effect of pressure solution in quartzite is the development of stylolites. These features were first reported by Sloss and Feray (1948) as "microstylolites" and were later studied by Heald (1955), who suggested a loss of material on the order of 15 percent during their formation. Stylolites are common in the upper Chilhowee quartzites of the Hacks Mountain area, but their amplitudes, generally on the order of 0.5 mm or less, prevent their being recognized as such except in thin section. In hand specimen most resemble (and probably represent) bedding laminae, but a few are normal to bedding. Their development ranges from good (Pl. 10) to crude (Pl. 11), and some are even doubtful (Pl. 12). Some of the laminae have little sinuosity and continuity, and may be incipient stylolitic forms. The stylolites are characterized by concentration of certain relatively insoluble minerals that occur disseminated throughout the beds. These include mica, zircon, tourmaline, feldspar, magnetite, and ilmentite. These minerals, possibly including some amorphous material, locally form thin dark seams generally parallel to bedding. Electron microprobe analysis indicates the presence of the following cations: K, Fe, Mg, Al, Si, and O. This suggests the material may be biotite. Comparison of the abundance of insoluble accessory minerals thus concentrated with the abundance of those disseminated in the quartzite seems to indicate a silica loss of little more than the amplitude of the stylolites.

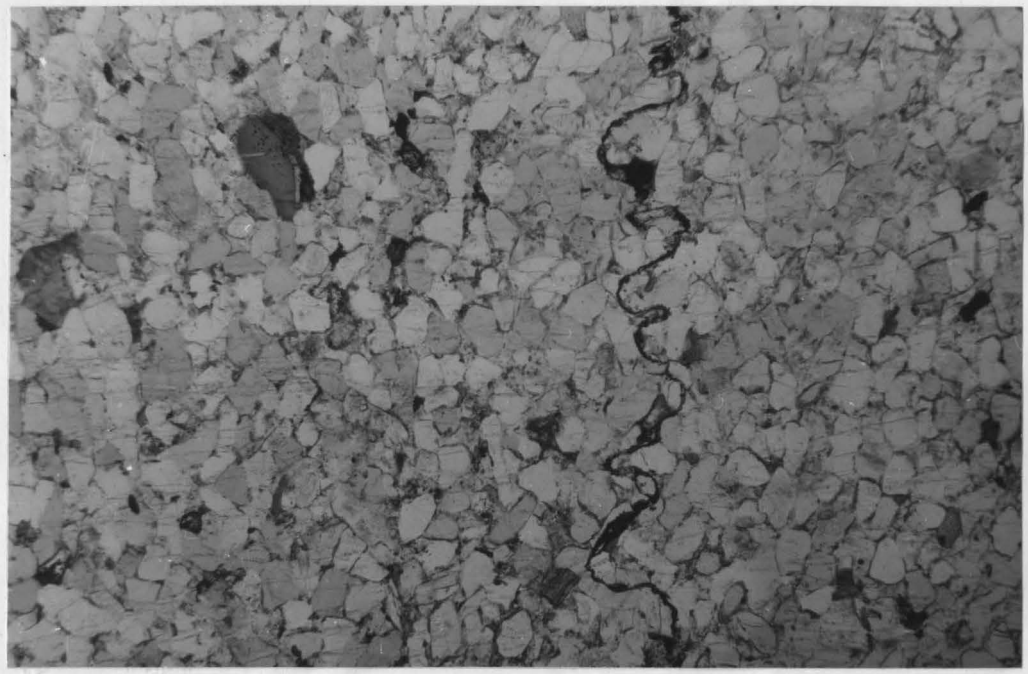
Plate 10

Photomicrographs of well-developed stylolite in quartzite along Laurel Creek. Bedding is vertical.

A. Plane light, x25.

B. Plane light, x100.

Plate 10



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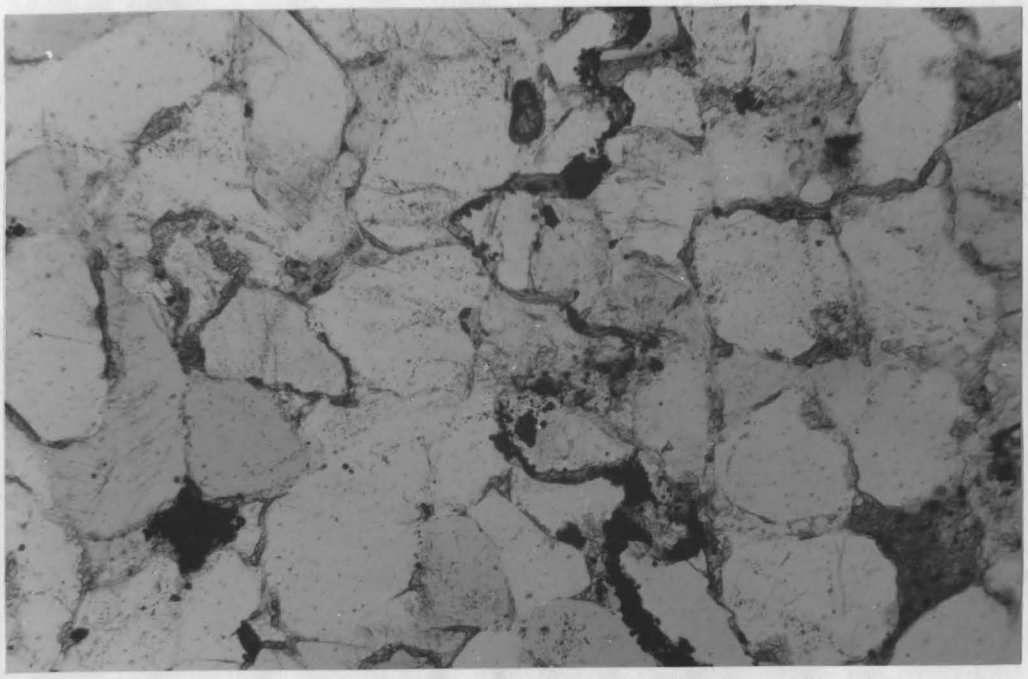


B

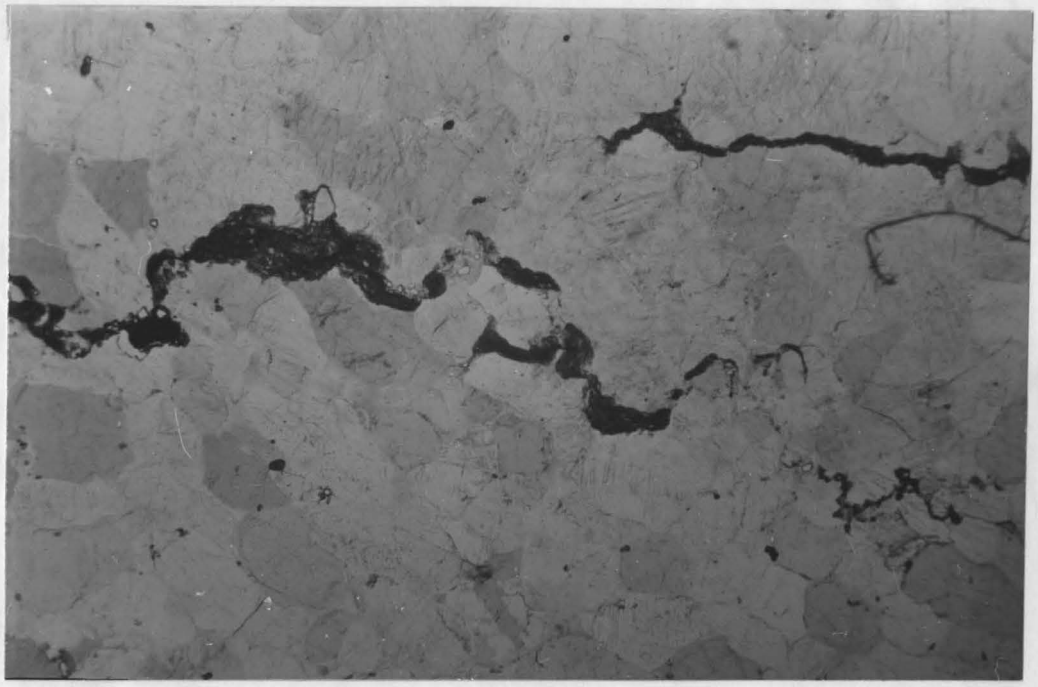
Plate 11

Photomicrographs of crudely developed stylolites in quartzite along Laurel Creek. Bedding is horizontal.

A. Plane light, x25. Relatively pure quartzite.

B. Plane light, x25. Relatively impure quartzite.

Plate 11



A

B

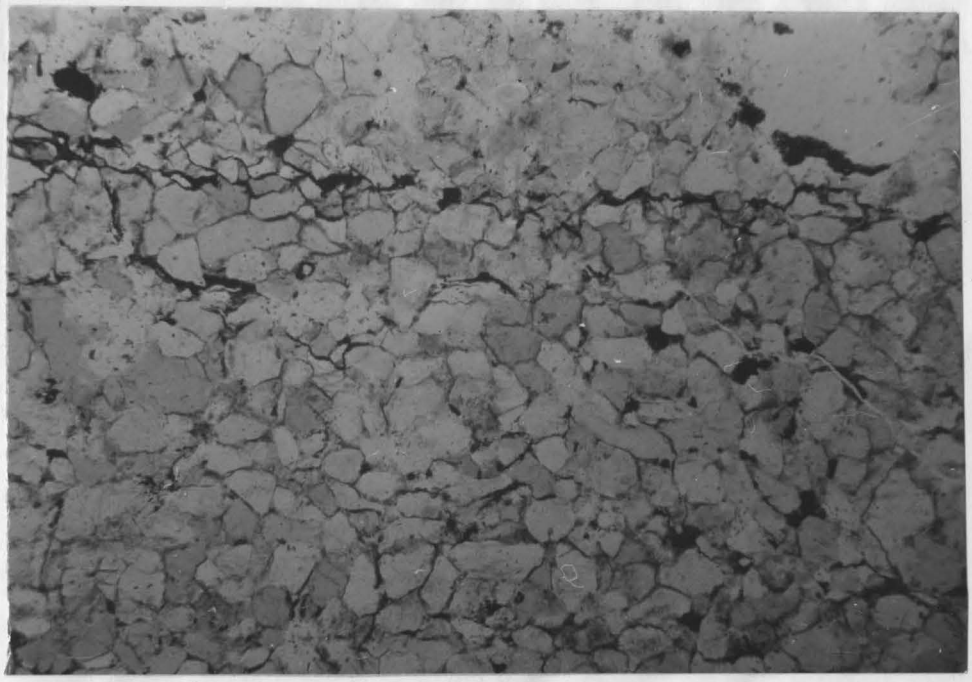
Plate 12

Photomicrographs of incipient stylolites in quartzite along Rock Creek.

A. Plane light, x25. Relatively pure quartzite. Bedding is horizontal.

B. Plane light, x25. Relatively impure quartzite. Bedding is vertical.

Plate 12



A

B

In the writer's limited thin section survey of Erwin quartzites (8 thin sections contained microstylolites) no definite conclusions could be reached concerning localization of stylolites or catalytic effects on pressure solution in general. Parallelism of stylolites to bedding suggests a concentration of some catalytic component during sedimentation, but the stylolites may only reflect distortion of bedding planes by interpenetration effects. Moreover, stylolites normal to bedding cannot have originated from bedding features. The localization of pressure solution by clay minerals suggested by Heald (1956, p. 23) could not be shown; indeed, interpenetration appeared more common in the more nearly pure quartzites. Thomson (1959, p. 105-106) suggested local increases in pH by cation exchange in illities as a catalytic mechanism, but this is not supported by the findings of Lowry and DeRudder (1966), who point out that stylolitic seams contain abundant phengitic mica which represents reconstitution of illitic clay by K-fixation. Moreover, the pH requirements for increased silica solubility are more rigorous than assumed by Thomson. In larger stylolites from equivalent beds some 75 miles to the northeast, Lowry and DeRudder (1966) observed a greater degree of suturing of quartz in the presence of mica, and concluded that solution of silica was promoted by the formation of mica.

Shady Dolomite

Definition.-- The Shady "Limestone" was named by Keith (1903, p. 5) for exposures in Shady Valley, Johnson County, northeastern Tennessee. The formation is predominantly dolomite and is apparently the oldest Paleozoic carbonate unit in the Appalachian miogeosyncline. It conformably overlies the thick basal "Cambrian" clastics (Chilhowee Group) and grades upward into shales, siltstones, sandstones, and carbonates of the Rome Formation. Neither boundary is sharp; the base, marked by several tens of feet of transition beds, is probably a time-stratigraphic horizon (King and Ferguson, 1960, p. 36) but the age relations of the upper limit of the formation are not as well fixed. The base of the Shady Dolomite is defined in the Macks Mountain area as the base of the lowest dolomite bed free of a significant amount of clastic components (although Currier (1935, p. 14) placed sandy dolomite of the transition zone within the Shady). The upper limit is placed at the base of the lowest red clastic unit above the carbonate succession.

Distribution.-- Shady Dolomite occurs in four structural blocks. It conformably overlies Erwin beds on plunging noses at both ends of the Hiwassee block. Along the railroad track southwest of Hiwassee an almost complete section of the Erwin-Shady succession is rather well exposed; probably less than 100 feet of beds is missing at

either top or bottom (Geologic Section 4, appendix). On the eastward facing slopes of Flinchum Mountain, above Little River, a thick carbonate sequence constitutes almost the entire Shady although large covered intervals make identification of the beds uncertain. Lowermost beds of the Shady are preserved in the trough of Chimney syncline on Irish Mountain. east of Hiwassee. Erwin-Shady transition beds can be found at each of these areas, but they are fresh and well-exposed only along Laurel Creek, south of Flinchum Mountain.

A belt of Shady Dolomite extends the length of Big Reed Island Creek Valley in a series of gentle, open folds plunging westward. The beds are locally well exposed along the creek. The upper contact with the Rome Formation is extremely well displayed in the large bluff at Rich Hill; it is also exposed along Road 693 a mile or so north of the bridge at the south end of the valley. Uppermost beds are marked by a zone of gray, locally banded, chalcedonic chert up to seven inches thick and as little as five feet below the lowest red beds of the Rome. The transition zone at the base is poorly exposed in a few other pits but is elsewhere concealed. It may be locally absent because of faulting.

The southwestern corner of the Powhatan block a few feet of Shady beds are preserved on the lower slopes of Ore Knob in Austin Hollow. They are apparently in normal

contact with the Erwin, but overlying beds have been faulted out.

Probable upper Shady beds (Anderson, 1968, p. 36-37), are exposed in a plunging anticline along the leading edge of the Tinytown fault slice.

Shady Dolomite is abundant in the adjacent area to the southwest (Currier, 1935; Stose and Stose, 1957) but is almost, but not, totally lacking to the northeast as far as Roanoke, some 40 miles away (Dietrich, 1954). In Virginia, outcrop of the Shady is restricted in most places to a rather narrow belt along the west foot of the Blue Ridge.

Thickness and Lithology.-- The Shady Dolomite is a carbonate succession without significant clastic beds and without much chert. It comprises several distinctive lithologies which in the past have served as a basis for dividing the unit into two or more members. In the Macks Mountain area, (see Geologic Sections 4, 5 and 6, appendix) six more or less distinct subdivisions were recognized: 1) basal "warty" dolomite, 2) lower "ribboned" dolomite, 3) bluish "ribboned" limestone, 4) "white" coarse-grained dolomite, 5) upper "ribboned dolomite", and 6) laminated dolomite. This subdivision does not imply uniform lithology within these units, only overall aspects. Traditionally the Shady has been divided into two members, the Patterson Member below and the Saccharoidal (or

Austinville) Member above (Butts, 1940, p. 41). An overlying limestone sequence, named "Ivanhoe Member" by Currier (1953, p. 16), was considered by him to be a third member of the Shady, but it was later regarded by some workers as the basal unit of the Rome Formation (Cooper, 1961, p. 23-24). The thick succession of dolomite and limestone above the "saccharoidal" member may be regarded as a transition zone between the Shady and Rome. Current investigations suggest that this succession may be considered a separate formation, for which the name "Wytheville Formation" has been proposed (Anderson, 1968, p. 9-16).

The lowermost beds of the Shady, overlying the Helenmode member of the Erwin, are chiefly fine-grained gray dolomites with little indication of bedding. They commonly contain calcite veins and associated sulfide minerals, generally pyrite but locally galena and sphalerite. Weathered surfaces tend to have pea-sized "warts" of sparry white dolomite which weather in relief. Succeeding beds also have "warts", veins, and sulfide minerals, but are distinguished by a "ribboned" bedding first described by Currier (1935, p. 20-21). The ribboned appearance is caused by thin alternating light and dark dolomite beds of variable thickness, resembling twisted or crumpled ribbons. The alternations entail both compositional and textural variations. Derby (1965, p. 55-58) found a similar lithology in the Nolichucky formation

(Middle and Upper Cambrian) of the southern Appalachians, and suggested an origin in part related to algal structures. These ribboned dolomites grade upward and, according to Currier (1935, p. 20-21), laterally into the ribboned limestone beds. This distinctive unit is a dark bluish-gray micrite and pelmicrite (locally micrudite, an uncommon lithology). Its ribboned appearance is caused by irregular light buff-gray dolomite partings (Pl. 13). Locally it has formed intraformational ("edgewise") conglomerate (Pl. 14) similar to that described by Currier (1935, p. 34) from near Austinville. In thin section alternating "ribbons" can be seen to have slight variations in grain size. The coarser beds locally show incipient dolomitization. Some bands have a faint pelletal or oolitic texture, and distinct oolites occur locally in small clusters (Pl. 15). On the basis of lithologic similarity this unit is apparently equivalent to the fossil-bearing beds near Austinville, although no identifiable fossils were discovered in the Macks Mountain area. The top of this unit is probably the top of the Patterson Member of other authors.

Overlying the limestone interval is a light - to pearl-gray ("white"), commonly coarse-grained dolomite. It is nearly pure and is perhaps the most distinctive and characteristic unit of the Shady. It is interbedded with darker gray dolomite, particularly in the lower part. In

Plate 13

Ribboned limestone in Shady Dolomite at the mouth of Dry Branch.

A. Bedding surface. Note features weathered in relief: oolites (single, in couplets, and in chains) and probable archeocyathids.

B. Surface normal to bedding.

Plate 13

A

B

Plate 14

Limestone ("edgewise") conglomerate in ribboned limestone unit of the Shady Dolomite, at the mouth of Dry Branch. Clasts are composed of fine-grained pelletal calcite; matrix contains calcite and dolomite.

A. Weathered surface. Compare Plate 12A, Currier (1935), reproduced as Plate 49A by Stose and Stose (1957), which shows a similar lithology in the Austinville basin.

B. Fresh surface.

Plate 14

A

B

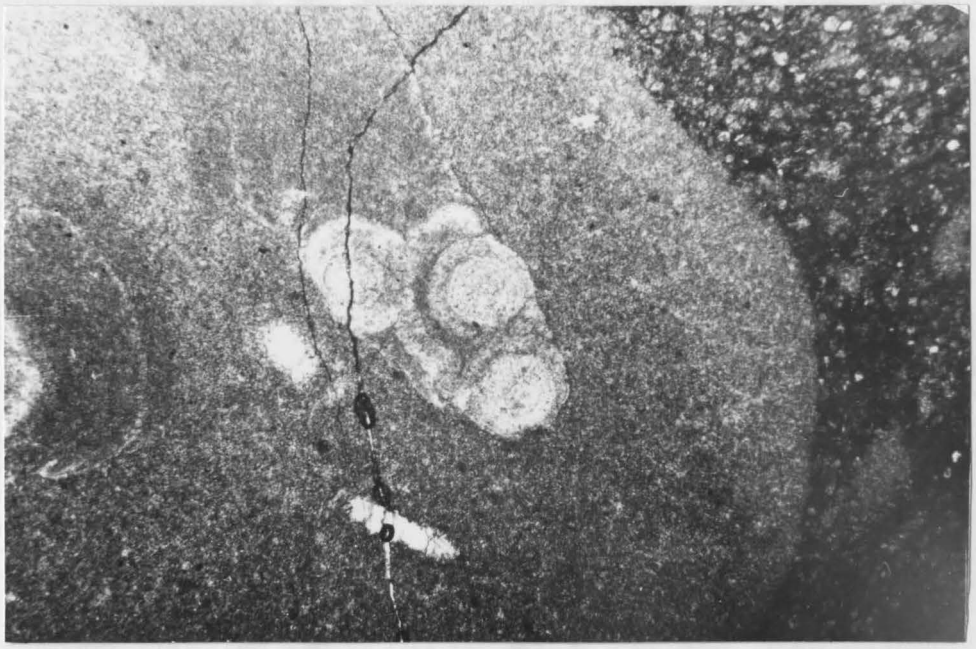
Plate 15

Photomicrographs of oolites in ribboned limestone.

A. Specimen from railroad cut east of Allisonia. Dark gray material at extreme right is partially dolomitized. Plane light, x25.

B. Specimen from the mouth of Dry Branch, outcrop shown in plate 16A.

Plate 15



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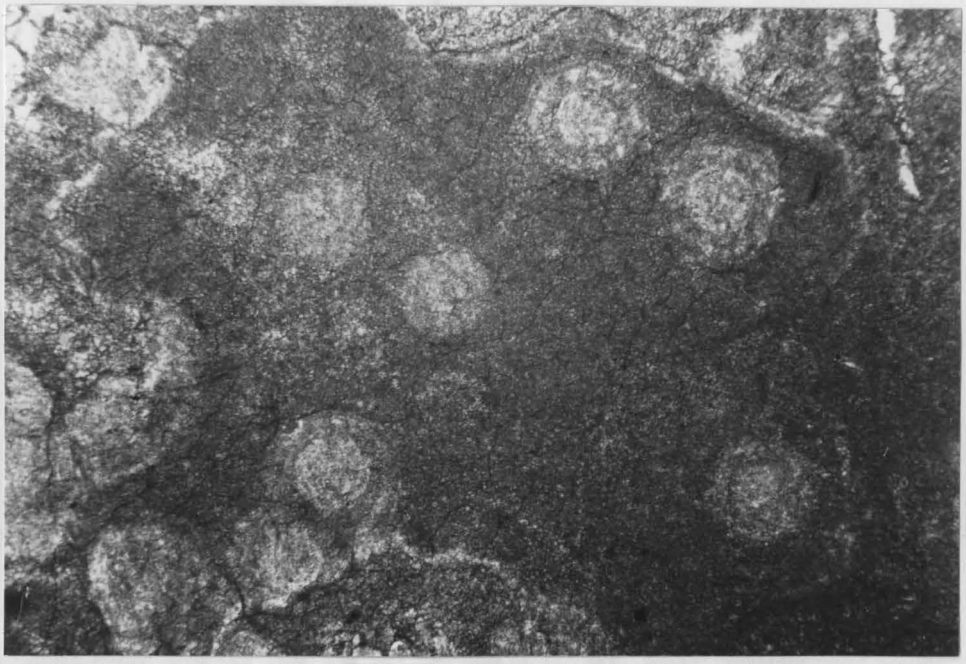


B

thin section it is unformly crystalline with a few widely disseminated, rounded quartz grains and essentially no porosity. This lithology has been called "saccharoidal" dolomite and these beds constitute the "Saccharoidal" or "Austinville" member of the Shady.

Succeeding the "white" dolomite is a sequence containing ribboned bedding. This sequence, the poorest-defined of the sub-units, also contains evenly bedded dolomite and locally (Geologic Section 4) small black chert blebs and a distinctive calcite-cemented breccia. Bedding is more regular in the uppermost (and thickest) unit of the Shady; most of the beds are laminated, although the laminae are commonly apparent only on weathered surfaces. Black chert nodules and irregular "splotches" occur in a few thin zones. Thin sections show a relict pellet texture in the chert, and the dolomite grains are coarser, more nearly euhedral, and darker in and adjacent to the chert than away from it (Pl. 16). Sparry blebs and sulfide minerals occur locally in these upper beds in a manner similar to their occurrence in the lowermost strata. A distinctive horizon in this sequence is characterized by purple fluorite crystals, up to about 1 mm across. The uppermost 400 feet of this unit contains about 100 feet of limestone (Geologic Section 6). Some of the limestone beds at Little River have prominent mudcracks (Pl. 17).

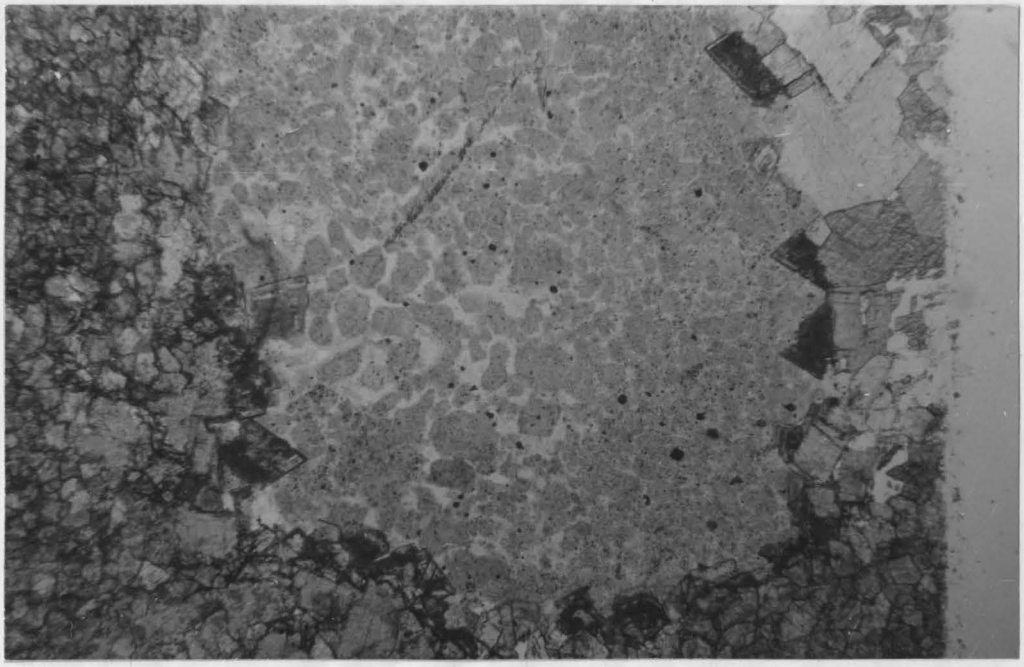
Plate 16

Photomicrographs of chert "blebs" in Shady Dolomite east of Allisonia. Note "pelletal" aspect of the chert, inherited from replaced carbonate.

A. Plane light, x25. Note dolomite rhombs are darker where they penetrate the chert.

B. Plane light, x25. Note decrease in size and development of crystal faces away from the chert.

Plate 16



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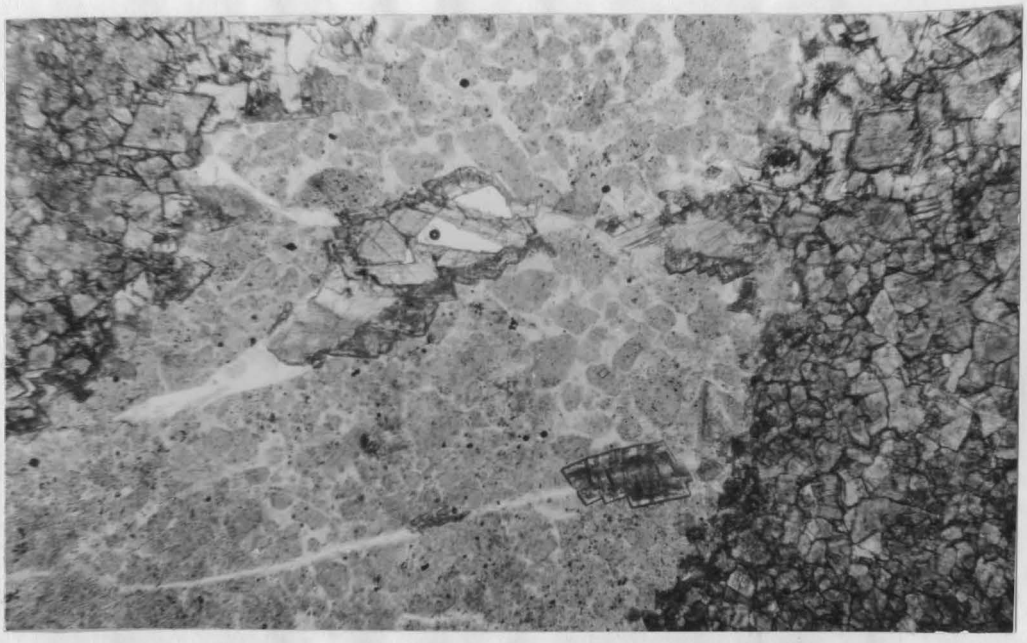
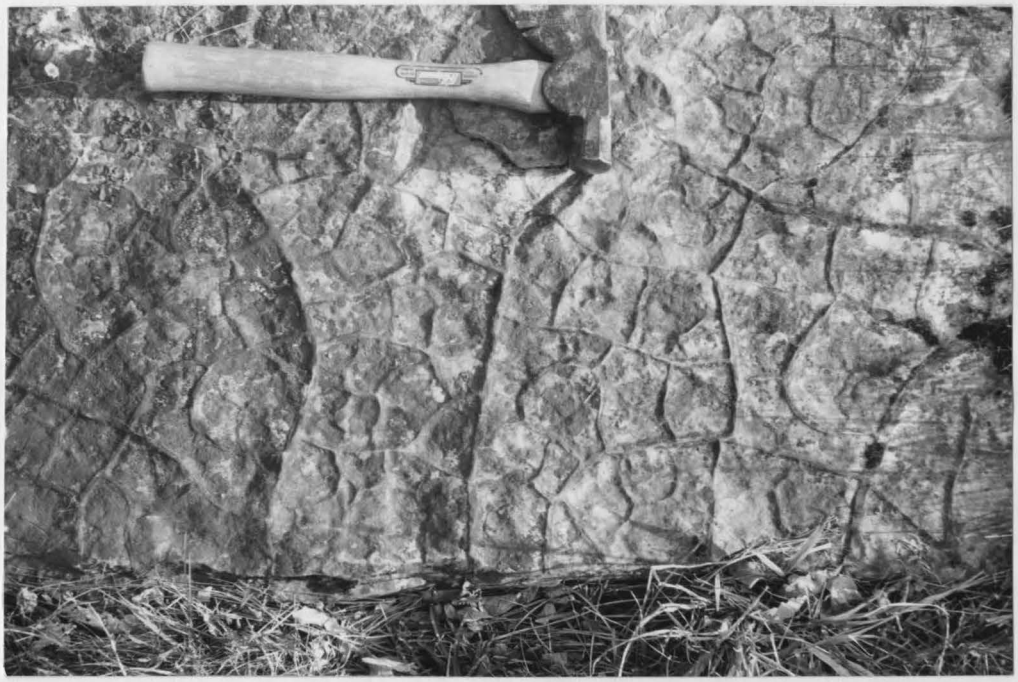


B

Plate 17

Mudcracks in limestone, upper Shady Dolomite near the mouth of Laurel Creek.

Plate 17



Thicknesses of the Shady lithologies apparently range considerably within short distances, as indicated by comparison of Geologic Sections 4, 5, and 6, all in the Hiwassee-Allisonia area (see Fig. 5). The basal Shady beds are thin or absent along Laurel Creek at the eastern end of the area, where ribboned dolomite occurs just above the Helenmode (Geologic Section 3).

The variations in thickness are probably caused by dissimilarity in environments of deposition, but may indicate variation in degree of diagenetic recrystallization. The pelletal appearance of some of the limestone and chert suggests that much, perhaps most, of the formation was originally a lime mud, of which the medial ribboned limestone is the least recrystallized remnant. The different degrees of recrystallization make correlation of the subdivisions of the Shady uncertain at best.

Thicknesses of the Shady subdivisions in the Hiwassee-Allisonia area are summarized in Table 2.

Section 4 is probably close to the maximum thickness of the formation. The Delton cross fault appears to have removed the uppermost beds near the Rome contact; most of the Shady is repeated southwest of the fault. The thickness in this area is, then, perhaps as much as 1,600 feet, compared to about 1,500 to 1,800 feet reported by Currier (1935, p. 11) and 1,300 feet reported by Stose and Stose (1957, p. 116) for the area just directly

Table 2

Thicknesses of Shady Dolomite Subdivision in the Macks Mountain area.

	Thickness in feet		
	Section 4	Section 5	Section 6
Transition beds	fault	covered	
Laminated gray dolomite	560	190	970
Upper ribboned dolomite	140	190	250
"Saccharoidal" Member	120	260	15
"White" crystalline dolomite			
Patterson Member	150	160	covered
Blue ribboned limestone			
Lower ribboned dolomite	390	not exposed	
Basal "warty" dolomite	70		
	1,430	800	1,235

to the southwest. Butts (1940, p. 41-50) gave several geologic sections in the same area indicating thicknesses of 1,400 to about 1,600 feet.

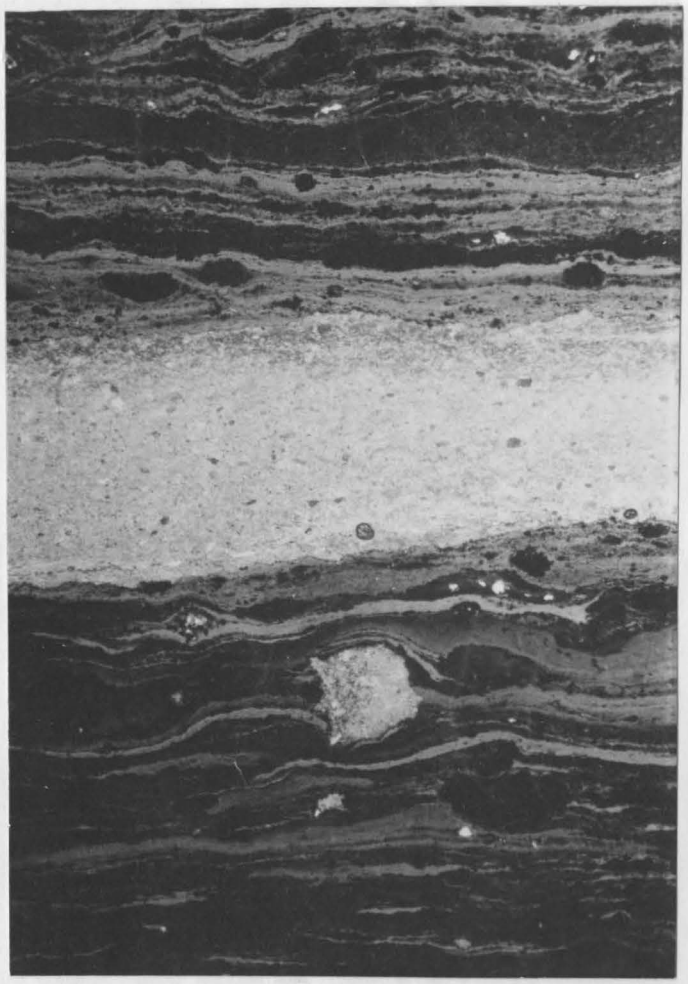
A local feature in the Shady is the abundance of jasperoid float in the iron-ore pits on Irish Mountain. It is a dense, brownish-yellow, chert-like rock, commonly with drusy quartz surfaces. Its origin as replacement of dolomite or limestone is indicated by relict features such as unaltered chert lenses (Pl. 18) and pelletal texture. It is widely distributed in the residuum of the Shady Dolomite throughout the southern Appalachians (Miller, 1944, p. 22; Rodgers, 1948, p. 15-17; Kesler, 1950, p. 47-49; King and Ferguson, 1960, p. 49-50). The origin of jasperoid is not clear, but it is generally thought to have formed in the zone of weathering (King and Ferguson, 1960, p. 50).

Age and Correlation.-- Unlike most younger Cambrian carbonate sequences, the Shady Dolomite is practically without fossils except in a few isolated localities. No fossils have been found in the Macks Mountain area, but Resser (1938, p. 6-7, 24-25) reported a very large fauna of the *Bonnia* zone from *Archeocyathid* reefs near Austinville, 12 miles southwest of Allisonia. The Shady has thus been assigned to Middle Lower Cambrian, and is equivalent to the Tomstown Dolomite of Maryland and northern Virginia (Howell and others, 1944). On the

Plate 18

Photomicrograph of jasperoid float in Irish Mountain ocher pit. Light-gray band (center) is a thin chert lens. Darker gray are microcrystalline quartz grains stained with iron oxide. Darkest bands are the finest grained. Interpreted to be silicified dolomite near the base of the Shady. Plane light, x25.

Plate 18



basis of lithological comparisons, Stose and Jonas (1939) regarded carbonate rocks in the immediate area of Austinville as Vintage Dolomite, Kinzers Formation, and Ledger Dolomite rather than Shady. These are names originally applied to beds in Pennsylvania equivalent to Shady and lower Rome.

Rome Formation

Definition.-- The Rome Formation was named by Hayes (1891, p. 143) for Rome, Georgia. The name is used as far north as Roanoke, Virginia, and beyond, for the chiefly clastic thick sequence overlying the Shady Dolomite. The base of the formation is generally taken at the lowest occurrence of red shale or siltstone. The upper contact of the Rome is not exposed in the Macks Mountain area, but the formation is overlain in exposures to the west by the Elbrook Dolomite of Middle Cambrian age (Hergenroder, 1957).

The thickness of the Rome Formation is difficult to determine because of its high degree of deformation. It has been measured as about 2,000 feet by Butts (1940, p. 63) near Buchanan, Virginia. The outcrop width of Rome belts is commonly several miles.

Distribution.-- The Rome Formation forms the northern border of the Macks Mountain area and underlies the western side of Big Reed Island Creek Valley. The base of the Rome is exposed only at the southwestern end of the area; else-

where the formation is in fault contact with overriding Erwin or younger beds.

Lithology.-- The Rome Formation includes a wide variety of lithologies. Most characteristic of the Rome are red shales and siltstones. Green sericitic shale and buff to yellow shales and siltstones are also common. Carbonates constitute a large proportion of the formation. Fine-grained quartzites also occur in the Rome and account for many of the elongate, rounded hills characteristic of the formation. Gradations commonly occur between adjacent lithologies.

The red shale beds commonly have both mudcracks and ripple marks (Pl.19A). Contorted laminae (Pl.19B) are also common in the Shale.

Age and Correlation.-- Fossils from the Rome in Virginia indicate the formation to be uppermost Lower Cambrian (Resser, 1938, p. 30), although Middle Cambrian fossils have been reported from some localities (Butts, 1940, p. 66). The formation has been called "Watauga Shale" in northeastern Tennessee and southwestern Virginia, and was named "Graysonton Formation" by Campbell (1894) for exposures along the Little River just north of the Macks Mountain area. The name "Rome" has priority over these and is in general usage. It is correlated with the Waynesboro Formation of the Central Appalachians, where carbonate rocks constitute a greater percentage of the unit.

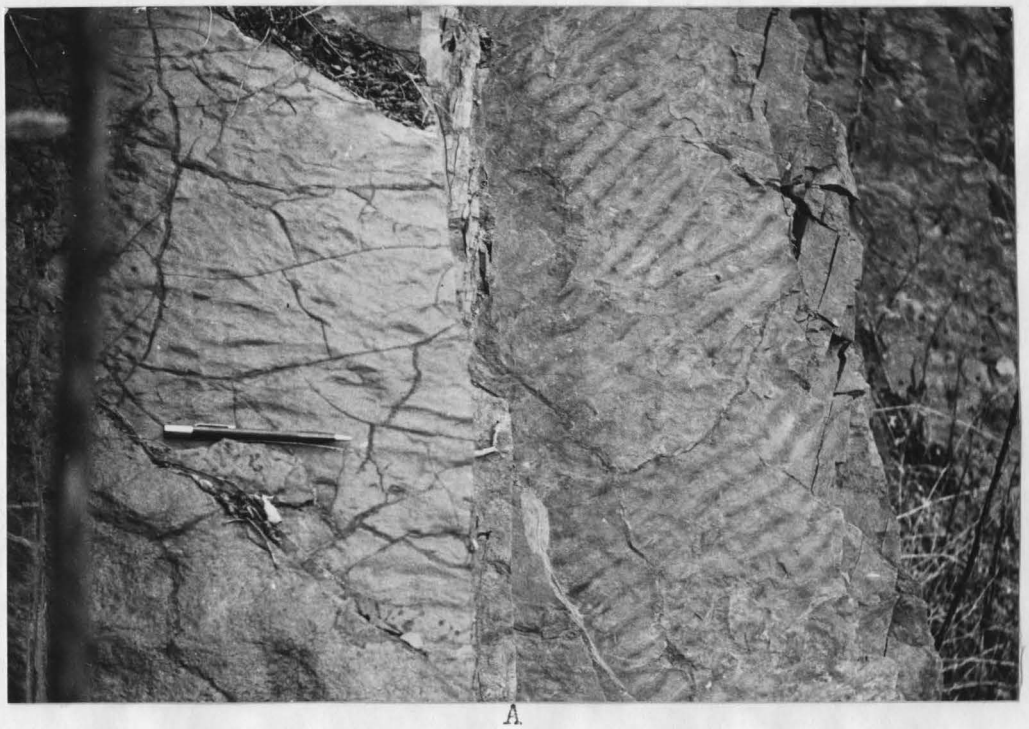
Plate 19

Bedding features in red shale, Rome Formation.

A. Mudcracks and ripple marks. The beds are a few inches apart stratigraphically. Just north of Simpkinstown.

B. Contorted laminae. Along Little River south of Snowville.

Plate 19



A

B

STRUCTURAL GEOLOGY

General Statement

Structural Setting

The Macks Mountain area occupies a critical position along the boundary between the highly deformed Lower Cambrian and older rocks of the Blue Ridge province and the generally less deformed Paleozoic rocks of the Valley and Ridge province. The boundary between the provinces is generally placed at about the contact between lower Cambrian clastics and younger, weaker Paleozoic rocks. In parts of northern Virginia the contact may be a normal depositional succession but elsewhere in the state it is an overthrust, commonly called the "Blue Ridge thrust". In both cases it approximately marks a distinct physiographic as well as geologic boundary.

The sedimentary rocks of the Valley and Ridge Province range in age from Early Cambrian to Mississippian, and are characterized in the Southern Appalachians by large, open folds and low angle thrusts with heaves measured in miles (Butts, 1933, map). The northwestern part of the Blue Ridge province is underlain by both sedimentary and crystalline rocks generally in tight, overturned folds and associated complex faulting. King (1959, p. 47) has described the structural differences between the two provinces in terms of flexure folding in the Valley and Ridge in contrast to shear (flow) folding in the Blue Ridge.

Structures in both provinces are distinctly asymmetrical. Most folds incline or are overturned to the northwest, and thrusts and cleavage dip to the southeast. The crystalline rocks of the Blue Ridge are presumed to extend westward under the Paleozoic strata as "basement", but are not exposed west of the Blue Ridge.

Figure 7 shows the structural setting of the area with respect to specific structures in adjacent regions. Most significant of these structures are the Pulaski thrust block and the Draper Mountain anticline, which is in the Saltville thrust block, adjacent to the northwest.

Structural Significance

The nature and cause of Appalachian deformation are not well understood. An important controversy concerns whether or not the crystalline basement beneath the thick Appalachian sedimentary sequence of the Valley and Ridge Province was involved in the deformation, and if so, how and to what extent. Allied with this question is another concerning the time of Appalachian deformation. If, as is now considered likely by some workers, deformation began shortly after sediments began to accumulate in the Appalachian geosyncline, basement involvement in deformation would seem to have been probable. This conclusion is resisted by many geologists, however, for two main reasons: 1) certain Appalachian structures such as

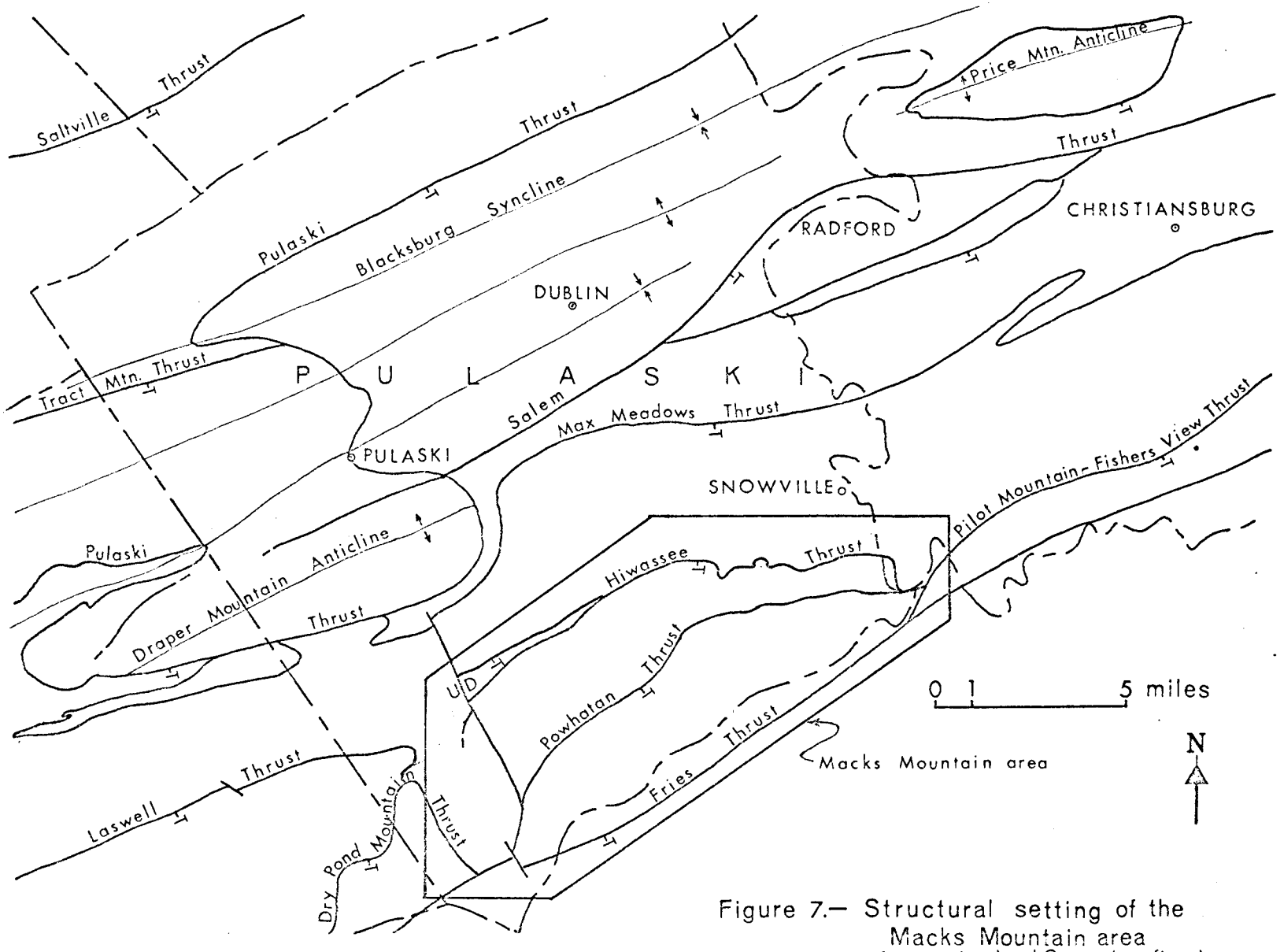


Figure 7.— Structural setting of the Macks Mountain area
After Butts (1933) and Cooper (1961, fig. 21)

the Cumberland overthrust block have been thought to be unrelated to the basement, and 2) no basement rocks have been exposed west of the Blue Ridge, and thus basement configuration can be determined only by indirect means, open to question.

Data necessary to resolve these fundamental questions might be obtained by three methods: 1) deep core drilling in well-chosen Valley and Ridge locations, 2) extensive geophysical studies of the basement, and 3) detailed mapping and analysis of the boundary zone between the Valley and Ridge and Blue Ridge provinces. Harris and Zietz (1962) used geophysical methods to show basement involvement in the Cumberland overthrust. Investigation of the boundary zone is the method used in the present study.

Discussion of the questions mentioned above and exposition of the different points of view may be found in Rich (1934), Miller (1945), Rodgers (1949; 1953, p. 150-166, 1964), Cooper (1961, p. 100-118; 1964), and King (1964).

General Description of the Structure

The Macks Mountain area consists of a number of structural blocks separated by thrust faults into three structural units. Within each unit there are more or less characteristic structures and related stratigraphic units (Fig. 8). From northwest to southeast these are: 1) the

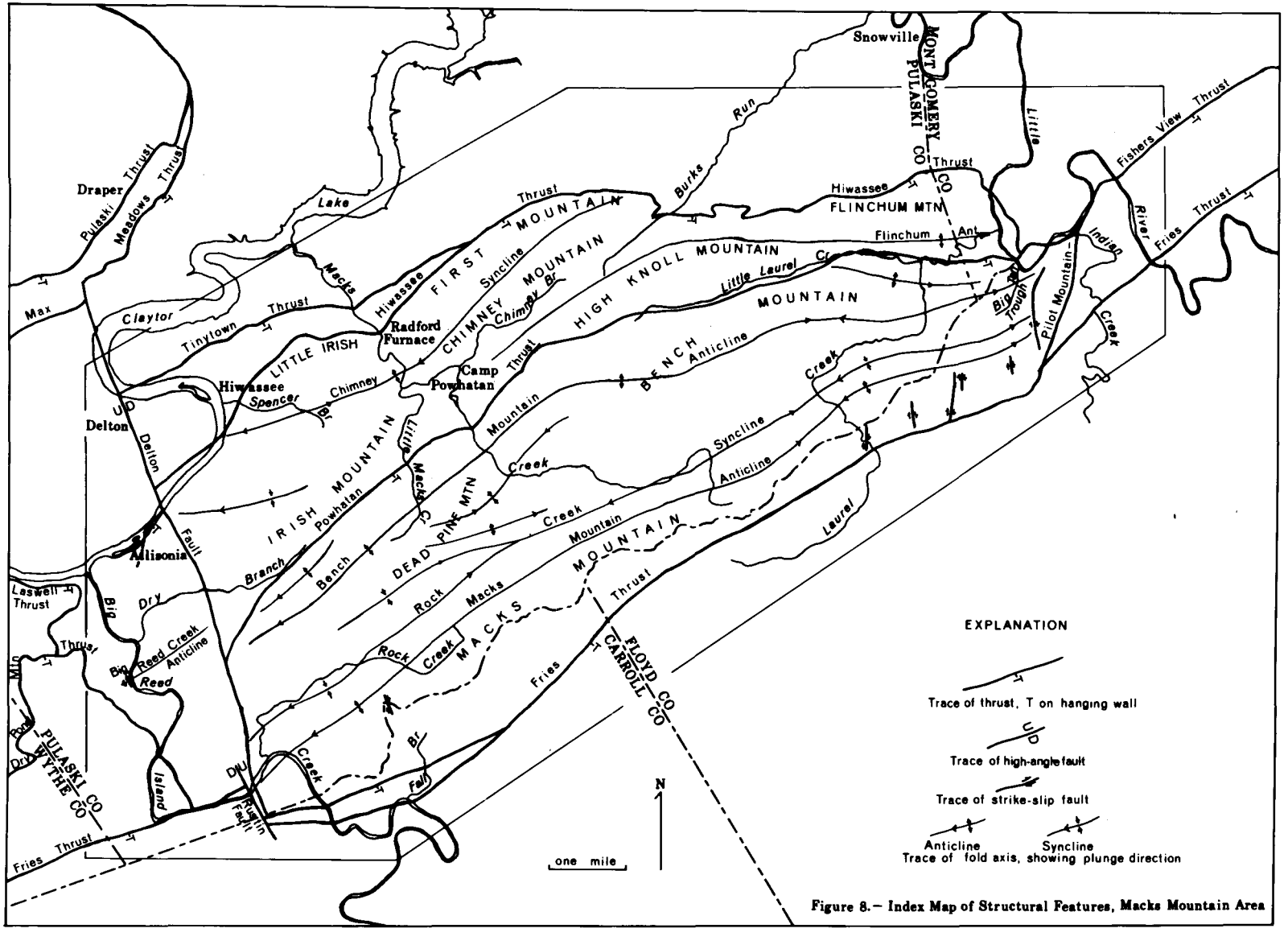


Figure 8.– Index Map of Structural Features, Macks Mountain Area

Pulaski block, 2) the Hiwassee-Powhatan blocks and 3) the Fries block.

The bulk of the mapped area lies within the Hiwassee and Powhatan blocks which are underlain mainly by extensively folded Chilhowee rocks (Pl. 1, Fig. 8). The overall structure is anticlinorial with a crumpled or corrugated aspect which results in a continuous outcrop breadth of Chilhowee rock of as much as five miles, a distance exceeded in Virginia only in the mountains east of Steeles Tavern.

The folding of the Hiwassee and Powhatan blocks generally appears to decrease in intensity and increase in amplitude northwestwardly. All folds are asymmetrical and some are locally overturned to the northwest. A structural salient and culmination centers in the Powhatan block. The thrust faults along which the Hiwassee and Powhatan blocks moved are chiefly bedding thrusts (as at Radford Furnace) but locally cut across beds and fold axes.

Most structural features, such as fold axes and fault traces, strike northeastwardly more or less parallel to the regional trend. A significant exception is the Big Reed Island Creek Valley, a structural reentrant in which most bedding planes and high angle faults have northwesterly strikes. At the south end of this valley Precambrian metamorphic rocks are in fault contact with

Rome shales and dolomites. The thick Chilhowee sequence is interrupted as an intervening belt between Blue Ridge crystallines and beds younger than Chilhowee in only three other localities in Virginia. Crystalline rocks are in contact with Shady Dolomite at Tices Mill (Dietrich, 1954) and with Shady and Rome in the Roanoke area (Butts, 1933), and overlie Ordovician Beekmantown Limestone near Front Royal (Butts, 1933).

Detailed descriptions of structures are given below by major structural blocks. All folds and cross faults, and the Tinytown, Hiwassee, and Powhatan thrusts, are described and named first in this report.

Pulaski Block

General Description

The northwestern margin of the Macks Mountain area contains Rome beds along the southeastern edge of the Pulaski thrust block, where it is overridden by a series of thrust blocks containing Chilhowee rocks (Fig. 8 and Structure Sections, Pl. 2). The block contains a large scale parallel auxiliary thrust, the Max Meadows fault (Cooper, 1961, p. 86; 1939, p. 58-63), whose trace lies just northwest of the area. Northwest of the Macks Mountain area the Pulaski block forms a large salient (Fig. 7) which Cooper (1964, p. 103) suggested as being preserved by downfolding of the thrust block into the

Blacksburg syclinorium as a result of continued subsidence of the fold. The thrust is more or less warped and has a horizontal displacement of at least seven to eight miles. Draper Mountain is a major anticline in a structural recess of the Pulaski thrust fault.

The Rome belt southeast of the Max Meadows fault is a series of parallel drag folds inclined northwestward, but the overall structure is problematic. Dietrich (1954, p. 23) suggested that the belt northeast of the Macks Mountain area may be synclinorial. The belt is transected by a cross fault in the Delton area (Fig. 8), and the axes of the drag folds curve to the south on both sides of this fault. The trends of these folds are readily seen on topographic maps or aerial photographs as nearly parallel, elongate hills. Figure 9 shows the trends as indicated by these elongate hills in the Claytor Lake area on both sides of the Delton cross fault.

The root zone for the Pulaski or Max Meadows thrust is not apparent in this region, but probably lies either to the southeast below overriding thrust blocks, or has been removed by erosion from a position above these blocks.

Tinytown Fault

A minor thrust extends from the Delton cross fault eastwardly through Tinytown and Macks Creek Village and disappears beneath the Hiwassee thrust north of First

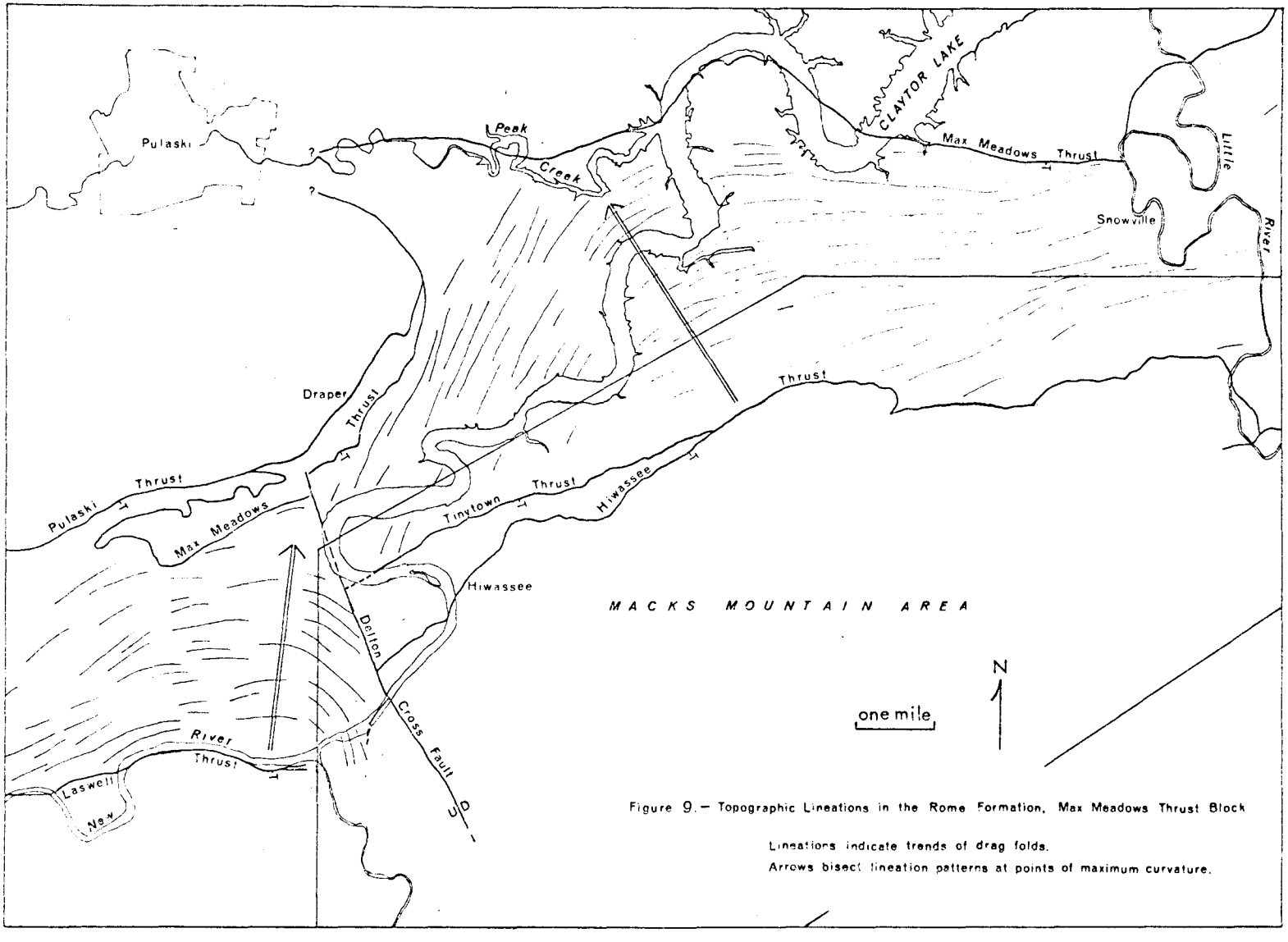


Figure 9.— Topographic Lineations in the Rome Formation, Max Meadows Thrust Block

Lineations indicate trends of drag folds.
Arrows bisect lineation patterns at points of maximum curvature.

Mountain. A thick belt of dolomite constitutes the sole of most of the fault block. Bedding of the hanging wall trends at nearly right angles to that of the footwall beds. The fault is well exposed on Macks Creek and at Claytor Lake. The fault slice is apparently relatively thin (see structure sections D-D', E-E', and F-F') and has been removed by erosion from the upthrown west side of the Delton cross fault.

Hiwassee-Powhatan Blocks

General Description

The Hiwassee-Powhatan blocks, which constitute most of the Macks Mountain area, consist of a highly folded succession of beds most of which are in the Chilhowee Group. The blocks have overridden the Rome of the Pulaski block on the northwest and have been overridden on the southeast by rocks of the Fries and Pilot Mountain-Fishers View blocks. The Hiwassee and Powhatan blocks extend from Little River on the northeast to Big Reed Island Creek on the southwest (Fig. 8). This structural unit is divided by the Powhatan thrust into the Hiwassee block on the northwest and the Powhatan block on the southeast.

The Hiwassee block contains Hampton through Rome beds in several broad, open, northeastwardly trending folds that plunge generally away from the center. Hampton shales occur at the center and Rome beds occur at the northeastern

and southwestern ends. The southwestern end of the block is a very broad, plunging, anticlinal nose cut by a cross fault.

The Powhatan block consists of a series of folds in the Chilhowee Group. The folding is closer and more intense than in the Hiwassee block. Near the center of the block fold axes are convex northwestward, forming a salient, and in the eastern end of the block the axes converge. The plunge of the axes is mainly away from the center, so that the salient concides with a structural culmination (see structure section G-G', Pl. 2).

The overall aspect of these folded blocks is anticlinorial; the blocks may be considered to constitute the "Macks Mountain anticlinorium". Structures within the blocks were determined chiefly by mapping of the ridge-making quartzites, and are shown in Figure 8 and in more detail on Plate 1.

Folds in the Hiwassee Block

Chimney Syncline.-- The northwestern side of the block is a broad, open syncline with its axis roughly coinciding with Chimney Mountain; Chimney Rock is composed of nearly flat-lying beds in the axial portion of the fold. The gently dipping, northwestern limb is exposed at Radford Furnace; southward along the road to Camp Powhatan the beds flatten and strike northwestward reflecting the gentle

southwestward plunge. Sharp upturn of the southeastern limb can be seen along Macks Creek and Little Macks Creek. In the Camp Powhatan area, the underlying Hampton beds are overturned.

A structural depression is located on Irish Mountain, where a small isolated mass of the lower part of the Shady Dolomite is preserved.

Flinchum Anticline.-- High Knoll Mountain is underlain by Hampton beds in a broad, gentle anticline. To the southwest, in the Camp Powhatan area, the anticline is much more tightly folded and locally overturned. The axial portion appears to have been overridden by the Powhatan fault southwest of Little Macks Creek, but reappears with a southwesterly plunge along Dry Branch south of Irish Mountain. Northeast of High Knoll Mountain the northeasterly-plunging nose of the fold forms Flinchum Mountain, which is held up by Erwin Quartzites. The overlying Shady Dolomite wraps around this nose along the eastern foot of this mountain, where the Little River cuts through the fold.

Big Reed Island Creek Anticline.-- The configuration of the beds along Big Reed Island Creek indicate a very broad anticlinal nose plunging toward the southwest. The axial trace is concealed east of the Delton cross fault, but the fold may be the southwestern nose of the High Knoll Mountain anticline. At Big Reed Island Creek the fold is

a very gentle warp recognizable only by geologic mapping; in the Powhatan area it is overturned to the northwest. In Big Reed Island Creek Valley the northwestern limb is thrust over Rome Beds of the Pulaski Block, and the southeastern limb has been cut by the Fries fault.

Minor warps occur between Big Reed Island Creek anticline and Chimney syncline.

The large bluff on Big Reed Island Creek at Rich Hill has a minor drag fold notable for its northward inclination in a thick sequence of homoclinal, northward-dipping beds (Pl. 20). It is interpreted to have resulted from slumping prior to lithification.

Folds in the Powhatan Block

The highly folded Powhatan block can be shown, by reconstruction of the folds, to have been shortened from an original width of 4.5 miles to a present width of 3.5 miles (22 percent) along structure section E-E' and from 3.5 to 2 miles (43 percent) along section B-B', as compared to estimates of 30 to 63 percent for the entire Valley and Ridge Province of the Central Appalachians (Dennison and Woodward, 1963, p. 669, fig. 2).

Bench Mountain Anticline.--South of the trace of the Powhatan thrust the Bench Mountain anticline extends the complete length of the Powhatan block. It is well exposed in the Laurel Creek gap through Bench Mountain (Pl.21A), at Big Tan Trough Branch (Pl.21B), and on Hacks Creek above

Plate 20

Slump fold in Rome shale along Big Reed Island Creek at Rich Hill, looking toward the west. The axis of Big Reed Creek anticline lies to the south (left).

Plate 20

Plate 21

Bench Mountain anticline.

A. Axis of the anticline at Laurel Creek, looking eastward. The northern flank is vertical (base of photograph, in stream); the southern flank dips gently to the south.

B. Northern limb of the anticline above Big Tan Trough Branch, looking westward. The limb, which dips steeply to the north, has been folded to form a structural terrace (lower center). See Figure 10. Flinchum Mountain is in the distance.

Plate 21

A

B

Camp Powhatan, and on Little Macks Creek and the ridges to the southwest.

The anticline has little plunge in the center of the area but plunges outward 10 to 15 degrees at each end. The northern flank of the anticline is locally flexed, as at Laurel Creek and Big Tan Trough Branch (Pl. 21B; Fig. 10). A sharp bend in the axial plane occurs just east of Macks Creek.

Rock Creek Syncline.-- South of Bench Mountain anticline is the Rock Creek syncline, which also extends the length of the Powhatan block. The axial portion is exposed along Rock Creek and at Laurel Creek.

Southwest of High Point the axis plunges gradually toward the southwest, but elsewhere plunge is not signifcant. A minor structural depression is located at Laurel Creek.

Macks Mountain Anticline.-- The Macks Mountain Anticline is the southeasternmost of the major folds. It is continuous over a greater distance than the other folds, and extends from Ore Knob to DeHart Mountain. The axial trace lies just northeast of Macks Mountain and along the crest of Line Ridge. The fold is exposed on the southwestern nose of Line Ridge, just above Laurel Creek, and along Big Reed Island Creek in the Ore Knob area. The southeastern limb crops out along the crest of Macks Mountain.

The plunge of the southwestern nose of the fold is steep (about 40 degrees) at Ore Knob. A slight structural

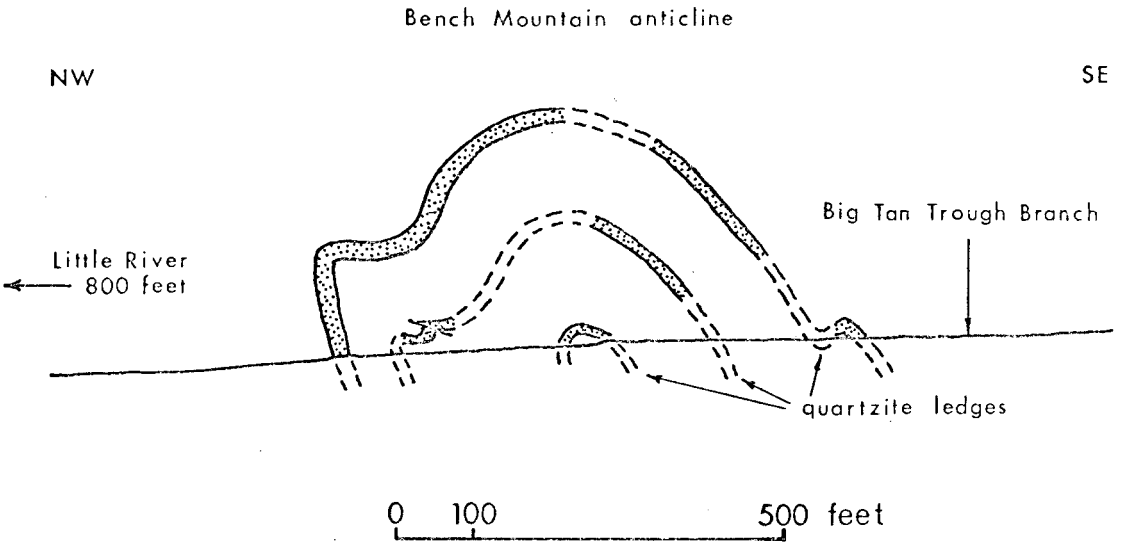


Figure 10.— Sketch of Folds along Big Tan Trough Branch

depression occurs at Laurel Creek. The anticline plunges sharply to the north at DeHart Mountain where it is complicated by tear faults.

Minor Folds.-- A number of smaller folds complicate the major structures. These folds appear to be flexures on the limbs of the major folds. Most persist for distances of less than two to three miles. Several of these are noteworthy. A tight anticline occurs on the northwestern limb of the Rock Creek syncline at its southwestern end. Northwest of this anticlinal fold, an open syncline is exposed on Dead Pine Mountain. Farther to the north, an east-west trending anticline is well exposed where it crosses Bark Camp Branch and Cove Branch. These appear to constitute a series of "wrinkles" of the common limb between Rock Creek Syncline and Bench Mountain anticline. Another anticline is exposed in the same structural position on Laurel Creek but it may not be continuous with those to the southwest.

Mechanism of Folding

Folds of two types may be recognized in the Macks Mountain area: 1) large-scale folds in which flexure (bedding plane slip) is dominant, and 2) small-scale folds formed by flow or shear, which may be called "drag folds" to indicate their formation by passive (without significant transmission of stress) response to the movement of

competent units. Whitten (1966, p. 151) has called such relatively minor structures "parasitic folds".

Folds of the two types are not everywhere distinct. The reaction of beds to deformational stresses is mainly controlled by competence, in turn a function of lithology. Generally, quartzites within the area responded by flexure whereas shales responded by flow and shear. Locally, however, quartzites have a draglike geometry (Pl. 21B, Fig.10), and incompetent units, such as siltstone, have folded by flexure.

Currie and others (1962) showed by field and laboratory analyses that the response of a rock sequence to deformation is significantly determined by the competence and arrangement of its members. They define "structural lithic units" (ibid., p. 670) as segments of the stratigraphic column having characteristic reactions to deformation. The Erwin Formation is a structural lithic unit in which the massive quartzite beds are "dominant members" that determine the structural geometry. Indeed, the development of this concept could theoretically serve as a basis for subdividing the Chilhowee Group where conventional stratigraphic data are insufficient. The difference in style of deformation between the Powhatan block and the Pilot Mountain-Fishers View block to the northeast (Dietrich, 1954) may reflect different structural lithic units more than a different relationship to the deformational forces.

The relationship of specific geometry of structures to deforming forces cannot be discounted altogether, however, as shown by drag folds in the "dominant" quartzite which were apparently caused by a strong force couple associated with thrusting (Fig. 10).

Response of the incompetent members of the stratigraphic sequence to deformational forces includes shear (slippage along closely spaced fractures, such as axial plane cleavage, called secondary S-surfaces), flexure (slippage along bedding planes, called primary S-surfaces), and flow (distortion unrelated to S-surfaces). Response of competent units, the "dominant members", is of greater interest because of their role in determining fold geometry. The competent units, thick massive quartzites, are locally sharply folded. The deformation is commonly devoid of macroscopic fractures and is an example of what is called uniform or solid flow (Badgely, 1965, p. 25). A possible mechanism was recrystallization of the quartz grains by Riecke's principle, and the pressure solution effects (described in this report in the section on the petrology of the quartzites) may have been intensified during the folding phase. The beds may thus be tectonites (having fabric developed by componental movement associated with deformation). Bedding plane slip was probably important in the thicker, competent units, and was possibly accomplished by brecciation roughly parallel to bedding where shaly

interbeds were lacking. Some flow may have been cataclastic, but such textures are apparently not common in this area. The numerous inclusion trails resembling Boehm lamellae may indicate a formerly more pervasive cataclasis which has partially "healed". Fellows (1943, p. 1411-1420) has described similar textures in quartzites from Pennsylvania, and used the term "annealing crystallization" for the process.

Extensive thin section comparison of the flanks and axes might indicate whether or not the Riecke mechanism was responsible for the flow. Presumably more solution would have taken place on the flanks and more redeposition at the axes; the flanks might then be more sutured, with more overgrowths and less suturing at the axes. This was the case in the present limited survey of thin sections, but the sampling was insufficient for conclusions.

Joints strike generally parallel to fold axes in the area and suggest greatest stress approximately horizontal and normal to fold axes, with least stress vertical.

Faults

Woodward (1932, p. 80) gave the name "Blue Ridge overthrust" to "a great thrust fault" along which Precambrian crystalline rocks or Chilhowee beds are separated from younger Paleozoic rocks near Roanoke; he stated that it "extends across the state". The term has been widely used

for thrust faults (and occasionally normal bedding contacts) in the stratigraphic position mentioned by Woodward (e.g. Butts, 1940, p. 440-443). The thrust zone, located along the northwestern foot of the Blue Ridge Mountains, is regarded by some as approximately the boundary between the Valley and Ridge and Blue Ridge physiographic provinces. The complexity of thrusting along the northwestern margin of the Blue Ridge province in much of southwestern Virginia renders the term ambiguous, and it is seldom applied southwest of Hiwassee except in a very general sense. In the Macks Mountain area, five distinct faults occupy to some extent the structural position of the Blue Ridge thrust: the Hiwassee and Powhatan thrusts, the Pilot Mountain-Fishers View thrust of Dietrich (1954, p. 20-21), and the Laswell and Dry Pond Mountain faults of Currier (1935, p. 52, 54) (See Fig. 8). The term Blue Ridge thrust is thus not appropriate in the Macks Mountain area for any single thrust, but "Blue Ridge faults" may be used as a general term for them all.

Hiwassee thrust.-- The Hiwassee thrust carried Chilhowee rocks over the Rome Formation of the Pulaski (Max Meadows) block (see structure sections A-A' through F-F', Pl. 2). The fault is well exposed on Macks Creek at Radford Furnace, where it has a southeastward dip of about 30 degrees. To the southwest, the trace of the fault, with a number of abandoned iron-ore pits along it, passes over Stony Mountain to Hiwassee, where it crosses Claytor

Lake. It is offset by the Delton cross fault (see below), and apparently dies out in the vicinity of Allisonia.

To the east of Macks Creek the thrust trends along the foot of First Mountain, wraps around the nose and continues along the northern flank of High Knoll Mountain to the western end of Flinchum Mountain, where other abandoned iron-ore pits are located, and sweeps around the northern and eastern sides of the mountain and passes under the Powhatan thrust at Little River. The thrust appears to flatten with distance northeastward from Macks Creek; this is indicated by the pronounced effect of topography on the trace of the fault. Minimum horizontal displacement along the fault at the northeastern end of the area is on the order of two miles, the length of the reentrant along the Little River. Displacement decreases markedly to the southwest, and a pivot point may be located near Allisonia.

Butts' (1933) reconnaissance map indicates the Hiwassee fault is continuous with the Laswell and Pilot Mountain-Fishers View faults; however, it may not be continuous with either. The Laswell fault does not appear to extend eastward from Reed Junction, inasmuch as northwest-trending Rome beds appear to be continuous across the New River between Reed Junction and Allisonia. The trace of the Laswell fault probably turns southward somewhere west of Reed Junction and disappears beneath the Dry Pond Mountain block. The trace of the Hiwassee thrust could not be found

west of the Delton cross fault, but it may follow the bed of Claytor Lake and disappear in the vicinity of Allisonia. Field evidence suggests such a fault at least to Allisonia, but its continuation beyond cannot be shown. At the northeastern end the Hiwassee fault is believed to be overridden by the Powhatan block, rather than continuous with the Pilot Mountain-Fishers View fault, because of dissimilarity of trend, inclination, and hanging wall rocks.

Powhatan thrust.-- Highly folded Erwin beds have been carried over the Hiwassee (and locally Pulaski) block along the Powhatan thrust. The thrust is exposed along Laurel Creek and at Little River, where Erwin is thrust over Shady and Rome, but its presence elsewhere is inferred from structural relations. As indicated on the geologic map and structure sections (Pl. 1 and 2), quartzite ledge-makers of the Chilhowee Group are nearly vertical at Macks Creek above Camp Powhatan where they form the northwestern limb of the asymmetrical Bench Mountain anticline. Northwest of these exposures, argillaceous shales form outcrops at the camp; these shales, forming a quartzite-free outcrop belt nearly half a mile wide, are thought to belong to the Hampton Formation. Certain of the ledge-makers on the southeast flank of the breached anticline do not appear on the northwest flank. Their absence is probably due to faulting. Northeastward from Macks Creek the lower Chilhowee plunges out and probable Hampton equivalent is

thrust over Hampton. Evidence that the fault continues through this area is the truncation of Shady beds along Laurel Creek.

The Powhatan fault does not appear to be exposed beyond the Macks Mountain area. Southwest of Camp Powhatan the trace of the fault turns toward the south and seems to merge with the Delton cross fault; possibly it assumes the aspect of a tear fault, or its trace has been concealed by the upthrown block to the west. To the northeast, the junction of Indian Creek and Little River, the fault trace passes under the Pilot Knob-Fishers View fault.

The dip of the fault plane is not known, but it is probably a low angle. Minimum displacement along the thrust is probably about a mile.

Pilot Mountain-Fishers View Fault.-- The eastern end of the Powhatan block has been overridden by the Pilot Mountain-Fishers View fault, mapped and named by Dietrich (1954, p. 20, map). The fault is well exposed along Little River and to the northeast, where Chilhowee rocks identified by Dietrich (ibid. map) as Hampton are thrust upon Rome dolomite. The block, which occupies a position between the Pulaski and Fries blocks analogous to the Hiwassee-Powhatan blocks, was interpreted by Dietrich (ibid. map, structure section A-A') to be an isoclinal anticline overturned to the northwest. Here again, in the vicinity of Copper Valley, Hampton beds are thrust upon probable

Hampton equivalents. The presence of the fault southwest of Indian Creek is surmised from structural trends.

Cross Faults.-- A prominent cross fault, herein named Delton fault, cuts across the western end of the Hiwassee block. The fault is revealed by drag effects and repetition of beds in Shady Dolomite along the railroad track about half a mile northeast of Allisonia, but the nature of the faulting becomes apparent only by mapping. The fault appears to extend northwestward through Delton and trends toward an apparent offset of the Max Meadows fault; to the south it seems to merge with (or overlap) the Powhatan thrust. The fault surface appears to dip steeply toward the west; in this case, the cross fault is actually a high-angle reverse fault. The length of the fault may be on the order of six or seven miles, compared to four miles for the Ivanhoe cross fault in the Laswell block to the southwest (Currier, 1935).

Lesser cross faults are indicated by repeated offsetting of the quartzite ledges chiefly in the eastern part of the area and less commonly elsewhere. The apparent movement of all of these faults is dextral strike-slip, trending more or less northwardly; displacement ranges from a few to several hundred feet. These faults lie directly in front of the trace of the Fries fault or of the Pilot Mountain-Fishers View thrust. The offsets are in the wrong sense to suggest a conjugate shear system;

it is suggested, therefore, that they represent rotation of the competent quartzite beds in response to drag along the thrust faults. The quartzites responded by brittle type failure rather than by shearing as in the shales. The tear faults thus formed may be thought of as "drag faults" and may indicate generally the direction of movement of the thrust block that produced them. Alternatively, dip-slip movement may have predominated, with the east sides of the faults upthrown.

Fall Branch Fault Slice

At Big Reed Island Creek, between Ore Knob and Fall Branch, a fault slice along the Fries fault has exposed quartzites, shales and conglomerates, which are mapped as lower Chilhowee. These beds resemble outcrops of pre-Erwin rocks along the Little River in the Pilot Mountain-Fishers View block. The beds dip toward the southeast, and poorly preserved crossbedding and well-defined scour-and-fill indicate them to be overturned. Cleavage and prominent drag folds (Pl. 22) support this conclusion.

The fault is in evidence south of Ore Knob, where it cuts off a thin slice of Shady dolomite. Its presence to the northeast is less certain.

Plate 22

Drag Folds in siltstone at Fall Branch, looking toward the northeast.

A. Along Road 764 just eat of Fall Branch.

B. In ledges above Road 764 just west of Fall Branch.

Plate 22

A

B

Laswell-Dry Pond Mountain Blocks

The Laswell and Dry Pond Mountain thrusts (Fig. 8) were named and first mapped in detail by Currier (1935). Stose and Stose (1957) later remapped the area and redefined the Dry Pond Mountain thrust as the Poplar Camp thrust. The thrust blocks lie southwest of Big Reed Island Creek Valley in a belt between the Fries fault and the Pulaski block and are structurally analogous to the Hiwassee and Powhatan blocks. The Laswell block adjacent to the Macks Mountain area contains Shady Dolomite, thrust over Rome shales, and the Dry Pond Mountain block consists of the Erwin Formation in a broad, north-trending anticline. Neither block was examined in more than reconnaissance for the present study, but the Dry Pond Mountain thrust was mapped where it passes through the Macks Mountain Quadrangle.

Big Reed Island Reentrant

Big Reed Island Creek Valley, composed of northwestward-trending beds ranging from Erwin through Rome, constitutes a structural reentrant between the Hiwassee and Powhatan blocks and the overriding Laswell and Dry Pond Mountain blocks. The reentrant coincides with the northeastern margin of a structural recess and depression in the Hiwassee and Powhatan blocks, with the southwestern portion covered by the Laswell and Dry Pond Mountain blocks.

The Fries fault in the Macks Mountain area is continuous with that of Stose and Stose (1957) in the adjacent area to the southwest and with that of Dietrich (1954, 1959) in the adjacent area to the northeast. The dip of the fault could not be determined, but the fault trace in this and adjacent areas cited above suggests a high-angle thrust. South of Elk Creek in Grayson County, Precambrian rocks of the "injection complex" (Stose and Stose, 1957, p. 21) are overridden by this fault block; from Elk Point northeast to Roanoke County, a distance of some 60 miles, Chilhowee beds form the footwall except near Tices Mill in Montgomery County and along Big Reed Island Creek at the southeast end of Macks Mountain, where the metamorphic rocks are thrust over Rome and Shady rocks (Fig. 8). This relationship was reported by Stose and Stose (1957, p. 172) but not by Butts (1933).

The Fries fault is characterized by cross-cutting relationships with younger beds at the south end of the Reed Island reentrant and by the sporadic presence of gossan-type material throughout its length. Precise location of the fault near Copper Valley is very difficult; it is probably represented by a shear zone.

A cross fault offsets the Fries fault in Rustin Hollow, southwest of Ore Knob. The offset suggests that the western block is downthrown, in opposite sense to the Allisonia and Delton cross faults.

Fries Block

The Fries fault was named by Jonas and Stose (1939) to designate a major thrust along which crystalline rocks of the Blue Ridge have been placed over Lower Cambrian and older rocks in southwestern Virginia. In the Macks Mountain area, Blue Ridge crystalline rocks are thrust over the Hiwassee and Powhatan blocks, and the adjacent Pilot Mountain-Fishers View and Dry Pond Mountain blocks.

The structure of the Fries block adjacent to the Macks Mountain area is not known. Dietrich (1959, p. 103) suggested that an isoclinal, eastward-plunging syncline is located in the Alum Phyllite of the hanging wall. Stose and Stose (1957, p. 169, Pl. 1) reported the block to be composed of mylonite in a zone about one mile wide, bordered on the southeast by the Gossan Lead fault. The overall structure of the Precambrian rocks southeast of the Fries fault is apparently a large anticlinorium, representing a welt or uplift of the basement in this belt (King, 1959, p. 47; 1964, p. 17-18; Cooper, 1961, p. 114).

The hanging wall rocks have apparently experienced retrograde metamorphism in the Big Reed Island Creek reentrant (see p. 20) but the dolomites of the Footwall appear to be unmodified.

Structural Synthesis

Pulaski Block

As previously noted, the Pulaski thrust sheet represents an unrooted allochthonous mass preserved as a synclinorium in a large salient north of the Macks Mountain area. Cooper (1961, p. 114-116) postulated gravity sliding as a mechanism for emplacement of large overthrust blocks in the Valley and Ridge province, and Lowry (1964) later proposed such an origin for the Pulaski block. Lowry (ibid.) suggested that the Pulaski fault, rooted in Rome and Elbrook, is related to the Blue Ridge thrust and that the Pulaski block broke away above the Rome and rode northwestward, leaving the Rome to be overridden by the Blue Ridge block.

The Pulaski fault surface is warped up over the Draper Mountain anticline, probably as a result of post-faulting folding (Cooper, 1939, p. 66, Pl. 10). Farther to the northwest the Pulaski block is downfolded into a "syncline of deposition", the Blacksburg synclinorium (Cooper, 1964, p. 103-104).

The Max Meadows thrust probably represents later movement of the trailing edge of the Pulaski block after the leading edge became impeded. The trailing margin is believed to have broken loose by development of a new fault (the Max Meadows thrust), which extended upward through the Rome from the original Pulaski fault surface; the Max Meadows block, with a sole of Rome beds, rode up

over the main Pulaski mass. It then seems reasonable for the Tinytown fault to represent a similar action which occurred when the Max Meadows thrust encountered the obstacle of the Draper Mountain anticline.

Another effect of the Draper Mountain anticline as a buttress may be represented by the Delton cross fault. A scissors-like tearing or flexing of the Max Meadows block may have taken place as it ramped up over the anticline.

Several problems of fundamental significance are presented by the Pulaski thrust block. First, as noted by Lowry (1964), is the absence of Rome (as well as older) beds along the leading edge of the Pulaski fault through much of its length and the prevalance of Rome as the overridden unit along the trace of the "Blue Ridge" faults. A further complication is illustrated in Figure 9, which indicates the pattern of the axial traces of minor folds in the Rome belt of the Max Meadows block. If the Rome formation were restored to pre-deformation horizontality, it would overlap along the Delton fault, a circumstance that suggests convergence of the belt along the break.

The stratigraphic position of the Pulaski and Blue Ridge faults has been discussed by Lowry (1964). He suggested that the original thrust, soled in the Rome, broke through to a higher stratigraphic position, and Elbrook or younger beds continued forward relative to the Rome. This process removed Rome from much of the leading

edge of the Pulaski block and exposed it at the trailing edge where later thrusting brought Chilhowee and older beds of the Blue Ridge block over it.

This hypothesis focuses on an essential problem: the general absence of post-Rome beds beneath the Blue Ridge thrust. Elsewhere in the Valley and Ridge province the soles of thrusts generally maintain a rather regular stratigraphic position, but overridden beds have a wider range in age and generally include Mississippian strata. This circumstance follows from the nature of Appalachian thrusting in which blocks consisting of thick Paleozoic successions were shoved northwestward over similar successions of beds, with the fault surface resolved along a stratigraphically low incompetent unit such as the Rome. Beds younger than Rome are overridden where the faults cut pre-existing local structures such as the Draper Mountain anticline.

The consistent presence of the Rome as the overridden unit along the "Blue Ridge" fault (which includes the Hiwassee, Powhatan, and other thrusts in the Macks Mountain area) suggests that either 1) post-Rome beds had been removed prior to thrusting, as by the mechanism proposed by Lowry, 2) post-Rome beds were forcibly removed by "bulldozing" during thrusting, or 3) stratigraphically lower units are exposed because of uplift along a belt nearer the root zone.

The post-Rome beds exposed in the Draper Mountain area constitute an aggregate thickness of about 10,000 feet (Cooper, 1939, Pl. 3), and would seem to represent a considerable impediment to "bulldozing". Possibly the succession was much thinner over the Rome belt of the Max Meadows block, which originally lay many miles to the southeast. Cooper (1964, fig. 19, p. 105) gave a restored cross section of the Blacksburg synclinorium in which Rome beds are exposed on the elevated southeast limb just prior to inception of the Pulaski thrust. If this is the case along the southeastern side of the Appalachian geosyncline, the presence of Rome under the Blue Ridge thrust is easily comprehensible.

The origin of the drag folds in the Rome has been questioned recently by Chen (1960). In the Roanoke area Woodward (1932, p. 79) suggested an origin due to drag effects of the overriding Blue Ridge thrust mass. He noted a greater parallelism between axial traces of the drag folds and the fault as the fault is approached. Chen (ibid., p. 82-83), however, found a lack of the asymmetry that would be expected for such an origin, and suggested somewhat vaguely that the folds were formed by compressive forces (resolved in various directions) ultimately responsible for thrusting. In the Macks Mountain area a fairly consistent but not marked asymmetry suggests a force couple with the upper stresses directed toward the north or north-

west. These stresses may have been transmitted through the Tinytown fault slice inasmuch as intensity of folding is apparently uniform across the Max Meadows block. The Tinytown fault is a very low-dipping thrust, whereas projections of the Hiwassee and Laswell thrusts would place those fault surfaces several thousand feet above the northwestern margin of the Max Meadows block.

Origin of the stress is not entirely clear, but it seems likely that it stemmed from overriding effects. Possibly it resulted from differential movement associated with large scale folding after faulting, specifically the development of the Draper Mountain anticline in the overthrust blocks. The overriding mechanism could be directly related either to Tinytown thrusting or to Hiwassee and Laswell thrusting. In the latter case, drag effects were transmitted through the Tinytown slice. The writer favors an overriding mechanism because of the apparent convergence within the Max Meadows block along the Delton cross fault as explained below.

The structure of the Pulaski block appears to be related to the overriding thrust blocks, which are considered next.

Hiwassee and Powhatan Blocks

The Hiwassee and Powhatan blocks represent a domal warping along the southeastern margin of the Appalachian

miogeosyncline. The structure is indicated by the outward plunges of folds and by the presence of progressively younger beds toward the margins of the blocks. The Big Reed Island anticline is possibly the western nose of the dome. The previously described slump fold on this nose at Rich Hill bluff suggests that the domal uplift may have begun as early as latest Early Cambrian time. Evidence has been reported from elsewhere in the Appalachians indicating early Paleozoic folding of Appalachian sedimentary strata (Kellberg and Grant, 1956; Lowry, 1957; Webb and Cooper, 1963; Cooper, 1965).

The Hiwassee-Powhatan dome has been highly deformed. Close folding in the Erwin Formation suggests strong lateral compression, probably under a high degree of confining stress to limit rupture. The deformational stress was probably tangential and directed northwestwardly because of the decrease in folding intensity in that direction. Transection of fold axes by fault surfaces indicates thrusting began later than folding.

The Laswell and Dry Pond Mountain thrusts, at the southwestern end of the area, are probably temporally related to the Hiwassee and Powhatan faults, but no direct connections are evident. The Laswell block has apparently overridden the southwestern margin of the Big Reed Island reentrant block west of Reed Junction, and the Dry Pond Mountain block has overridden both the Laswell block and Big Reed Island reentrant.

The Big Reed Island reentrant represents a structurally deprssed area, probably a part of the Hiwassee block which has been overridden by the blocks on the southwest.

The Pilot Mountain-Fishers View block has overridden the Powhatan block at the northeastern end of the area, along Little River. No direct relationship has been found between Pilot Mountain-Fishers View faulting and Hiwassee or Powhatan faulting. The latter probably represents an earlier faulting phase.

Fries Block

The crystalline rocks of the Blue Ridge have been called an uplifted core of basement rocks (King, 1964, p. 17). The Fries fault represents the northwestern margin of that crystalline core where it overrides the southeastern margin of the sedimentary cover. North of Roanoke the crystalline rocks have been shown to have moved many miles over the sedimentary rocks along a nearly flat thrust fault (Chen, 1960). In the Macks Mountain area the crystalline rocks appear to have moved along a higher angle thrust. In both cases the fault is rooted in Precambrian basement rocks.

The Austin Hollow fault is a cross fault cutting the Fries block, apparently an unusual occurrence. The cross fault is interpreted from the offset of the Fries fault as a normal fault with the east side downthrown, opposite in sense to the Delton cross fault to the north.

Origin of Present Structure

All of the structures described above are considered to be genetically related.

Chronological Sequence of Thrusting

Badgely (1965, p. 228) has made the assumption that vertical tectonism and resulting gravity glide are the primary mechanisms of deformation in "mobile belts" (such as the Blue Ridge axis in the Appalachians) and that gravity gliding exerts a lateral compression of the flanking portions of the geosynclinal belt. This is in agreement with the proposal by Cooper (1961, p. 114) that the upwarp of the Blue Ridge into a regional anticlinorium generated unilateral compressive force that served to localize thrusts in the adjacent miogeosyncline. Gwinn (1962, p. 894) has suggested a similar origin for thin overthrust sheets in the central Appalachians. Badgley (ibid.) added that several major thrust sheets can be piled on top of one another where gravity gliding is the major mechanism.

The sequence of thrust development is of fundamental importance in understanding the genesis of deformational structures. Badgley (1965, p. 231-243) considered this question in some detail and indicated a preference for an outward sequence of fault formation, i.e. the faults decrease in age away from the deforming force. A series of imbricate "back-limb thrusts" were described, however, in which thrusts increase in age outward from the source of stress (Badgley, 1965, p. 190-191, Fig. 6-5).

If the Pulaski thrust formed earlier than thrusts to the southeast, then the entire set of thrusts could have been produced by either gravity gliding or tangential compression. If, on the other hand, the Pulaski thrust was the latest to form and the imbricated Pulaski and "Blue Ridge" blocks moved as a unit, it seems unlikely that the earlier faults could have been gravitational, unless movement along the "Blue Ridge" faults continued after movement of the Pulaski block . "Bulldozing" or off-gliding of the post-Rome beds, suggested as mechanisms to account for the presence of Rome as the footwall of the "Blue Ridge" thrusts, seems to require movement of these thrusts later than at least some movement along the Pulaski thrust.

The evidence in the Macks Mountain area suggests a chronological order of thrusting from the Pulaski fault southeastward. First, the Hiwassee, Powhatan, and other "Blue Ridge" type faults are each transected by thrust blocks from the southeast. Second, the Tinytown fault slice is cut off on the east by the Hiwassee fault; the slice has been interpreted as a smaller version of the Max Meadows block. By analogy, the Hiwassee fault followed Max Meadows thrusting. The Pulaski fault seems to be older than the Max Meadows fault in that it appears to be uncut by the Dolton cross fault - perhaps an indication that the Draper Mountain anticline was not yet large enough

to affect significantly overriding rocks. Hergenroder (1957, p. 39-40) found, moreover, that two of the high angle faults cutting the Pulaski block in the Radford area, just to the north, have been overridden by the Max Meadows thrust sheet. As implied in the preceding paragraph, this chronological order is based on the latest movement of the blocks. There is no evidence to indicate that the Fries block, for example, apparently the last block to move, was not also the first.

The absolute age of thrusting cannot be stated with certainty, but recent K-Ar and Sr-Rb dating has indicated that the Pilot Mountain-Fishers View thrust and the Fries thrust near Copper Valley are no older than 330-355 m.y., or middle Paleozoic (Dietrich et al., 1967).

Evidence for Convergence

No evidence was found in the Macks Mountain area to bear on the problem of whether the post-Rome beds of the Pulaski block advanced beyond the Rome of the Max Meadows block as suggested by Lowry (1964), or whether they were missing because of nondeposition, erosion, or bulldozing. In any case, post-Rome beds were seemingly absent during thrusting of the older, pre-Rome Shady and

Chilhowee beds over the Rome of the Max Meadows block. As previously discussed, the pervasive drag-folding of the Rome in the Max Meadows block was possibly produced by passive response to overriding blocks. Assuming that drag folds in the Rome were produced by the drag effect of ovverriding blocks, the axial trace pattern of the drag folds (Fig. 9) indicates, as previously suggested, convergence of the Rome along the Delton cross fault. The bending of the axes of the drags was possibly imposed by convergent movement of the overriding blocks, perhaps along the directions indicated by arrows on Figure 9. Parallel movement of the blocks would not appear as a likely cause for such a pattern.

The problem of "too much Rome" mentioned previously also argues for convergence: reconstruction of the Rome belts to their original horizontality would result in overlap along the Delton cross fault.

Big Reed Island Reentrant

The convergence of thrust blocks in the Allisonia-Delton area appears to be related to the Big Reed Island reentrant. The structure is interpreted as the eastern part of a recess and the depression of the southwestern nose of the Macks Mountain anticlinorium. The Laswell and Dry Pond Mountain blocks appear to have overridden the western part of the recess, probably as a result of convergent movement with the Kiwassee and Powhatan blocks.

An inference that may be drawn from this analysis is that the Laswell and Hiwassee thrusts may originally have been continuous, with the continuity obscured by subsequent cross faulting along which the Laswell block overlapped the Hiwassee block. The easternmost end of the Laswell fault, which swings toward the south near Reed Junction, is a part of this reverse movement that constitutes the cross fault. It then becomes likely that the Chimney syncline represents a northeastern extension of the Galena basin of the Laswell block, as described by Currier (1935, p. 46).

The structure of the Big Reed Island reentrant can be explained by the mechanism of fault block convergence. The northwest trending beds on the nose of the anticlinorium could have been preserved and the high-angle reverse fault (structure section G-G') could have been produced by such convergence. The Dry Pond Mountain thrust along the western side of the reentrant indicates convergence of that block also on the Hiwassee block.

A more problematic question concerns the reason for block convergence. The original break along the Delton cross fault has been ascribed to ramping of the Max Meadows sheet over the Draper Mountain anticline. The relatively high angle of the Laswell and Hiwassee thrusts may also be related to a buttress effect of the anticline. Bauerlein (1966, p. 51) has shown that modification of an overriding block is a natural consequence of thrusting and may account

for certain complex structures in the thrust-faulted Appalachians. Nevertheless, subsequent convergence along the Delton cross fault and in the Big Reed Island reentrant does not appear to be related to surface structures. Instead, the basement is believed to have exercised a significant control of deformation in the sedimentary succession.

Pilot Mountain Anticline

Dietrich (1954, p. 24) interpreted the Chilhowee rocks in the Pilot Mountain-Fishers View block as an anticline overturned to the northwest. The Fall Branch fault slice, suggested herein to be an isolated remnant of the Pilot Mountain-Fishers View block, consists of beds overturned to the northwest, and may thus be a fragment of the northwestern limb of the Pilot Mountain anticline. Both the major block and the fault slice are overridden by the Fries fault.

Fries Block

The crystalline rocks of the Blue Ridge, considered herein (on the basis of investigations by other workers) to be an uplifted core of basement rocks, has apparently supplied the tangential compressive stress evidenced by the close folding in the Powhatan and Hiwassee blocks. Structures in the Fries Block are not well understood. Dietrich (1959) has mapped in reconnaissance a few synclines

and anticlines south of the Pilot Mountain-Fishers View block; probably the overall structure is anticlinorial.

Summary: Nature and Chronology of Deformation

The evidence and interpretations given previously may now be integrated into an overall view.

The earliest tectonic movement in the Macks Mountain area for which there is any evidence took place by latest Early Cambrian time, if the slump fold at Rich Hill is a result of tilting. This necessarily resulted from basement movement, inasmuch as the sedimentary cover was then thin and probably incompetent. This incipient deformation possibly marked the origin of the doming later to become the Macks Mountain anticlinorium.

The Blacksburg synclinorium to the northwest had an Ordovician inception, probably in response to vertical movements of the basement (Cooper, 1964, p. 107). The Draper Mountain anticline possibly began forming not long after, inasmuch as it appears to have been a factor in Max Meadows thrusting. All of these early folds would seem to require basement control if the time of their origin is correctly assessed.

Among the earliest deformation features with strong horizontal components are the Pulaski and Max Meadows thrusts. These faults almost certainly owed their formation to the rising Blue Ridge anticlinorium; it is not clear,

however, whether they were impelled by gravity or by tangential compression produced by gravitational flattening of the rising mass. In either case, the Pulaski block overrode the Blacksburg synclinorium in Mississippian time, and folding of the Pulaski thrust surface indicates that deformation of the Valley and Ridge province continued to be active after the thrusting. The fault may have formed low in the Rome formation and broken upward into Elbrook or higher strata at the forward edge. The Pulaski block eventually became impeded by some buttress, and the fault broke upward through the Rome at the trailing edge, bringing Rome over Elbrook. This suggests that Elbrook may have been uncovered in this area (the southeastern margin of the Pulaski block), but no evidence is known to support this idea.

The Max Meadows thrust was broken along the Delton cross fault either during thrusting, as part of the block ramped up over the Draper Mountain anticline, or (less likely) during subsequent folding of the block.

Convergence of the succeeding fault blocks in the Allisonia area is probably related to the structurally low position of the Big Reed Island reentrant. This low must represent a depression in the basement, possibly extending some distance to the south, so that tangential compression felt elsewhere as a result of uplifted crystalline rocks was not so highly developed in this area.

Blocks adjacent to this low would likely have moved laterally somewhat to fill this potential gap thus placing a lateral (northeast-southwest) compression on the area.

The later thrust blocks, containing chiefly Chilhowee rocks, were folded prior to thrusting. These "Blue Ridge" thrusts brought the Lower Cambrian clastics and Precambrian crystalline rocks northwestward over a Rome belt which was quite possibly exposed by erosion at the time. These blocks are overlapped in a series of thin decken.

Farther to the north in the Poor Mountain area (Dietrich, 1954) and in the Goose Creek area (Chen, 1960) the older rocks may represent immense nappe-like structures with crystalline cores. In the Macks Mountain area the core appears to have broken through the clastic beds, along the Fries fault, and to have overridden the clastics and locally younger units. The Macks Mountain anticlinorium appears to have been pushed ahead of this mobilized core, causing the original domal structure to crumple into folds, and to break loose from underlying beds and move toward the northwest. In the Big Reed Island reentrant, the structurally low sedimentary units were overridden along stratigraphically higher beds, and although possibly detached from the root zone, were probably not moved as far forward as adjacent beds. The potential gap thus created in front of the advancing crystalline core was partially filled by convergence of adjacent sedimentary blocks.

It is possible, as Lowry (1964) suggests, that the Pulaski fault is essentially the same as the "Blue Ridge" faults. The original break, rooted in elevated basement rocks, would have broken upward stratigraphically as it extended westward toward the geosynclinal area. The entire mass would probably have moved toward the northwest until the leading edge became impeded, whereupon the fault would have broken upward along some zone of weakness to the rear and overlap, shingle-like, the leading portion.

Folding of the major Valley and Ridge structures, apparently in response to a different set of stress conditions than that which caused the thrusting, continued for some time after thrusting ceased. The stresses that resulted in thrusting were resolved largely into horizontal components, whereas the longer-acting stresses, which caused formation of the major Appalachian folds and the folding of thrust surfaces, appear to have been mainly vertical. The Rustin Hollow fault probably developed in this post-thrusting phase of continued deformation, possibly in response to further subsidence of the Big Reed Island Reentrant.

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APPENDIX

Geologic Sections

See Columnar Sections, Figure 6

Section 1. - Along road 692 and Spencer Branch, Hiwassee, near axis of Chimney syncline.

Erwin Formation:

	Transition beds:	feet
51.	Sandstone, friable, porous; glauconitic; .....estimated	30
	Middle member:	
50.	Covered.....estimated	250
49.	Quartzite, gray, thin-bedded, fine-grained; interbedded shale.....	100
48.	Covered.....	5
47.	Quartzite, gray, thin-bedded, fine-grained; shaly partings.....	16
46.	Quartzite, gray, thick-bedded, coarse-grained	2
45.	Quartzite, gray, thin-bedded, fine-grained...	9
44.	Quartzite, light-gray, thin-bedded.....	6
43.	Quartzite, gray, thin-bedded, fine-grained; shaly partings.....	16
42.	Covered.....	32
41.	Quartzite, buff-gray, very coarse-grained; vitreous.....	2
40.	Quartzite, light-gray, thin-bedded.....	8
39.	Covered.....	3
38.	Quartzite, light-gray, massive, coarse-grained; ledge maker.....	9
37.	Shale, dark-gray, and coarse-grained quartzite lenses up to 1 ft thick, 10 ft wide.....	12
36.	Quartzite, gray, massive, coarse-grained.....	3
35.	Shale, bluish-gray, micaceous; non persistent.	1/2
34.	Quartzite, light-gray, thick-bedded, coarse-grained.....	2
33.	Quartzite, buff, thin-bedded, coarse-grained; interbedded shale; shaly partings.....	6
32.	Shale, dark-gray, and thin beds of quartzite..	3
31.	Quartzite, buff, thin-bedded, coarse-grained; interbedded shale, shale partings.....	12
30.	Quartzite, gray, shaly partings.....	4
29.	Quartzite, gray, massive.....	4
28.	Quartzite, gray, shaly partings at top.....	6

		feet
27.	Covered.....	5
26.	Quartzite, gray, laminated, shaly partings; blocky weathering.....	6
25.	Siltstone, gray, irregular bedding.....	2
24.	Covered.....	11
23.	Quartzite, gray, massive; scour-and-fill; ledge maker.....	8
22.	Quartzite, gray, massive, coarse-grained; pinches down toward northeast.....	5
21.	Quartzite, gray, massive, coarse-grained; shaly partings; blocky weathering.....	12
20.	Covered.....	3
19.	Siltstone, gray; shaly partings.....	6
18.	Covered.....	2
17.	Siltstone, gray, and shale.....	47
16.	Quartzite, gray, massive, variable thickness; shale lenses.....	5
15.	Shale, dark-gray, micaceous, and buff, thin-bedded quartzite; platy weathering.....	7
14.	Shale, irregular bedding; platy weathering..	15
13.	Quartzite, gray, laminated, pinches out to northeast.....	2
12.	Quartzite, gray; convolute lamination; shaly partings.....	16
11.	Quartzite, gray, laminated.....	1
10.	Quartzite, gray, no bedding.....	1
9.	Shale, dark-gray, micaceous and buff, thin-bedded, fine-grained quartzite, platy weathering.....	5
8.	Shale, irregular bedding; platy weathering..	9
7.	Quartzite, gray, cross-bedded; variable-thickness.....	2
6.	Shale, irregular bedding; platy-weathering..	9
5.	Covered.....	4
4.	Shale, dark gray, micaceous, and buff, thin-bedded, fine-grained quartzite; platy weathering near top.....	28

Massive Quartzite Member:

3.	Quartzite, buff, massive, coarse-grained vitreous.....	3
2.	Shale, gray, mealy; highly weathered.....	1
1.	Quartzite, gray, massive, coarse-grained, vitreous; brecciated near top; non-persistent blue mealy shale, 6 inch bed, 4 feet above base.....	28
	Covered. Lower quartzite not exposed.	
	Total Erwin Formation exposed:	784

Section 2. - Along Hacks Creek, about one mile above Camp Powhatan; southeast flank of Bench Mountain anticline.

		feet
Lower Chilhowee beds, probably Unicoi:		
9.	Covered.....	
8.	Quartzite, light-gray, thick-bedded, locally cross-bedded, slightly feldspathic.....	12
7.	Covered.....about	375
6.	Quartzite, gray, massive, slightly feldspathic	45
5.	Covered.....about	90
4.	Quartzite, gray, massive, feldspathic.....	3
3.	Siltstone, gray, thin-bedded.....	8
2.	Quartzite, light gray, massive; cross-bedding, scour-and-fill.....	12
1.	Siltstone, shale, quartzite.....not measured	
	Total section measured:	545

Section 3. - Along Laurel Creek 0.5 miles from Little River, at Montgomery-Pulaski county line; west of Flinchum anticline.

		feet
Shady Dolomite:		
9.	Dolomite, gray, fine-grained; sparry blebs, disseminated sulfides; locally ribboned.....not measured	
Erwin Formation:		
	Transition beds:	
8.	Sandstone, buff, massive, coarse-grained, dolomite-cemented; much limonite stain; locally cross-bedded on weathered surface; locally overlain by 6-inch bed of non-persistent granule conglomerate.....	6
7.	Siltstone, gray, laminated.....	1
6.	Sandstone, buff, massive, coarse-grained, dolomite-cemented; a few thin, non-persistent granule conglomerate beds.....	8
5.	Siltstone, gray, thin-bedded, shaly partings; locally calcareous.....	4
4.	Sandstone, buff-gray, coarse-grained, dolomite-cemented.....	4
3.	Siltstone, gray, flaggy, glauconitic.....	3
2.	Sandstone, gray, dolomite-cemented.....	3
1.	Siltstone and shale.....not measured	
	Total Transition beds:	29

Section 4. - Along railroad tract from about 0.75 miles southeast of Hiwassee for about 1 mile.

		feet
Shady Dolomite:		
	Laminated gray dolomite:	
71.	Dolomite, dark-gray, massive, fine-grained; fault contact in covered interval above.....	28
70.	Covered.....	85
69.	Dolomite, gray; platy to shaly weathering.....	19
68.	Dolomite, gray; irregular black chert "splotches"; beds slightly deformed.....	15
67.	Dolomite, dark-gray, shaly weathering.....	4
66.	Dolomite, gray, fine-grained.....	18
65.	Dolomite, dark-gray, evenly bedded, platy weathering, and buff, fine-grained dolomite...	40
64.	Covered.....	10
63.	Dolomite, gray, well-bedded, weathers brownish gray; includes zone of black chert nodules....	22
62.	Covered.....	22
61.	Dolomite, dark-gray, fine-grained.....	79
60.	Dolomite, gray, evenly bedded, fine-grained; zone of black chert nodules and "splotches"...	79
59.	Covered.....	10
58.	Dolomite, gray, evenly bedded, fine-grained...	58
57.	Dolomite, laminated.....	19
56.	Covered.....	14
55.	Dolomite, laminated.....	37
	Upper ribboned dolomite:	
54.	Dolomite, gray, fine-grained; weathers dark gray, blocky.....	50
53.	Dolomite breccia.....	7
52.	Dolomite, gray, fine-grained; numerous calcite veins; 1 ft. bed containing small black cert blebs.....	82
	"White" crystalline dolomite:	
51.	Dolomite, pearl-gray, fine-grained.....	1
50.	Dolomite, light-buff, granular; blocky weathering.....	35
49.	Covered.....	34
48.	Dolomite, dark-gray.....	1
47.	Covered.....	7
46.	Dolomite, blocky weathering.....	30
45.	Dolomite, gray, buff-weathering.....	15

		feet
	Blue ribboned limestone:	
44.	Limestone, ribboned; shaly weathering.....	11
43.	Dolomite, gray, massive.....	16
42.	Dolomite, buff, granular, locally weak; sparry blebs.....	18
41.	Covered.....	12
40.	Limestone, blue-gray; ribboned bedding; fine-grained; irregular dolomite partings.....	40
39.	Covered.....	11
38.	Dolomite, gray; ribboned bedding; fine-grained.....	5
37.	Covered.....	10
36.	Limestone, blue-gray; ribboned bedding, fine-grained; weathers to calcareous clay.....	8
35.	Limestone, blue-gray; ribboned bedding with dolomite partings.....	16
	Lower ribboned dolomite:	
34.	Dolomite, buff and gray mottled; ribboned bedding.....	4
33.	Covered.....	31
32.	Dolomite, gray mottled with buff; ribboned bedding.....	36
31.	Dolomite, gray; ribboned bedding.....	5
30.	Dolomite, gray, sparry blebs, disseminated sphalerite.....	19
29.	Dolomite, gray, evenly bedded.....	2
28.	Dolomite, gray, massive.....	10
27.	Dolomite, gray, evenly bedded, weathers dark buffy gray.....	12
26.	Covered.....	76
25.	Dolomite, dark gray, evenly bedded, fine-grained; sparry blebs; weathers light gray..	10
24.	Covered.....	15
23.	Dolomite, dark gray, evenly bedded, fine-grained; sparry dolomite; weathers white; reddish partings.....	7
22.	Covered.....	44
21.	Dolomite, dark gray, fine-grained; ribboned bedding.....	12
20.	Covered.....	34
19.	Dolomite, dark gray, fine-grained; ribboned bedding.....	38
18.	Dolomite, light gray; ribboned bedding; weathers dark buffy gray; numerous sparry blebs; sulfides associated with calcite veins.	32

		feet
	Basal "warty" dolomite:	
17.	Dolomite, dark gray, massive, fine-grained; sparry blebs.....	14
16.	Dolomite, dark gray, massive, fine-grained;.. calcite veins with sulfide minerals.....	11
15.	Dolomite, light gray, massive, fine-grained;. calcite veins with sulfide minerals; includes 30 feet of covered interval at the base.....	46
	Total Shady dolomite exposed:	1,426
	Erwin Formation:	
	Transition beds:	
14.	Covered; friable sandstones and glauconitic quartzite exposed 500 feet to the south.....	30
	Middle Member:	
13.	Siltstone, dark gray, thin-bedded, fine-grained; with thin lenses of light-gray, coarse-grained quartzite; includes 30 feet of covered interval at the top.....	158
12.	Quartzite, gray, thin-bedded, fine-grained, with interbedded dark gray siltstone and shale near the top.....	42
11.	Covered.....	32
10.	Quartzite, gray, laminated, fine-grained, with interbedded dark gray siltstone and coarse-grained quartzite lenses.....	150
9.	Covered.....	58
8.	Siltstone, laminated.....	5
7.	Quartzite, dark gray, with interbedded thin-bedded siltstone.....	92
6.	Covered.....	54
	Massive Quartzite Member:	
5.	Quartzite, light-gray, massive, coarse-grained, vitreous.....	35
4.	Sandstone, fine-grained, arkosic, mealy.....	1
3.	Quartzite, light-gray, coarse-grained.....	2
2.	Sandstone, thin-bedded, and black silty shale.	34
1.	Sandstone, thin-bedded, locally arkosic, with interbedded laminated siltstone; partly covered.....	60
	Total Erwin Formation exposed:	753

Section 5. - Along road 693 and Big Reed Island Creek from about 0.3 mile south of road 607 to the mouth of Dry Branch.

		feet
Shady Dolomite:		
	Laminated gray dolomite:	
58.	Covered; probably 500 or 700 feet Stratigraphically to Rome contact	
57.	Dolomite, gray, massive, coarse-grained; weathers dary gray.....	2
56.	Covered.....	22
55.	Dolomite, gray, massive, fine-grained, weathers dark buffy gray.....	2
54.	Dolomite, gray, massive.....	9
53.	Dolomite, buff-gray, massive, coarse-grained.	12
52.	Covered.....	6
51.	Dolomite, black, massive, coarse-grained.....	5
50.	Covered.....	6
49.	Dolomite, light-gray, fine-grained; disseminated sulfide minerals.....	6
48.	Dolomite, buff-gray, laminated, fine-grained.	10
47.	Dolomite, gray, laminated, fine-grained, calcareous.....	16
46.	Dolomite, black, massive.....	3
45.	Covered.....	15
44.	Dolomite, buff-gray streaked.....	8
43.	Dolomite, gray, styloitic.....	4
42.	Dolomite, light gray, sparry blebs.....	8
41.	Dolomite, gray, laminated, fine-grained.....	1
40.	Dolomite, dark gray, laminated, fine grained.	21
39.	Dolomite, gray, laminated.....	3
38.	Dolomite, dark-gray, laminated, fine-grained.	27
	Upper ribboned dolomite:	
37.	Dolomite, gray, ribboned bedding.....	25
36.	Covered.....	6
35.	Dolomite, gray.....	2
34.	Covered.....	4
33.	Dolomite, gray.....	10
32.	Dolomite, gray, fine-grained.....	1
31.	Dolomite, gray; sparry blebs.....	16
30.	Dolomite, gray, fine-grained.....	10
29.	Dolomite, gray.....	13
28.	Dolomite, gray, fine-grained.....	4
27.	Dolomite, gray, numerous sparry blebs.....	4
26.	Dolomite, black, coarse-grained.....	5
25.	Dolomite, dark gray, laminated; sparry blebs.	28
24.	Dolomite, buff-and-gray mottled, fine-grained ribboned bedding.....	11

		feet
23.	Dolomite, light-gray, laminated.....	13
22.	Dolomite, dark-gray.....	1
21.	Dolomite, gray, fine-grained; shaly partings....	3
20.	Dolomite, light-buff, laminated, fine-grained...	16
19.	Dolomite, dark-buffy gray, coarse-grained.....	6
18.	Dolomite, buff, fine-grained, shaly weathering..	2
17.	Dolomite, gray, laminated, fine-grained; locally streaked with dark gray.....	12
16.	Dolomite, "white" crystalling, pearl gray, massive, coarse-grained; weathers dark buffy gray.....	40
15.	Dolomite, pearl gray.....	73
14.	Dolomite, pearl gray, fine-grained.....	35
13.	Dolomite, pearl gray.....	31
12.	Dolomite, pearl gray, coarse-grained.....	7
11.	Dolomite, light-gray, coarse-grained.....	17
10.	Dolomite, light-gray, fine-grained.....	4
9.	Dolomite, light-gray, fine-grained.....	4
8.	Dolomite, gray, laminated, fine-grained.....	19
7.	Dolomite, gray.....	3
6.	Covered.....	12
5.	Dolomite, gray.....	6
4.	Dolomite, dark gray.....	1
3.	Covered.....	4
	Blue ribboned limestone:	
2.	Dolomite, gray, ribboned bedding.....	14
1.	Limestone, blue-gray, fine-grained; ribboned bedding with irregular dolomitic laminae; conglomeratic near top. Underlying beds not exposed because of dip reversal.....	150
	Total Shady Dolomite exposed:	798

Section 6. - Along road 693 and Big Reed Island Creek for 0.5 miles at south end of their parallel courses.

Rome Formation:

100.	Siltstone, dark-red, laminated, shaly.....	41
99.	Covered.....	2
98.	Sandstone, buff-gray, irregular bedding, fine-grained; limonite-stained.....	2

Shady Dolomite:

97.	Covered; probably dolomite.....	26

		feet
96.	Dolomite, gray, massive	4
95.	Dolomite, buff, irregular bedding, shaly weathering; calcareous	1
94.	Covered	6
93.	Dolomite, buff-gray, massive fine-grained; limonite stained	5
92.	Covered	32
91.	Dolomite, dark-gray, laminated, fine-grained.	1
90.	Covered	3
89.	Dolomite, buff, laminated, fine-grained	2
88.	Covered	29
87.	Dolomite, light-gray, fine-grained, shaly weathering	1
86.	Dolomite, buff, fine-grained, calcareous	1
85.	Covered	50
84.	Dolomite, light-gray, fine-grained, weathers buff	5
83.	Limestone, dark-gray, fine-grained	1
82.	Dolomite, gray, fine-grained	1
81.	Dolomite, gray, fine-grained, shaly	2
80.	Dolomite, gray, fine-grained	1
79.	Dolomite, dark-gray, evenly-bedded, fine-grained; calcareous laminae	1
78.	Dolomite, light-gray, fine-grained	2
77.	Covered	7
76.	Limestone, dark-gray, uneven bedding, fine-grained, argillaceous	2
75.	Dolomite, light-gray, fine-grained, interlaminated buff dolomite	3
74.	Limestone, magnesian, gray, fine-grained	5
73.	Dolomite, light-gray, laminated, fine-grained	5
72.	Limestone, magnesian, light-gray, laminated, fine-grained; weathers buff	13
71.	Limestone, dark-gray, fine-grained	1
70.	Limestone, magnesian, gray, laminated	14
69.	Limestone, dark-gray, fine-grained, dense and pure	3
68.	Dolomite, gray	2
67.	Limestone, gray, fine-grained, and interlaminated dolomite	1
66.	Dolomite, gray, laminated, fine-grained	26
65.	Dolomite, light-gray, massive, fine-grained	21
64.	Dolomite, gray, fine-grained	3
63.	Covered	11
62.	Dolomite, light-gray, thin-bedded, fine-grained; platy weathering	23
61.	Limestone, black, laminated, fine-grained	7
60.	Dolomite, dark-gray, fine-grained	3
59.	Limestone, black, fine-grained, with interbedded magnesian limestone	6

		feet
58.	Dolomite, black, fine-grained.....	6
57.	Limestone, nearly black, fine-grained, with interbedded dolomite containing limestone lenses.....	9
56.	Dolomite, dark-gray, laminated, fine-grained	6
55.	Limestone, nearly black, laminated, fine-grained.....	28
54.	Dolomite, buff and gray, laminated, fine-grained; locally ribboned bedding.....	8
53.	Limestone, dark-gray, laminated, fine-grained.....	14
	Laminated gray dolomite:	
52.	Covered; probably dolomite, may contain some limestone.....	141
51.	Dolomite, light-gray, fine-grained.....	1
50.	Dolomite, buff.....	12
49.	Dolomite, gray, weathers dark gray.....	9
48.	Dolomite, buff, fine-grained.....	11
47.	Dolomite, light-gray, fine-grained.....	6
46.	Dolomite, gray.....	11
45.	Dolomite, buff, fine-grained; weathers light gray, blocky.....	7
44.	Dolomite, light-gray, fine-grained.....	8
43.	Dolomite, gray, laminated, weathers dark gray.....	11
42.	Dolomite, light-gray, fine-grained.....	9
41.	Dolomite, light-gray, laminated, fine-grained	6
40.	Dolomite, gray, laminated, fine-grained.....	19
39.	Covered.....	15
38.	Dolomite, light-gray, fine-grained.....	17
37.	Dolomite, dark-gray, fine-grained.....	5
36.	Dolomite, buff, fine-grained, weathers light-gray.....	6
35.	Dolomite, mottled gray, fine-grained, brittle	7
34.	Dolomite, buff, fine-grained, weathers light gray, blocky.....	8
33.	Dolomite, light-gray, massive, fine-grained.	6
32.	Dolomite, buff, fine-grained, blocky.....	34
31.	Dolomite, dark-gray.....	3
30.	Dolomite, buff, laminated, fine-grained.....	37
29.	Covered.....	5
28.	Dolomite, buff, laminated, fine-grained.....	2
27.	Dolomite, light-gray, laminated, fine-grained.....	2
26.	Dolomite, dark-gray, coarse-grained.....	5
25.	Dolomite, dark-gray, fine-grained.....	3
24.	Dolomite, light-gray, laminated, fine grained.....	3

		feet
23.	Covered	34
22.	Dolomite, dark-gray, fine-grained, highly fractured	5
21.	Dolomite, gray, massive, fine-grained	15
20.	Dolomite, buff-gray, laminated, fine-grained, shaly-weathering	9
19.	Dolomite, buff, massive, fine-grained	1
18.	Dolomite, light-gray, massive, fine-grained	4
17.	Covered; buff, shaly dolomite chips in soil	81
16.	Dolomite, light-gray	2
15.	Covered	8
14.	Dolomite, light-gray and buff, laminated, coarse-grained	7

Upper ribboned dolomite:

13.	Covered	35
12.	Dolomite, buff-gray, massive, fine-grained	15
11.	Dolomite, gray, fine-grained, blocky	10
10.	Dolomite, buff-gray	7
9.	Dolomite, light-gray, coarse-grained	5
8.	Dolomite, buff, coarse-grained	2
7.	Dolomite, light-gray, fine-grained, some ribboned bedding	10
6.	Dolomite, ribboned	24
5.	Dolomite, gray, some ribboned bedding	4
4.	Dolomite, dark-gray, coarse-grained and buff, coarse-grained dolomite, ribboned bedding	30
3.	Dolomite, dark-gray, coarse-grained; ribboned bedding; locally thin streaks of dark-gray chert, locally sparry dolomite	56

"White" crystalline dolomite:

2.	Covered	9
1.	Dolomite, pearl-gray, coarse-grained, weathers dark-gray; underlying beds covered	5
	Total Shady dolomite exposed:	1,236

STRUCTURAL GEOLOGY OF THE MACKS MOUNTAIN AREA, VIRGINIA

by

Robert Carter McDowell

ABSTRACT

The Macks Mountain area occupies most of that part of Pulaski County south of Claytor Lake, and includes small sections of the adjacent counties of Montgomery, Floyd, Carroll, and Wythe. The area is largely mountainous and uninhabited. Maximum relief is about 1,650 feet.

The present investigation was undertaken to determine the structure of the area by means of detailed field mapping. The Macks Mountain area is situated across the boundary between the Valley and Ridge province and the Blue Ridge province, and is thus in a critical position for interpreting the evolution of deformation of the sedimentary Appalachians.

About 6,000 feet of sedimentary beds are exposed in the area. They include in ascending order part of the Unicoi Formation and the Hampton Formation of Early Cambrian or Precambrian age, the Erwin Formation, and the Shady Dolomite, and part of the Rome Formation of Early Cambrian age. The first three formations constitute the Chilhowee Group, which is composed of clastic sedimentary rocks. The Shady is a carbonate succession about 1,600 feet

thick, and the Rome Formation includes both carbonate and clastic rocks. Most of the area, including virtually all of the mountainous interior, is underlain by Chilhowee beds, with Shady and Rome strata located in lowlands adjacent on the west, north, and east. The area is bordered on the southeast by metamorphic rocks of Precambrian age.

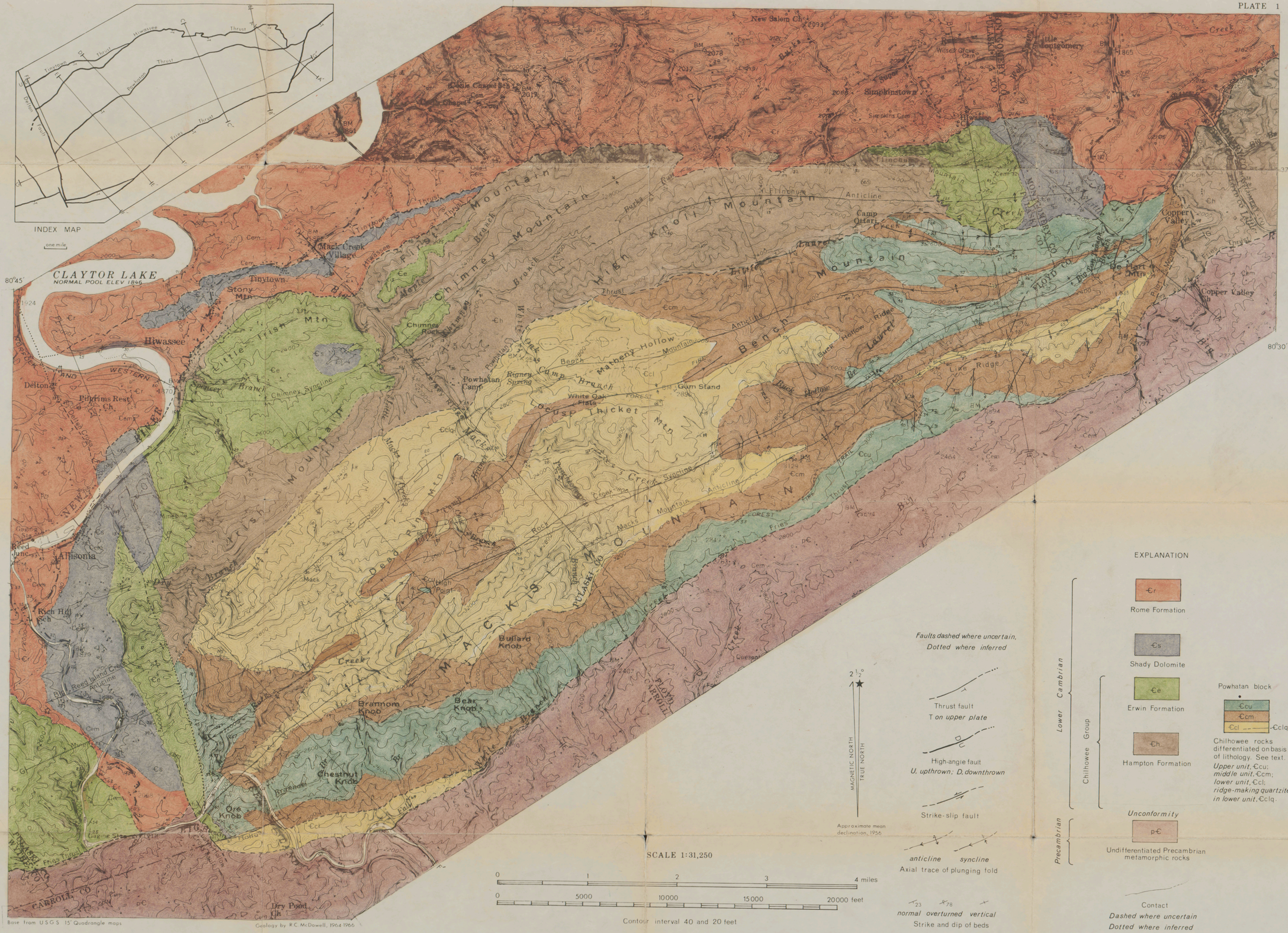
Thin section analyses indicates that quartz grains in quartzites of the Erwin Formation have undergone extensive interpenetration, probably by pressure solution according to the Riecke principle. Overgrowths are common, but lack of pore space or interstitial cement suggests a net loss of silica. Stylolites are a common feature related to pressure solution in the quartzites. Most are microscopic in scale and appear to be related to bedding lamination. Electron probe microanalysis of material within the stylolitic seams indicates a chemical composition similar to that of biotite.

The Macks Mountain area is divided by thrust faults into a number of structural blocks that can be considered in three units: the Pulaski block on the northwest, the Hiwassee-Powhatan blocks, and the Fries block on the southeast. The Pulaski block is represented in the area by Rome beds of the Max Meadows block, a subsidiary structure within the Pulaski block. Another such subsidiary block, delineated by the Tinytown thrust, lies wholly within the area.

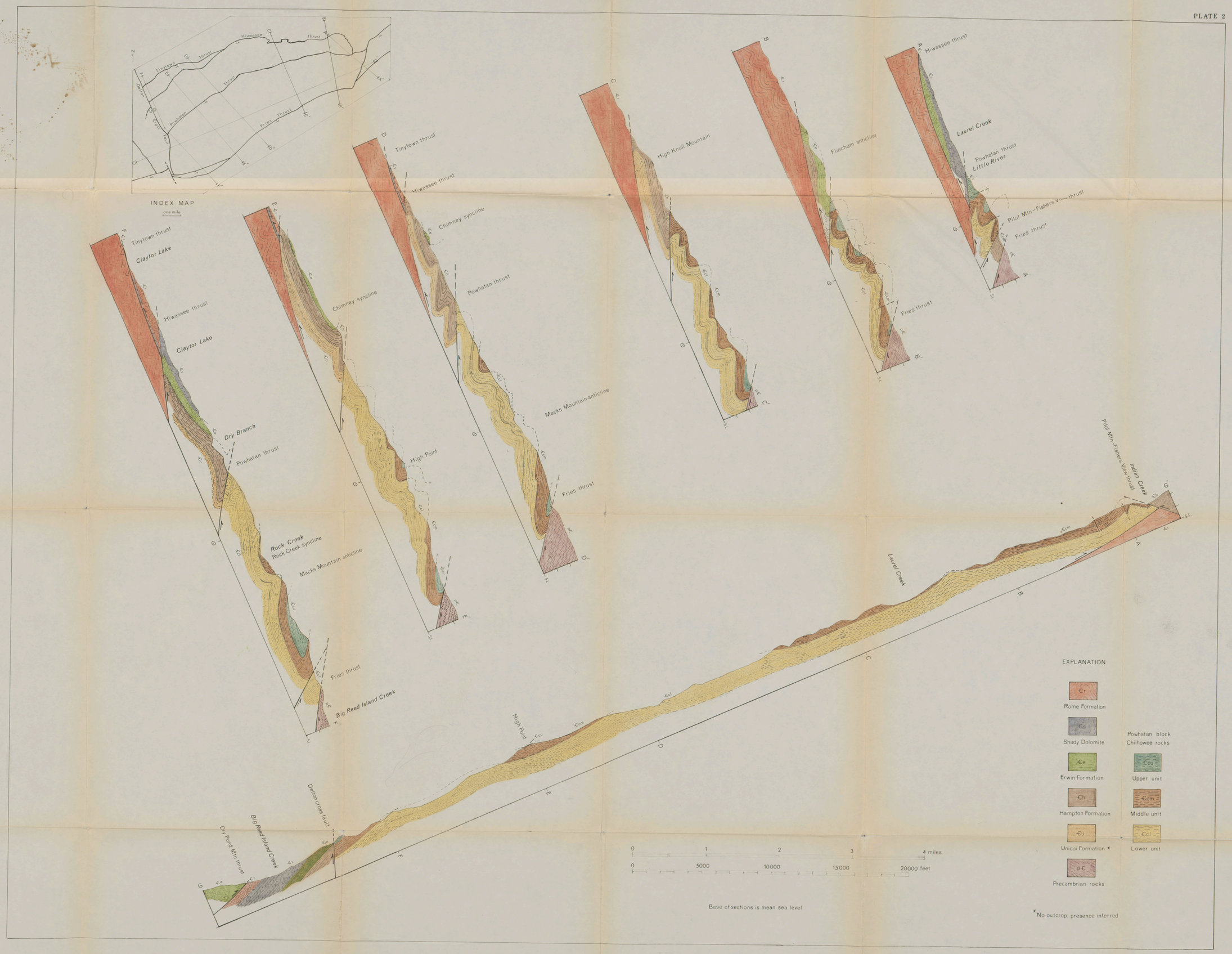
Rome beds are overridden by Chilhowee and locally younger rocks along the Hiwassee and Powhatan thrusts. The Fries thrust marks the emergence of the Precambrian crystalline rocks on the southeast.

The beds of the Hiwassee and Powhatan blocks have been deformed into a series of asymmetrical folds having the overall structure of a doubly plunging anticlinorium. This anticlinorium has been lapped onto by the Laswell and Dry Pond Mountain blocks in the vicinity of Allisonia. This convergence is a possible mechanism for the development of a prominent cross fault near Allisonia.

Deformation appears to be mainly a consequence of tangential compression, possibly from lateral expansion of the rising Blue Ridge anticlinorium.



GEOLOGIC MAP OF THE MACKS MOUNTAIN AREA VIRGINIA



STRUCTURE SECTIONS OF THE MACKS MOUNTAIN AREA, VIRGINIA