RELATION OF PULASKI AND SEVEN SPRINGS FAULTS IN SOUTHWESTERN VIRGINIA

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INTRODUCTION

The area covered in this report is in southwestern Virginia between Marion, Smyth County, and Rural Retreat, Wythe County (Fig. 1). It lies within the Valley and Ridge Province a few miles northwest of the Blue Ridge and covers portions of the Atkins, Cedar Springs, Nebo, and Rural Retreat 7.5-minute T.V.A. topographic sheets on a scale of 1:24,000.

The area is bounded on the west by the 81° 30' meridian and on the east by the 81° 15' meridian. The west border of the area is between the 36° 53' 30" parallel to the north and the 36° 50' 00" parallel to the south. The east border is between the 36° 58' 10" parallel to the north and the 36° 50' 00" parallel to the south.

Accessibility for geologic study is excellent. Interstate Route 81, paralleled by U.S. Route 11 to the south, passes through the area in a northeast-southwest direction approximately dividing it equally. A well developed network of secondary roads provides access to most parts of the area.

The topography is typical of the Valley and Ridge Province and exhibits alternating northeast-trending linear valleys at elevations of about 2,400 feet separated by ridges whose elevation is 2,600 to 2,700 feet. The total relief of the area is about 1,000 feet.

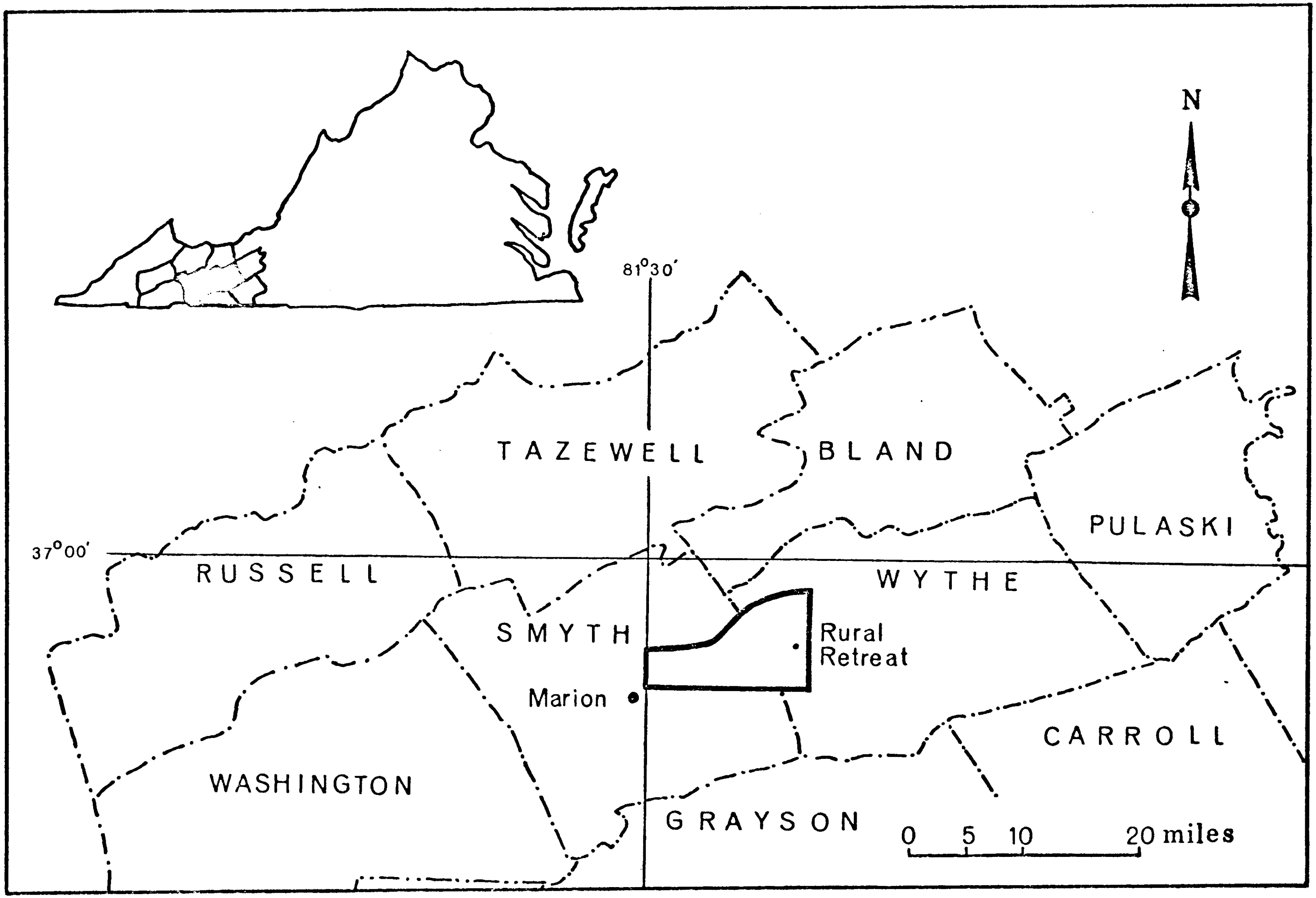


Figure 1. Index map of the Marion-Rural Retreat area, Virginia.

PURPOSE AND NATURE OF INVESTIGATION

Butts' (1933) "Geologic Map of the Appalachian Valley of Virginia" is a masterful accomplishment of one of the great Appalachian geologists. It produced a fairly accurate regional base map out of a wide range of topographic maps of various vintages — some really primitive. It necessarily blended a great deal of original reconnaissance geologic mapping with a minimum of previous, detailed geologic work. There are, however, several rather peculiar enigmas in delineation of bedrock geology on the "Valley Map." One of these intriguing problem areas attracted the attention of Cooper (1936), who worked his Master's thesis in the Marion area of Virginia only a few years after the appearance of the Butts' (1933) map. At the suggestion of Professor Cooper, the writer investigated the relations of the Seven Springs and Pulaski overthrusts and specifically explored the possibility that these two thrusts — separate and distinct faults on Butts' map — somewhere merged.

It is curious that a number of geologists actually assumed the sameness and continuity of these two faults without any substantial proof that such was the case. Campbell and Holden (1925), Butts (1933, 1940), Cooper (1939, 1941, 1946, 1961), Cooper and Haff (1940), Woodward (1936), Rodgers (1953) and others have alluded to the continuation of the Pulaski thrust southwestward into Tennessee. If one examines Butts' "Valley Map," however, the specific evidence supporting such allusions is lacking. The Pulaski fault trace continues southwestward along the southeast base of Little Brushy Mountain in eastern Smyth County and becomes the Hungry Mother fault of Cooper (1936) which dies out in Wassum Valley about 4 miles northwest of Marion (Fig. 2). The fault, which has been generally assumed to be the continuation of the Pulaski fault southwestward into Tennessee is Cooper's Seven Springs fault delineated by him in his 1936 paper only as far east as 81° 30' west longitude —— the eastern boundary of the old Abingdon 30-minute topographic sheet. On the 1933 "Valley Map" the eastward continuation of the Seven Springs fault was delineated by Butts as a separate fault which died out on the south side of the Pine Ridge syncline near Rural Retreat in western Wythe County, Virginia (Fig. 2).

According to B. N. Cooper (oral communication, 1968) the general zone commonly referred to as the Pulaski fault is in many places really two separate thrusts, both of which are marked by a peculiar and widely distributed tectonic breccia (Cooper, 1939, 1946, 1960, 1961; Cooper and Haff, 1940) which Campbell and Holden (1925, p. 18) misinterpreted as surficial alluvial deposits and which Butts (1940, Pl. 60) misidentified as cave fillings. Cooper (1946) established that the Pulaski and Staunton faults were one and the same thrust and one of his strongest corroborative arguments for this

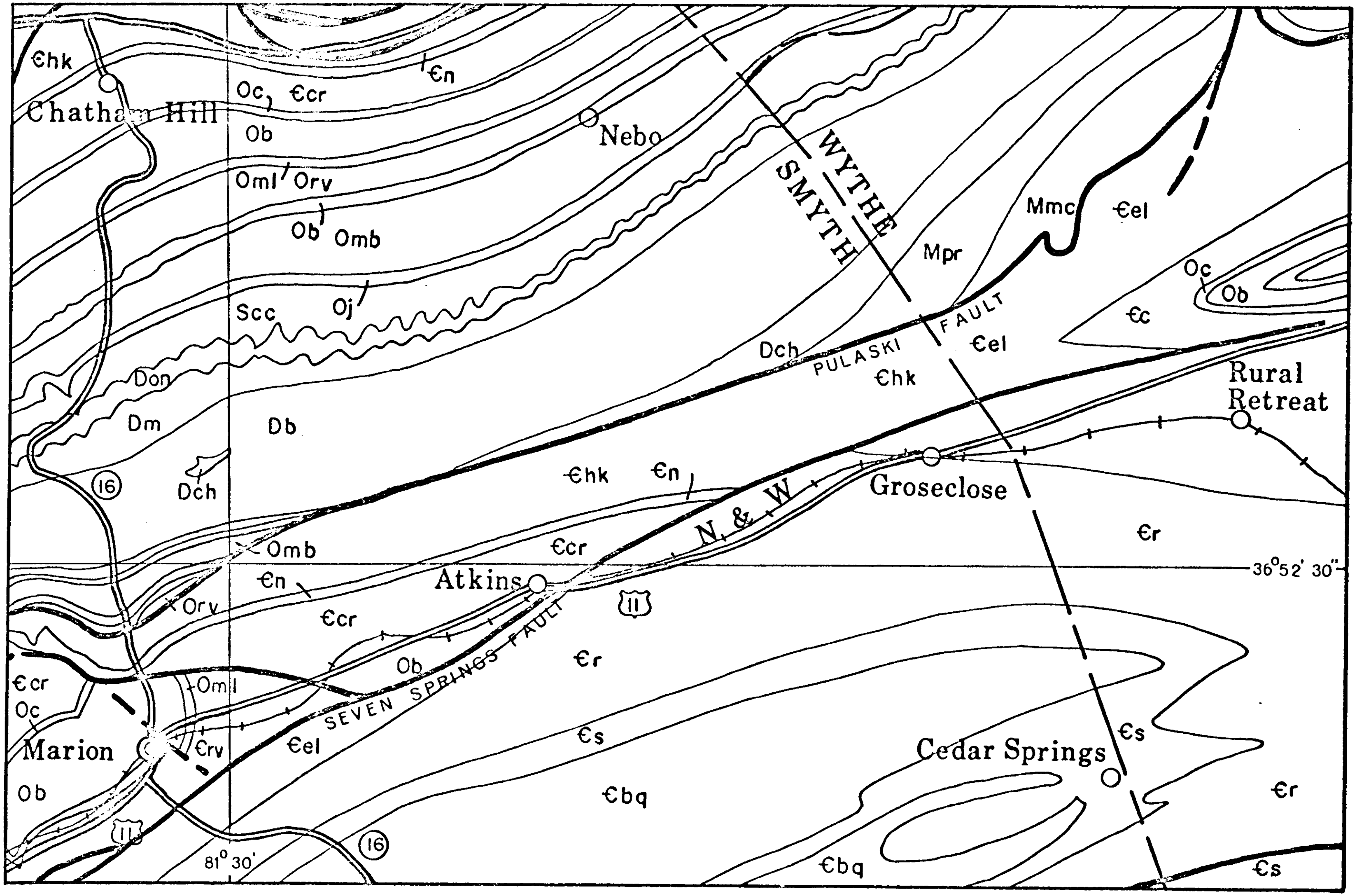


Figure 2. Marion-Rural Retreat area modified slightly from Butts (1933-1940).

conclusion was that both the Staunton and Pulaski thrusts as mapped by Butts (1933) northeast of Lexington, Virginia, are characterized by tectonic breccias of the Max Meadows type. The Max Meadows crush conglomerates and phyllite breccias, which are so well developed in Montgomery and Pulaski counties, Virginia, have been identified at least as far southwest as the Virginia-Tennessee line and doubtless persist almost all the way to the southwest terminus of the associated fault in Cocke County, Tennessee (B. N. Cooper, oral communication, 1968). The breccias are extensively displayed along Interstate Route 81 near State Highway 16 exits and approaches to the superhighway near Marion. The fault associated with the breccias at this locality is the Seven Springs fault as mapped by Cooper (1936). The tectonic breccias cannot be followed east of Groseclose along Butts' Seven Springs fault (Fig. 2), but the breccias can be identified along Little Brushy Mountain and on to the northeast along the Pulaski thrust. Such occurrences pose an analog to those of the Pulaski and Staunton Faults in the Shenandoah Valley.

Another relationship which suggests that the Pulaski and Seven Springs faults are, despite Butts (1933) delineation, one and the same in his unique grading of the Elbrook (€el) outcrop belt into that of the Honaker (€hk) Dolomite belt north of Groseclose, Smyth County (Fig. 2). An examination of all the published geologic mapping carried out in the Appalachian Valley of Virginia, beginning with Butts' 1933 "Valley Map" and continuing to the present, suggests that the Honaker Dolomite is confined to the Saltville and more northwesterly fault blocks in the folded Appalachians and that the Elbrook formation occurs only on the Pulaski or more southeasterly fault blocks (B. N. Cooper, oral communication, 1968). The fact that the Elbrook belt is shown by Butts (1933) as merging into a Honaker Dolomite terrane just at the place where one would expect the Seven Springs and Pulaski fault traces to merge if, indeed, the two faults were one (Fig. 2), more or less pinpointed the area investigated by the writer.

Near Atkins, in some of the critical places where one would have desired most to have good exposures, a somewhat freakish localization of coarse alluvium occurs along the bottom lands of the Middle Fork of the Holston River and conceals portions of the traces of the faults in question. The bedrock geology, however, clearly substantiates the linkage of the Seven Springs and Pulaski faults.

STRATIGRAPHY

General Statement

The Marion-Rural Retreat area is underlain by marine sedimentary rocks of Cambrian and Ordovician age in the area south of the Pulaski and Hungry Mother faults along the southeast base of Little Brushy Mountain, and of Devonian and Mississippian age on the north and footwall side of these faults (Pl. 1). The large amount of stratigraphic displacement along these faults accounts for the absence of the Silurian system in the Marion-Rural Retreat area.

Limestone, dolomite, siltstone, and shale are the common rock types in the area. Minor sandstones are present in the carbonate successions. The sedimentary record from Middle Cambrian to Middle Ordovician time is primarily represented by carbonate material which is indicative of a moderately low energy depositional evnironment. The dominance of clastic material in Upper Ordovician and Devonian-Mississippian beds may indicate an increase of environmental energy at that time.

The stratigraphy in the Marion-Rural Retreat area is represented by formations of the Pulaski thrust block southeast of the trace of the Pulaski and Seven Springs faults and by formations of the Saltville thrust block to the northwest of the Pulaski and Seven Springs fault trace. A comparison of the stratigraphy of these two thrust blocks shows that there is a readily recognizable difference in the lithologies between the thick Middle and Upper Cambrian time-equivalent formations; however, the lithologic differences between the relatively thin time-equivalent Ordovician formations are more subtle.

Formations of the Pulaski Block

Rome Formation

The southern border of the area of study is bounded by a broad belt of the Rome Formation (Smith, 1890, p. 149) of Lower Cambrian age. The Rome beds constitute a heterogeneous succession of maroon-red, brown, and green shales, siltstones, and fine-grained sandstones. Bedding throughout is slightly contorted to highly folded and ranges in thickness from a few inches to a few feet. A little carbonate material occurs in the Rome which is exposed along the southern border of the area. Because of much folding, faulting, and erratic dip reversals, no thickness was determined for the Rome in this area. Cooper (1936, p. 133) estimated the full section of Rome to be about 1,400 feet thick.

An arcuate salient is formed by the Rome Formation between Marion and Rural Retreat. There, it has overridden the Elbrook Formation to the northwest and comes within 0.75 mile of the base of Little Brushy Mountain. Midway between Atkins and Groseclose, Smyth County, the Rome is within 200 feet of rocks of the Saltville block as it forms the southeast side of a narrow corridor through which the Pulaski fault trace extends (Pl. 1).

Butts (1933, map) mapped the Rome-Elbrook contact as normal except where his Seven Springs fault parallels the contact just southwest of Groseclose (Fig. 2). Actually, however, right-side-up Rome beds override the younger Elbrook and are separated from the latter by tectonic breccias similar to those described by Cooper and Haff (1940, p. 946). The two formations are in fault contact in this area just as they are in the Draper Mountain area of Wythe and Pulaski counties, Virginia (Cooper, 1939, p. 11).

The Rome Formation is the basal unit in the Pulaski thrust block in the area mapped. This is evident from an exposure of Rome near Monkey Run at the base of Little Brushy Mountain. At this locality, the Rome is in normal contact with the overlying Elbrook Dolomite to the south, and is in fault contact with the Mississippian Maccrady Formation to the north. About 800 feet east of this exposure of Rome (Pl. 1), is a small erosional opening in the Elbrook Dolomite through which more Rome is exposed.

Elbrook Dolomite

The Elbrook Dolomite (Stose, 1906, p. 209) of Middle Cambrian age is about 2,000 feet thick in the area studied. Near its base, the Elbrook is a gray, fine-grained, thin-bedded, shaly dolomite. Portions of it are gently to highly contorted and many of the dolomite beds are autobrecciated. This shaly dolomite commonly leaches to a yellowish-brown, punky material.

The upper portion of the Elbrook is composed of interbedded dolomites and limestones and is less shaly than the lower portion. Some of the massive, blue-gray limestone beds contain algal-like structures and intercalated dolomite. Minor amounts of chert are scattered throughout the width of the outcrop belt.

The main exposures of the Elbrook are in the two broad belts enclosing the Pine Ridge syncline. The Elbrook also forms a narrow zone which extends from south of Marion northeast to Atkins where it is covered by thick alluvium along the Middle Fork of the Holston River.

Conococheague Formation

The Conococheague Formation (Stose, 1908, p. 701) which is exposed in both limbs of the Pine Ridge syncline in the eastern half of the area, is a sequence of interbedded, blue-gray, fine-grained, limestones and light-gray to buff, fine-grained dolomites. The Conococheague is of Late Cambrian age and correlates with the Copper Ridge Formation in the adjacent Saltville fault block. The maximum thickness of the Conococheague in this area is slightly less than 2,000 feet.

The contact between the Elbrook Dolomite and the Conococheague Formation is gradational. However, quartz sandstones, which are lacking in the upper Elbrook, are present in the Conococheague. The basal 300 feet of the Conococheague is composed mainly of light-gray dolomite with thin, intercalated beds of blue limestones and light-brown sandstone. The dolomite weathers to a dark, dull, brownish-gray color. Sandy beds, which range from relatively pure quartzose sandstones to sandy limestones or dolomites, do not continue along strike for any great length but come and go in lenses. The thickest bed of sandstone observed in the Conococheague Formation was 12 inches.

Ribbon-banded limestones with algal-like structures and scattered beds of chert are present in the middle 800 feet of the Conococheague Formation (Pl. 2-A).

The top 500 to 800 feet of the Conococheague is predominantly limestone. In this portion of the formation are several occurrences of a limestone, dolomite, sandstone, limestone successions in which the dolomite appears to be highly weathered in a cross-hatched pattern (Pl. 2-B). The beds in this succession range from one to two feet in thickness. A few algal-like structures along with several thin zones of intraformational breccia are present in these upper beds. The breccia is mainly redeposited angular fragments of limestone and dolomite in a fine-grained, impure limestone matrix.

Jonesboro Limestone

The Jonesboro Limestone (Ulrich, 1911, p. 672) used in this report as redefined by Rodgers (1953, pp. 62-64) is of Early Ordovician age and predominantly a dark-blue,

Plate 2

A. Ribbon-banded limestone in Conococheague Formation along County Road 680, 0.2 mile north of intersection with U. S. Route 11, Wythe County, Virginia.

B. (From left to right) Vertical limestone, dolomite, sandstone, limestone succession near top of Conococheague Formation. Location same as Plate 2-A.

fine-grained, thick-bedded limestone with numerous intercalations of light-gray, buff-weathering, silty dolomite. Near the top of the Jonesboro are several thick limestone beds with anastomosing dolomite stringers and wavy partings.

Weathered surfaces of the Jonesboro are extremely uneven and rough; especially the dolomite interbeds which are cross-marked with deep grooves that appear to be developed along microveins of calcite.

Only a few exposures of Jonesboro limestone are found within the boundary of the area mapped by the writer; however, 0.6 mile east of the area where County Road 729 cuts through Pine Ridge, good exposures of Jonesboro are present on both limbs of the Pine Ridge syncline. At this locality, the Jonesboro is estimated to be about 800 feet thick.

Post-Canadian Disconformity

A widespread disconformity recognized throughout the southern and central Appalachians is present just above the top of the Jonesboro Limestone in the Pulaski fault block. The erosional break is marked by a zone of sedimentary breccia composed of limestone, dolomite, and chert clasts set in a matrix of calcarenite. The rocks above and below the disconformity are very similar to those described by King and Ferguson in Denton Valley, Washington County, Virginia (1960, p. 57).

Probably an eustatic lowering of sea level near the end of Canadian time bared the Canadian carbonate rocks to prolonged erosion. Returning seas reworked the residuum into the basal beds of the Middle Ordovician.

Lenoir Limestone

The Lenoir Limestone (Safford and Killebrew, 1876, pp. 108, 123, 130-131, 137) of Middle Ordovician age disconformably overlies the Jonesboro Limestone in the Pine Ridge syncline. The best exposure of Lenoir Limestone is 0.6 mile east of the Marion-Rural Retreat area along County Road 729. At this locality the Lenoir is 38 feet thick. The Lenoir weathers to a dove-gray color and portions of it commonly exhibit a smooth fluted surface. Fresh surfaces are dark bluish-gray. Bedding is generally from 1 to 3 inches thick.

At the base of the Lenoir Limestone and above the disconformity described above is a thin sedimentary breccia containing angular chert and subrounded carbonate-rock clasts. Several feet above this basal breccia zone is a 5 inch zone of intraformational breccia composed of redeposited angular fragments of limestone. Some minor faults showing slight offsets of calcite-filled fractures are present. No chert was observed in the Lenoir except for that in the basal breccia zone.

Fetzer Limestone

The Fetzer Limestone named by B. N. Cooper and G. A. Cooper (G. A. Cooper, 1956, p. 64) consists of a 2 to 5 foot zone of dark-blue, medium-grained, thin-bedded, rusty-weathering, Middle Ordovician limestone. The Fetzer has been identified in the southern Appalachian region mainly by its characteristic assemblage of fossils which includes Trinodus elspethi, Bronteopsis gregaria, Nicholsonella, Christiania, Bimuria, Titanambonites, Cyrtonotella, and other brachipods (G. A. Cooper, 1956, p. 64).

Outcrops of Fetzer are extremely sparse. No known outcrop of Fetzer exists in the actual mapped area. However, along County Road 729, 0.6 mile east of the area, is a fine exposure of Fetzer Limestone overlying Lenoir Limestone and underlying Paperville shale. These relations are almost precisely like those described by Tyler (1960, p. 50).

Paperville Formation

The Paperville Formation of Middle Ordovician age was named by B. N. Cooper and G. A. Cooper (G. A. Cooper, 1956, p. 82). It is composed of black, paper-thin graptolitic shales. It contains a few thin beds of gray siltstone and fine-grained sandstone. The fissile shales weather quickly to a soft, tannish-orange, clayey material. Fresh exposures of the shales are coal-black and locally exhibit a well-ordered pattern of en echelon veins of white calcite.

The Paperville Formation is best exposed in a small quarry along County Road 629 one mile east of the intersection with County Road 680. This exposure represents the most westward occurrence of the Paperville Formation in the Pine Ridge syncline. At this locality it is estimated to be 200 feet thick.

Tellico Formation

The name "Tellico Formation" (Keith, 1895) is used in this report as redefined by Newman (1955, p. 145). It is the youngest formation in the Pine Ridge syncline and is estimated to be well over 1,000 feet thick.

The Tellico consists of alternating 2- to 6-inch beds of dark-gray to brown, fine- to medium-grained feldspathic sandstones and subgraywackes separated by thin zones of grayish-green calcareous shale. Beds of sandstone up to 5 feet thick and zones of bluish-gray, limy, micaceous siltstone 2 to 4 inches thick are common. Some siliceous and calcareous cementing material is present. Only a very small portion of the mapped area contains Tellico beds.

Formations of the Saltville Block

Honaker Dolomite

The Honaker Dolomite (Campbell, 1897, p. 2) is of Middle Cambrian age. The thickness of exposed Honaker in this area is between 1,000 and 1,100 feet. It forms the hanging wall of the Hungry Mother fault exposed in a narrow belt from Mitchell Valley northeast to Davis Hollow, north of Groseclose. The best fresh exposure of Honaker is in a quarry about 1,000 feet southwest of the intersection of County Roads 617 and 713.

The Hungry Mother fault along the north edge of the Honaker belt forms the contact between Devonian-Mississippian strata of Little Brushy Mountain and Honaker Dolomite.

The Honaker is a relatively homogeneous, gray, fine-grained, silty dolomite. It is generally thicker-bedded and more competent than the Elbrook Dolomite and contains much less limestone. Nodules of black chert are present in only a few beds. This belt of Honaker exhibits little fracturing and brecciation which is a contrast to the highly brecciated condition of the Honaker in other belts in Virginia.

Weathered exposures of the Honaker are dark, dull-gray to black and exhibit bedding better than do fresh exposures. Exposed bedding surfaces are extremely rough and deeply furrowed.

Nolichucky Formation

The Nolichucky Formation (Keith, 1896, p. 2) of Middle Cambrian age overlies the Honaker Dolomite and follows its same trend of outcrop. The Nolichucky is a relatively thin but persistent succession of alternating limestones and shales. In the mapped area, it does not exceed 400 feet in thickness. The belt of outcrop narrows to less than 500 feet in width in the central portion of the area where it is in fault contact with the Elbrook Dolomite.

Although shale is the major lithology of the Nolichucky Formation, its predominance in the sequence is somewhat variable along strike. The shale of the Nolichucky is yellowish-brown to dark-brown and commonly silty. Bedding is generally thin, but never paper thin. The Nolichucky, despite its inconspicuous outcrop, is a resistant unit and holds up a prominent bench along which it can be traced continuously by its shaly residuum.

The hard, blue to bluish-gray, fine-grained limestone of the Nolichucky Formation is characteristically ribbon-banded with light-gray and buff clayey partings. This persistent feature provides a reliable criterion for distinguishing the Nolichucky limestone from the overlying Copper Ridge Formation and the underlying Honaker Dolomite. Beds in this limestone are generally 0.5 to 1.5 inches thick.

Copper Ridge Formation

The Copper Ridge Formation (Stose, 1908, pp. 701-703) of Late Cambrian age crops out in a northeast-trending belt paralleling belts of the Honaker and Nolichucky formations.

Nowhere in this area is a complete section of Copper Ridge present because the Greenwood and Seven Springs faults have eliminated its uppermost beds. The maximum thickness of Copper Ridge in this area is about 1,700 feet. From Marion, the outcrop belt of the Copper Ridge continuously thins to the east until it is cut off completely by the overriding Pulaski fault block southwest of Groseclose.

The Copper Ridge Formation is characterized by dark, dull-gray, coarsely crystalline, thick-bedded dolomite with several thick beds of intercalated sandstone. A few thin beds of fine-grained, blue limestone are present. Near the bottom of the Copper Ridge Formation is a 4 to 5 foot bed of brown-weathering, resistant, quartz sandstone (Pl. 3-A). This bed of sandstone holds up the first major ridge that parallels U.S. Route 11 on the north in the western half of the area. It can be traced northeast to where its outcrop is overridden by the Elbrook Formation of the Pulaski fault block.

The Copper Ridge weathers to rough surfaces of dark brownish-gray color. Many of the Copper Ridge dolomites contain varying amounts of silt and disseminated quartz grains. Coarsely crystalline grains of dolomite that have

Plate 3

A. Thick-bedded quartz sandstone near base of Copper Ridge Formation along County Road 685, 0.2 mile north of intersection of U.S. Route 11, Smyth County, Virginia. Hammer is resting on sandstone unit, beds above and below are dolomite.

B. Black Rich Valley shale overlying Middle Ordovician limestones in abandoned quarry along County Road 691, 0.5 mile southeast of intersection of U.S. Route 11, Smyth County, Virginia.

weathered in relief add to this rough surface texture.

The sandy, red soil from the weathered Copper Ridge Formation is loosely compacted and is very susceptible to gullying. Chert nodules and large Cryptozoon heads up to a foot or more in diameter are found in the soil, but they are seldom seen in place.

Canadian Dolomite Formations

The term "Canadian dolomite formations" is used in this report to include a series of cherty, dolomitic beds that elsewhere in Southwestern Virginia and East Tennessee have been separated into the Chepultepec, Longview, Kingsport and Mascot formations (Rodgers, 1953, p. 55). The general name as used applies to the same succession as the Jonesboro Limestone of the Pulaski block, but the Jonesboro is limy only in the lower 250 feet or so, which represents the Chepultepec-Longview equivalents.

The Canadian dolomite formations attain their greatest thickness just southeast of Marion where they are about 1,000 feet thick. Since these formations are bounded on the north by the Goodpasture and Greenwood faults, and on the south by the Seven Springs fault, their true thickness can not be precisely determined. The Greenwood and Seven Springs faults intersect near the center of the area where the Canadian formations are pinched against the faults.

The Canadian dolomites are predominantly dove to dark-gray, fine-grained, and have thin partings of greenish-gray to orange-buff shale, thin layers of intraformational limestone-pebble conglomerates, and some beds of chert. Algal structures occur in the limestone beds, and stringers of quartz sand are present in the upper dolomites.

Post-Canadian Disconformity

The Post-Canadian Disconformity is present in the Saltville fault block between the Canadian dolomite formations and the Middle Ordovician limestones. Cooper (1936, p. 140) recognized the local absence of rocks of Late Canadian age in the Marion area by the absence of fossils such as the distinctive genus _Ceratopea_ and other species of nautiloid cephalopods. However, because the Middle Ordovician limestones have been overridden by the Canadian dolomites along the Goodpasture fault, no evidence of the Post-Canadian Disconformity on the Saltville fault block could be found by the writer in the area mapped.

Middle Ordovician Limestones

The general name Middle Ordovician limestones is used in this report to refer collectively to four formations of Middle Ordovician age previously recognized in the Marion vicinity by French (1967, pp. 36-40). These are the Tumbez, Mosheim, Giesler, and Arline limestones.

These Middle Ordovician limestones are predominantly gray to dark-gray, fine to medium-grained, and impure. Bedding is commonly thick. Some beds are silty and contain broken fossil fragments. Freshly broken pieces of these limestones give off a strong petroliferous odor. They crop out sparsely for a distance of about 5,000 feet along strike in a narrow, northeast-trending belt southeast of Marion. Their exposure is terminated by the Goodpasture fault along which the Canadian dolomite formations of the hanging wall have overridden younger footwall strata to the north. The average thickness of the Middle Ordovician limestones in this area is estimated to be about 60 feet. The Middle Ordovician limestones are overlain by the Rich Valley Formation.

Rich Valley Formation

The Rich Valley Formation named by B. N. Cooper and G. A. Cooper (G. A. Cooper, 1956, pp. 86-88) is of Middle Ordovician age. It is exposed in the extreme west edge of the area, south of Marion, where it overlies Middle Ordovician limestones (Pl. 3-B). A good exposure of Rich Valley black shales and limestones is in a quarry along County Road 691, 0.5 mile southeast of U.S. Route 11. At its northern boundary, the Rich Valley is in fault contact with the Copper Ridge Formation.

The Rich Valley Formation is primarily a black, limy, graptolitic shale that is interbedded with dark-gray to black, thin-bedded, shaly limestones. Near its base, the shale tends to be somewhat fissile. It weathers chocolate-brown. Minor crumpling, folding and faulting make it impossible to determine the true thickness of the Rich Valley succession. Cooper (1936, p. 144) estimates it to be about 850 feet thick in the Marion area.

Undifferentiated Devonian Formations

Due to the large stratigraphic displacement along the Hungry Mother and the Pulaski faults, the Silurian formations are not exposed in the Marion-Rural Retreat area.

The Devonian formations along Little Brushy Mountain from Mitchell Valley east to Crow Hollow, several miles northeast of Atkins, were not differentiated in this report. Devonian units recognized and mapped by French (1967, p. 52-62) on Little Brushy Mountain in the Marion area, Virginia, include Ridgeley Sandstone, Huntersville Chert, Needmore Shale, Millboro Shale, Brallier Formation and Broadford Formation.

The Devonian formations consist primarily of clastic sediments including sandstones, siltstones and shales of various thicknesses. Drab, greenish-brown to orange-buff colors are dominant throughout these Devonian rocks.

The best exposures of the Devonian formations are along County Road 622 which extends from west of Atkins north across Little Brushy and Walker mountains to Nebo, Smyth County, Virginia.

Price Formation

The Price Formation (Campbell, 1894, pp. 171, 174) of early Mississippian age crops out in a northeast-trending zone along the lower southern slopes of Little Brushy Mountain from Crow Hollow to Dutton Hollow close to the Hungry Mother and Pulaski faults. The true thickness of the Price in the area studied was not determined; however, B. N. Cooper (oral communication, 1968) has estimated it to be about 800 feet.

Much of the Price Formation is light-orange to buff, thin-bedded sandstone and green-gray shale but thin coaly shales occur near the top. The base of the Price is a thin quartz-pebble conglomerate which makes prominent ridges. The coal beds near the top of the Price Formation and about 50 feet below the base of the Maccrady Formation are well known to many of the local people in the area who for years extracted small quantities of coal for personal use. The coal is not persistent enough along strike, thick enough, or good enough to have ever been mined for commercial use.

The Price is overlain by the Maccrady Formation. The beds of the Price are fairly resistant and make low ridges that are ruggedly dissected.

Maccrady Formation

The Late Mississippian Maccrady Formation (Stose, 1911, p. 234) is the youngest formation in the Marion-Rural Retreat area. It overlies the Price Formation along a portion of the south slope of Little Brushy Mountain where it is approximately 1,200 feet thick.

The striking characteristic of the Maccrady Formation is its predominantly red color. The formation is primarily a siltstone, mudstone, sandstone, shale succession. Drab shades of red, orange, green and gray are exhibited throughout the section, especially by the shale beds. Crumbly weathering siltstones and feldspathic sandstones that show cross-bedding form a minor portion of the Maccrady Formation with shales and mudstones being dominant. Bedding ranges to more than a foot thick in some of the sandstones, but the shales and siltstones are generally thin bedded.

The Maccrady Formation is best exposed at the north termination of County Road 735 near Monkey Run in the northeast portion of the area.

Alluvium and Colluvium

The Marion-Rural Retreat area contains a belt of alluvium and colluvium extending from south of Marion up the valley of the Middle Fork of the Holston River along U.S. Route 11 and the Norfolk and Western Railway to roughly 1.5 miles north of Atkins.

Alluvium consisting of smooth, rounded, quartzite cobbles and boulders that are largely derived from the Erwin quartzites exposed on the west slopes of the Glade Mountains is transported to the Holston River Valley by way of Nicks Creek. The Middle Fork of the Holston River is responsible for transporting large, abraded nodules of chert that were probably obtained from the Cambrian carbonate strata in the northern half of the area. Much of the smaller, more slabby, impure quartz sandstone material is most likely supplied to this belt by Bear Creek, which cuts the Devonian strata to the north.

Colluvium has been contributed locally from the weatherings of bedrock exposed on the immediately adjacent higher ridges. The Copper Ridge Formation probably is the chief source for large rounded Cryptozoon heads so often present in loose lag material.

STRUCTURE

General Statement

In the area studied the unraveling of the structural complexities of the northwestern portion of the Pulaski thrust block and the overridden southeastern border of the Saltville thrust block to the northwest has been accomplished primarily by detailed mapping of mainly three formations which are not elsewhere seen in such close association. The Elbrook Dolomite is not identifiable northwest of the Pulaski fault block and the Honaker-Nolichucky succession, of equivalent age but quite different lithology, is nowhere identifiable southeast of the Saltville thrust block. In the mapped area the key to the location of the Pulaski thrust is the discordant contact of the Elbrook with the Honaker-Nolichucky succession. This discordant contact is made somewhat easier to recognize by occurrences of tectonic breccias similar to those described by Cooper (1939). By following the northern border of the distinctive Elbrook with its associated tectonic breccias, the fault which Butts (1933, map) correctly identified as the Pulaski thrust north of Rural Retreat, can be traced into the Seven Springs fault as identified and named by Cooper (1936, p. 162) in the adjacent Marion area west of Atkins.

The most important relationships for understanding the structural geology of the Marion-Rural Retreat area and expecially the relationship of the Seven Springs-Pulaski and Max Meadows faults is the recognition of the existence of two fault blocks, each with its own characteristic succession of beds. The separation of the Saltville and Pulaski blocks with their distinctive stratigraphic successions is difficult because of the narrowness of the corridor through which the Pulaski fault zone passes between Groseclose and Atkins. In the vicinity of Atkins the actual distance across strike from the foot of the inlier of Lower Cambrian quartzites of the Glade Mountains (Miller, 1944, map) northward to the Silurian sandstone ridge, Walker Mountain, in the Saltville block is barely 2 miles. Within this narrow, critical area, a relatively prominent belt of alluvium conceals portions of the fault zone, but careful mapping of the formations bordering the bottom land along the Middle Fork of the Holston River has afforded a reliable basis for joining the Pulaski and Seven Springs faults.

Structures of the Pulaski Block

Pulaski and Seven Springs Faults

The faults of Primary interest in this report are the Pulaski fault (Campbell and Others, 1925, p. 43) and the Seven Springs fault (Cooper, 1936, p. 162). The Seven Springs fault west of Marion is the same as the Walker Mountain fault of Stevenson (1881, p. 227). A relationship between the Seven Springs and Pulaski faults was first suggested by Butts (1940, p. 449) when he mentioned that the Pulaski fault may continue southwest through Marion and on into Tennessee as the Seven Springs fault. It was out of this statement along with the incongruity of stratigraphy as shown on Butts' "Geologic Map of the Appalachian Valley in Virginia" (Fig. 2) that B. N. Cooper (oral communication, 1968) realized and pointed out to the writer the paradoxial relations of the Elbrook and Honaker-Nolichucky belts north of Groseclose, Smyth County, Virginia. He suggested to the writer that this discrepancy might be resolved if the Pulaski thrust could be traced into the Seven Springs fault.

The Pulaski fault can be followed continuously along the base of Little Brushy Mountain from near Reed Creek in the northeast corner of the Marion-Rural Retreat area, southwest to a point near Davis Hollow (Pl. 1). Along this portion of the Pulaski fault trace, Lower Cambrian Elbrook

Dolomite froms the hanging wall. The beds overridden by the Elbrook are Mississippian strata of the Saltville fault block. The fault trace has several irregularities which indicate that in this area the fault probably dips at a relatively low angle and its surface is probably furrowed instead of planar.

East of Dutton Hollow (Pl. 1) a marked irregularity in the trace of the Pulaski fault signifies folding of the low angle thrust surface after or during the final stages of emplacement. Similar, but larger, features of the Pulaski fault have been described by Cooper (1939, 1964) in Pulaski and Montgomery counties.

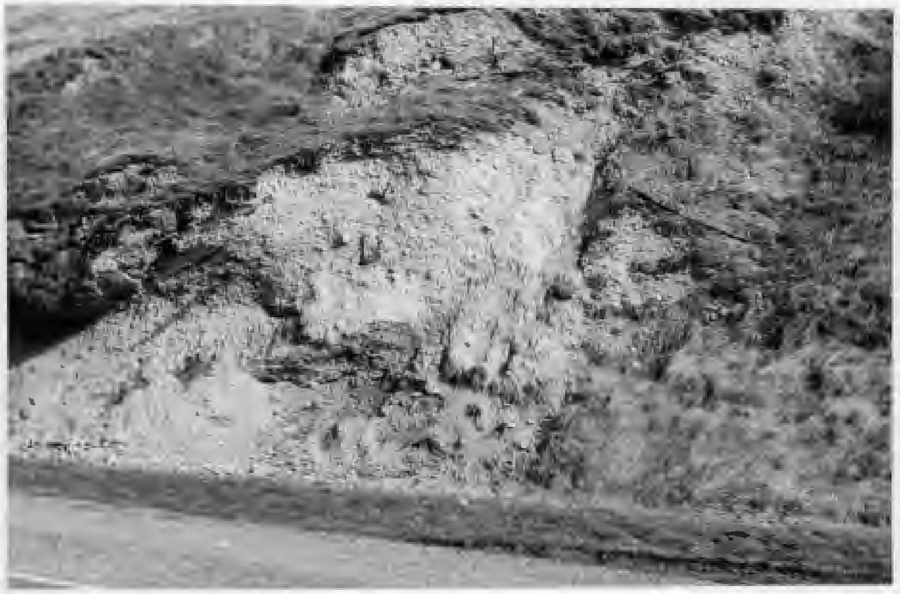
East of Davis Hollow at a point 0.7 mile southwest of the Smyth and Wythe county line the trace of the Pulaski fault leaves the base of Little Brushy Mountain and veers southward toward Atkins and the Hungry Mother fault emerges from under the Pulaski thrust block and continues westward into the Marion area. Several thousand feet southwest of the point where the Pulaski fault block crosses the Hungry Mother fault is an excellent exposure of Max Meadows-type breccia, characteristic of that found along the Pulaski fault from Rockingham County, Virginia, southwestward to and beyond the Virginia-Tennessee line (B. N. Cooper, oral communication, 1968).

The name "Max Meadows fault breccia" has been used by Cooper (1946, p. 99; 1959, p. 6; 1961, p. 86) for a variety

Plate 4

A. Land slump exposing Max Meadows tectonic breccia, 1,000 feet north of U.S. Route 11, 1.4 miles west of Groseclose, Smyth County, Virginia.

B. Close up of breccia in Plate 4-A.



of cataclastic rocks produced by the crushing and rolling out of the hanging wall and footwall rocks along the Pulaski and Max Meadows thrusts. Cooper and Haff (1940, p. 946) described three zones of Max Meadows breccia in the Draper Mountain area. Of these, the autoclastic zone consisting of angular blocks and fractured masses of Elbrook limestone and dolomite and the crush conglomerate zone composed chiefly of rounded fragments of limestone, dolomite, and bluish-green phyllite can readily be recognized along the Pulaski, Seven Springs and Max Meadows fault in the Marion-Rural Retreat area (Pl. 4-A, 4-B). No exposure of such breccia was found along the Hungry Mother fault.

In the north-central portion of the area about 0.7 mile southwest of the Smyth and Wythe county line, the Copper Ridge Formation emerges from beneath the Pulaski thrust block, but a little farther southwest where the Pulaski fault veers southward the overthrust Elbrook Dolomite of the Pulaski thrust block overrides all the Copper Ridge and a substantial portion of the Nolichucky Formation for a distance of about 0.9 mile along strike. Beyond that point the Copper Ridge again emerges and forms a widening belt continuing west of the border of the area mapped.

From that point southwestward toward Atkins, the Elbrook belt becomes very narrow and at a point about 1.6 miles east of Atkins it disappears beneath alluvium. Toward Atkins, the overthrust Elbrook belt thins greatly because the Rome Formation of the Max Meadows fault block has overridden it. At Atkins the Rome comes close to resting directly on the Copper Ridge Formation of the Saltville block (Section D-D', Pl. 1). Just west of Atkins alluvium conceals the Elbrook rocks but farther southwest the Elbrook is exposed on the south side of the Middle Fork of the Holston River and continues westward into the Marion area (Cooper, 1936, map).

Along the trace of the Pulaski fault (previous Seven Springs fault) from Atkins southwest to Marion (Section E-E', Pl. 1), Elbrook Dolomite of the hanging wall is in contact with a belt of Canadian dolomites which represent the southeast limb of a minor anticline that was sliced off and carried along with the advancing Pulaski block when the latter was emplaced (Fig. 3). An excellent exposure of Max Meadows-type breccia occurs at the contact between these two formations along County Road 689, 255 feet north of the intersection with County Road 691.

Pine Ridge Syncline

The major fold of the Pulaski thrust block in the Marion-Rural Retreat area is the Pine Ridge syncline (Pl. 1). This structure is named for the long narrow ridge that trends westward from Wytheville to near Rural Retreat, and which composes the eastern half of the area.

The Pine Ridge syncline is asymmetrical. The north limb dips to the south at relatively low angles, whereas the south limb is vertical or nearly so in many places (Section A-A', Pl. 1). The resistant beds of the Tellico Formation, which are the youngest beds of this syncline, make Pine Ridge. Elbrook Dolomite is the oldest formation in the Pine Ridge syncline.

The Pine Ridge syncline was probably a well-developed major fold before the Pulaski thrust block was emplaced upon the parautochthonous strata of Little Brushy Mountain. However, during or after thrusting, the strong compressional forces from the southeast probably further compressed the syncline to produce its present asymmetry.

Max Meadows Fault

Along the southern border of the Marion-Rural Retreat area the Elbrook Dolomite has been overridden from the southeast by the Rome Formation (Section B-B', Pl. 1). The contact between these two formations is characterized by an abundance of Max Meadows phyllite breccia which was derived by maceration of the Rome shales as they overrode younger beds. The best exposure of phyllite breccia is along the Middle Fork of the Holston River behind the Village Motel, 1,000 feet northwest of the intersection of U.S. Route 11 and County Road 683. No fresh breccia is exposed east of this point; however, decalcified breccia occurs along the

Rome-Elbrook contact on State Route 90, a mile south of Rural Retreat.

The fault relations inferred from the presence of the Rome Formation lying on the Elbrook, as well as the breccia found along this fault, suggests that it is probably the southwestward continuation of the Max Meadows fault of Cooper (1939, p. 59), which he mapped in the Draper Mountain area.

Structures of the Saltville Block

Hungry Mother Fault

The Hungry Mother fault (Cooper, 1936, p. 165) is not a southwesterly extension of the Pulaski fault as shown on Butts' (1933) map. It is a reverse fault developed within the Saltville block which pushed the Honaker Dolomite over the great overturned syncline of Devonian-Mississippian beds south of Walker Mountain, which is so well displayed along State Highway 16 north of Marion, Virginia. The stratigraphic throw of the Hungry Mother fault decreases westward and eventually disappears in the Marion area, but east of State Route 16 the heave and throw of the fault increase so that the overthrust Honaker having overridden the southeast limb and trough of the syncline, rests on the northwest upright limb (Section C-C', Pl. 1).

In the area mapped by the writer, the Hungry Mother fault can be traced from Mitchell Valley in the northwest corner of the area to Davis Hollow, north of Groseclose, where it apparently disappears under the Pulaski thrust block. The relatively straight trace indicates that this fault is a relatively high angle reverse fault (Pl. 1).

Greenwood Fault

The Greenwood fault (Cooper, 1936, p. 164) can be traced from east of Marion where it enters the area, northeast a short distance to Mt. Carmel where it is covered by alluvium. However, to account for the progressive loss of section of the Copper Ridge Formation along the fault toward the center of the area mapped, the Greenwood fault must continue to near Atkins where it probably passes under the Seven Springs fault.

The curious faulted relation of the Copper Ridge Dolomite to the body of the Rich Valley Shale should not be misread to indicate that the southeasterly-dipping fault is a normal fault. Actually the differential movement along this fault was primarily strike-slip. Since the beds south of the Greenwood fault plunge strongly to the east, the displacement of the south block of the Greenwood thrust mainly by strike-slip but with a minor component of upthrust has produced the somewhat anomalous condition of younger beds faulted upon older beds (Fig. 3). The strike-slip movement of the Greenwood fault is plainly shown on Cooper's (1936) map of the Marion area.

Goodpasture Fault

The name Goodpasture fault is proposed for a fault just south of Marion along which the right-side-up Canadian dolomite is thrust over right-side-up Middle Ordovician limestone and Rich Valley shale to the north. The Goodpasture fault is probably a low angle fault within the

Canadian dolomites (Fig. 3).

The Goodpasture fault is well exposed in an abandoned quarry along County Road 691, 0.5 mile southeast of U.S. Route 11. In that quarry, Canadian dolomite beds dipping about 24° south are thrust over essentially flat Middle Ordovician limestone and Rich Valley shale.

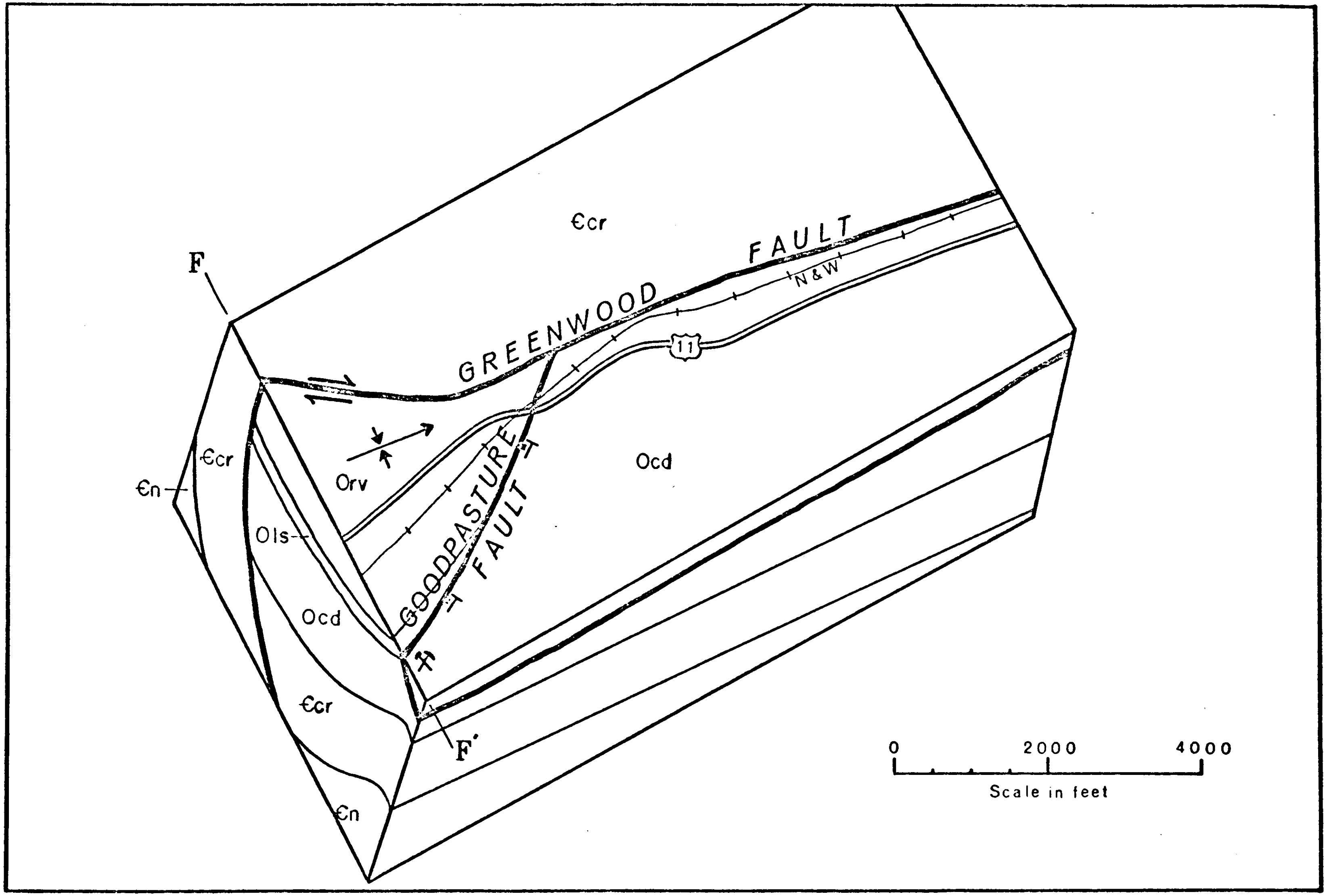


Figure 3. Block diagram showing structure of Greenwood and Goodpasture faults. (Symbols and reference line, F-F', shown on Pl. 1.)

SUMMARY

The Pulaski and Seven Springs faults constitute one continuous break which swings southward away from Little Brushy Mountain north of Groseclose and which curves around the southeastward dome-like salient of the Saltville fault block, constituting the main part of the area mapped by Cooper (1936). The key to this interpretation is mainly stratigraphic. The Honaker-Nolichucky-Copper Ridge succession south of the Hungry Mother reverse fault is part of the Saltville block. The edge of the Pulaski block north of Groseclose is defined by Elbrook dolomites and associated tectonic breccias which lie variously upon Copper Ridge dolomites and Nolichucky beds of the Saltville block. The juxtaposition of Elbrook Dolomite with time-equivalent Nolichucky shales and Honaker dolomites of the Saltville block is the unique feature of the geology of the area north of Atkins and Groseclose which Butts in his earlier reconnaissance studies did not interpret correctly.

The actual course of the Pulaski fault trace where it veers southward away from Little Brushy Mountain toward Atkins is marked by tectonic breccias typical of the Pulaski fault zone. Since no breccias occur along the Hungry Mother fault to the southwest, which Butts considered the extension of the Pulaski fault in the Marion area, the localization of these unusual and distinctive breccias themselves corroborates the writer's relocation of the Pulaski fault in

the critical area northeast of Atkins.

The eastern extension of the Seven Springs thrust toward Rural Retreat, as shown on Butts (1933) map, probably does not exist (Fig. 2). There seems to be room for the full section of Conococheague and Elbrook formations on the south side of the Pine Ridge syncline so that no fault is necessary. The Elbrook-Conococheague contact is therefore considered a normal contact.

The narrowness of the corridor between the Saltville block and the Glade Mountains anticlinorium to the south crowds a great deal of complicated, faulting within an area little more than 1.5 miles wide. It is doubtful whether the correct interpretations of the local geology could have been worked out without the new and better topographic base maps on a scale of 1:24,000, which were published shortly before the writer began his study of the Marion-Rural Retreat area.

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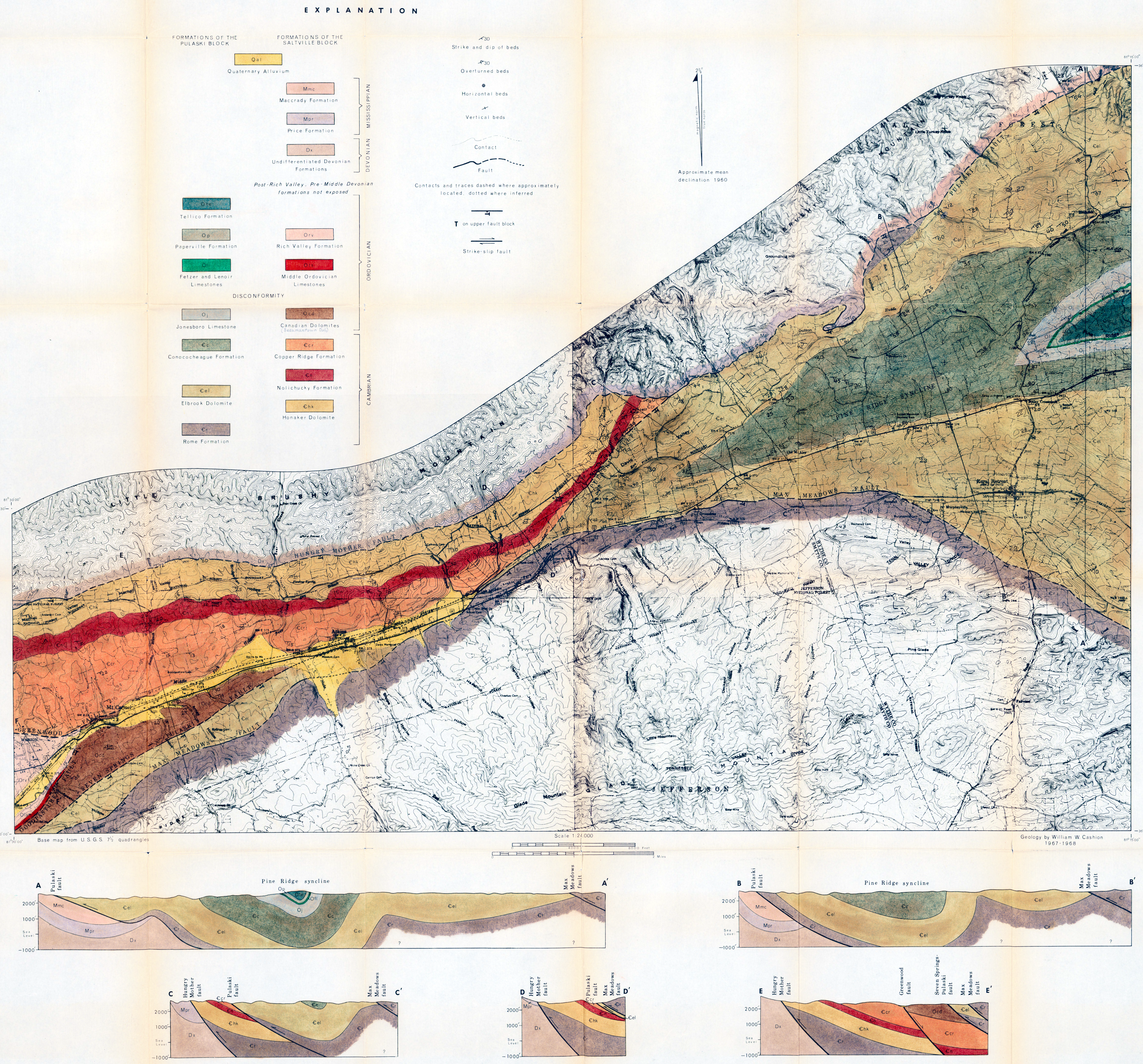
William Wade Cashion
Relation of Pulaski and Seven Springs faults in southwestern Virginia

GEOLOGIC MAP AND SECTIONS OF THE MARION-RURAL RETREAT AREA, SMYTH AND WYTHE COUNTIES, VIRGINIA



Geology by William W. Cashion 1967-1968

RELATION OF PULASKI AND SEVEN SPRINGS FAULTS
IN SOUTHWESTERN VIRGINIA

by

William W. Cashion

ABSTRACT

The Marion-Rural Retreat area of Smyth and Wythe counties, Virginia, contains the "missing link" to the long assumed, but heretofore unproven, continuation of the Pulaski fault trace southwestward around the structurally complex Marion dome area. The Seven Springs fault of Cooper (1936) has long been assumed to be the southwestward continuation of the extensive Pulaski fault; however, the linkage of these two faults was not established or understood.

Through detailed field mapping of mainly the Elbrook Dolomite, which is not known to exist northwest of the Pulaski fault block, and the time equivalent Honaker-Nolichucky succession, which is not known to exist southeast of the Saltville fault block, the writer has been able to delineate the trace of the Pulaski fault in this area.

The fault shown on Butts' (1933) "Valley Map" as extending east along the southeast base of Little Brushy Mountain from Marion to a point north of Groseclose, is not the Pulaski fault but instead a separate and distinct, high

angle reverse fault called by Cooper (1936) the Hungry Mother fault. Near the center of the area, the Pulaski fault passes over the Hungry Mother fault and veers south away from the base of Little Brushy Mountain toward Atkins, Smyth County, Virginia, where carefull mapping of the formations along the Valley of the Middle Fork of the Holston River affords a reliable criterion for joining the trace of the Pulaski fault with that of the Seven Springs fault.