GEOLOGY OF THE ADWOLF-THOMAS BRIDGE AREA, VIRGINIA

by

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INTRODUCTION

Location

The area described in this report is located in the central portion of Smyth County, south of Marion, Virginia (Fig.1). It is included in the 7 1/2-minute Marion, Virginia, Quadrangle (TVA 218-SE) mapped and edited by the Tennessee Valley Authority and published by the United States Geological Survey in 1958.

The area covers approximately 28 square miles, bounded on the north by the 36° 48' 45" parallel and on the south by the 36° 45' parallel. It is bounded on the east by the 81° 30' meridian and on the west by the 31° 37' 30" meridian.

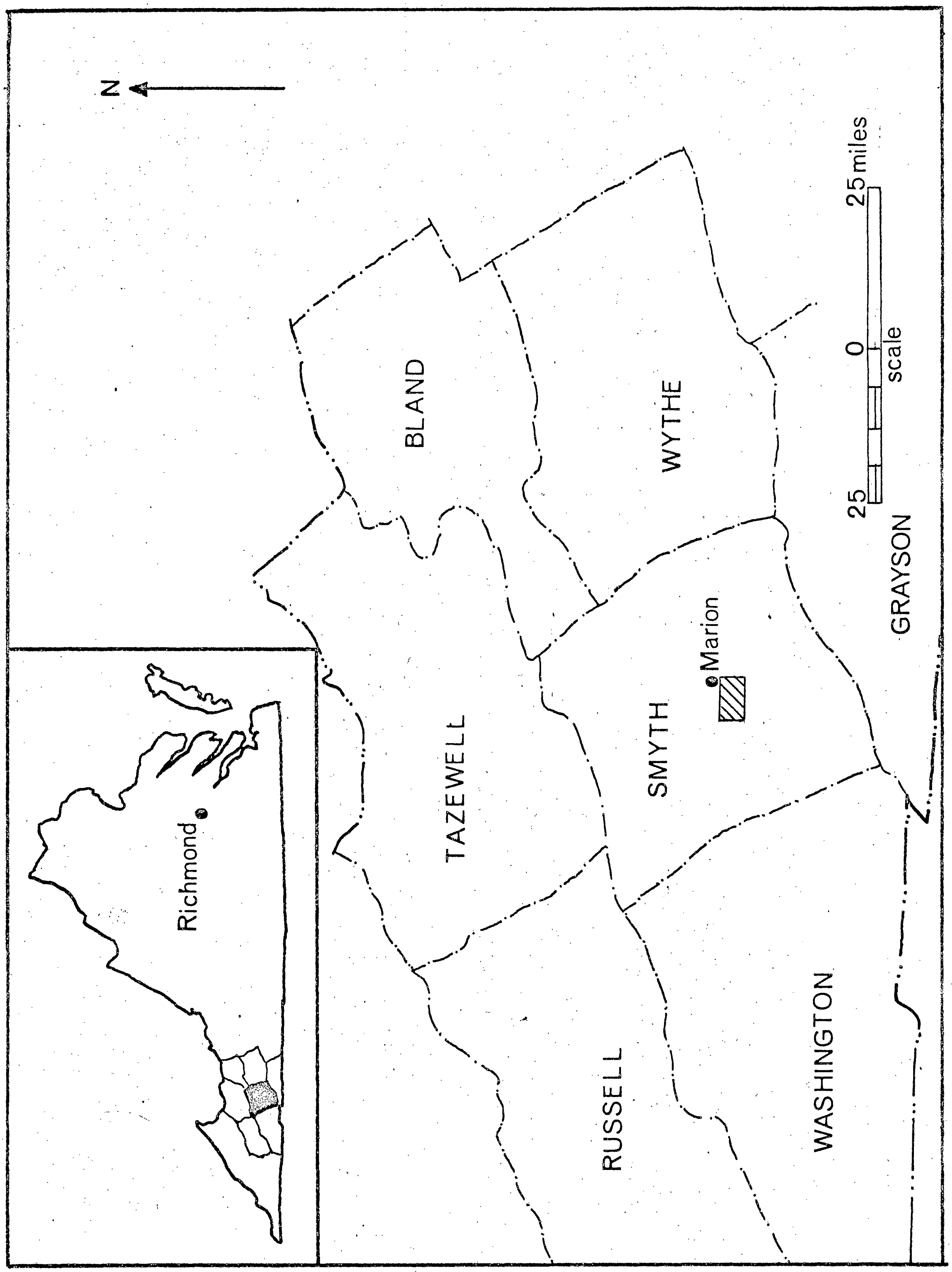
Purpose of the Investigation

The purpose of this investigation was to prepare a geologic map (Pl. 1) of the area and to construct geologic cross sections in order to depict the subsurface relationships; to study and describe rock units, to analyze the structure, and to interpret the geologic history.

Method of Investigation

Mapping of the Adwolf-Thomas Bridge area was done on the south half of the U. S. Geological Survey 7 1/2-minute topographic map of the Marion, Virginia area. The scale of this map is 1:24,000 or 1 inch equals 2,000 feet. Aerial photographs were used as an aid in the mapping. The geologic section was measured by means of a steel tape and Brunton compass.

Figure 1


N
BLAND
WYTHE
TAZEWELL
SMYTH
Marion
GRAYSON
RUSSELL
WASHINGTON
Richmond
25 miles
0
25
scale

Previous Work

Prior to this report several other workers had mapped this area in whole or in part. The earliest work was a topographic and geologic map by Boyd and Barnes (1899). Stose, Miser, Katz and Hewett (1919) did some work on the manganese deposits in the area. Cooper (1936) mapped the geology of the Marion dome which included a strip approximately a mile wide at the northern edge of this area. Butts (1940) mapped this area on a reconnaissance basis. Currier (1935) included the mountainous portion of this area in his work on the lead and zinc deposits of Virginia. Miller (1944) mapped roughly the same portion of the area.

Acknowledgments

The writer appreciates the advice of who suggested the project and also for his added help in arranging for transportation and other financial aid. The writer also thanks and for their advice and field assistance.

Drainage and Relief

The area is drained by the South and Middle Forks of the Holston River. A low drainage divide exists between these two streams which follows the structural trend of the area which is approximately N. 60° E. The two major streams are fed by smaller tributaries which have trellis drainage patterns.

North of Pond Mountain the streams drain into the Middle Fork. From Pond Mountain the divide strikes southwest through Adwolf down the axis of the Holston River syncline. South of Pond Mountain and the axis of the syncline, the streams drain into the South Fork of the Holston River.

Within the Holston River syncline the abundant sink holes indicate a highly developed system of underground drainage.

The highest point in the area is on Rich Mountain at the site of the Quebec Knob lookout tower. The elevation at this point is 3,627 feet. The lowest point is 1,981 feet near the gaging station on the Middle Fork of the Holston River at Seven Mile Ford in the northwestern corner of the area. The total relief is 1,646 feet.

Topography

The bedrock in this area shows marked control over the topography. There are three major types of bedrock in this area, carbonates (limestones and dolomites), shale and sandstone.

The areas underlain by carbonates have relatively low relief. The carbonates, predominantly the limestones, have developed karst topography and the dolomites to a lesser degree.

The topography developed on the shale consists of relatively steep-sided, round-crested hills which rise 300 to 400 feet above the intervening valleys. These hills are characteristically elongated in the direction of the strike and are held up by hard, fine-grained, thin-bedded sandstones.

The mountain ridges of the area are held up by sandstone interbedded with thin units of quartzite. The narrow, intervening valleys are underlain by dolomite. This situation results in a series of distinct, parallel ridges which strike northeast. The southeast side of the ridges are essentially dip slopes and the northwest sides, outcrop slopes, which are slightly steeper and more rugged. Very little bedrock crops out on the northwest slopes because of tremendous amounts of talus which in most areas covers the bedrock.

The South Fork of the Holston River presents an interesting problem in regard to its time and mode of development. The stream cuts through what are obviously anticlinal ridges in the eastern part of the area, and to the west across vertical beds without regard to structure.

Stratigraphy

General Statement

All the rocks in the area are sedimentary and marine formations ranging in age from Early Cambrian to Middle Ordovician.

The oldest unit exposed in this area is the Erwin Formation which is Early Cambrian in age and the youngest formation in the Chilhowee Group. The next younger formation is the Shady Dolomite which is also Early Cambrian in age and overlies the Erwin with apparent conformity. The Rome Formation overlies the Shady Dolomite, with apparent conformity. Overlying the Rome Formation is the Elbrook Dolomite which is Middle to Late Cambrian in age. The depositional contact between the Rome and Elbrook is gradational in most places; however, the contact is very commonly a fault contact. This fault probably has little stratigraphic displacement although large amounts of tectonic breccia occur along this contact.

Normally the red shales of the Rome Formation grade into argillaceous dolomite of the Elbrook Formation that weathers shaly. The Elbrook grades upward into the Conococheague Limestone which is Late Cambrian in age. The Conococheague Limestone and the Elbrook Dolomite are very similar lithologically, and it is difficult in places to map the contact between these formations. The Conococheague has the distinct characteristic of thin lenses of sandstone and it is at the first occurrence of this sandstone that the contact is drawn.

The next younger unit exposed in this area is the upper part of the Knox Group. The intervening formations, the Chepultepec Limestone and Longview Limestone, are not exposed in the area. The units that directly underlie the Middle Ordovician limestones are called the Knox Dolomite in this report.

Overlying the Knox Dolomite unconformably is a series of Middle Ordovician limestones of varying lithology and thickness. There is a major disconformity between the Knox Dolomite and the Middle Ordovician limestones in many places throughout the Appalachians.

The Middle Ordovician limestone succession is overlain by the Rich Valley shale which is Middle Ordovician in age and is the youngest unit exposed in this area.

Description of the Rocks

Cambrian System

Erwin Formation

Name and age. - The Erwin Formation, youngest unit in the Chilhowee Group, was named by Keith (1903) from exposures near Erwin, Unicoi County, in northeast Tennessee. The Erwin is Early Cambrian in age.

Distribution and thickness. - The Erwin Formation is the prominent ridge-maker in the area. It is exposed in a series of sub-parallel ridges. These ridges which trend northeast in the eastern part of the area range in elevation from 2,750 feet to 3,627 feet above sea level. These ridges are part of the group of ridges known as the Glade Mountains. The individual ridges are called, from northwest to southeast, Pond and Rich mountains, Dunford Ridge and Barton Mountain. There is also a small unnamed ridge at the southeast corner of the area.

Fault contacts on the northwest sides of all these ridges make it impossible to obtain an accurate measure of the thickness of the Erwin Formation. However, thicknesses up to 1,500 feet have been reported from other areas (Butts, 1940, p. 40).

Lithology. - The lower part of the Erwin Formation consists predominantly of yellowish-white to tan, fine- to medium-grained, massive-bedded sandstones and thin interbedded quartzites which are almost vitreous. The sandstones contain feldspar which on the outcrop is altered to kaolinite.

The Erwin also contains a unit of black, micaceous siltstone to fine-grained sandstone which is poorly exposed in most places.

The unit, about 15 feet thick, occurs about 75 feet below the Erwin-Shady contact. The unit is almost black where fresh but weathers yellowish-tan.

Above the micaceous unit the sandstone, mostly medium-grained, contains much coarse-grained material including large quartz pebbles ranging from .125 to .25 inches in maximum dimension which increase in abundance to the top of the formation where locally a quartz pebble conglomerate forms the topmost unit of the Erwin Formation. The upper sandstones also contain clay galls which have been partially weathered out leaving cavities in the rock ranging from 2 to 3 inches in maximum dimension. Interbedded with this lithology are beds of shaly, glauconitic sandstones. The entire unit, including the black, micaceous beds, about 75 feet thick, is probably equivalent to the Helenmode member of the Erwin, which was named by P. B. King and others (1944) for the Helenmode pyrite mine near Sadie in Stony Creek District, Carter County, Tennessee.

The clay galls in the upper part of the unit were probably derived from the clayey beds in the lower part of the unit. This would seem to indicate that parts of the underlying units were exposed to some sort of erosion, possibly submarine, while part of the overlying units were being deposited. Mild deformation, which served to expose the lower part of the unit to erosion, may have been taking place in the basin of deposition while sedimentation was going on.

Fossils. - Prior to this report the only fossils to be reported from the Erwin Formation were rare occurrences of Olenellus trilobites, Obollela brachiopods and abundant Scolithus, (Butts, 1940). The writer has found another group of problematical fossils in the Erwin.

Overlying the shaly micaceous unit approximately 75 feet from the top of the Erwin and underlying the uppermost massive pebbly sandstones, there is a unit approximately 15 to 20 feet thick which contains the heretofore undescribed fossils in large numbers.

The fossils are preserved as cylindrical external molds which are usually 0.25 to 0.5 inch in diameter and from 0.75 to 3.5 inches long. Most of the cavities have a slender rod of sand down the center of the cylinder. The rod is from 0.125 to 0.25 inch in diameter, depending upon the radius of the enclosing cylinder.

The new fossils are usually oriented parallel to bedding; however, there is no preferred orientation on the bedding surface. The fossils were probably originally calcareous, but the carbonate is not preserved. The sediment zone in which the fossils were preserved is a coarse-grained sandstone, and little or no external morphology has been preserved.

Although _Scolithus_ occurs in the massive sandstones both above and below this zone, the new fossils were never found associated with _Scolithus_ which may indicate that the environment which these new fossils occupied was different from that occupied by the _Scolithus_. The micaceous, sandy shale which occurs below the zone may indicate a quieter, possibly slightly deeper, environment than the coarser conglomeratic _Scolithus_-bearing sandstones which overlie the fossil-bearing zone. In this case the newly found fossil represents a type of organism that lived in a slightly deeper environment than _Scolithus_.

There is no way to determine with certainty what type of organism the newly found fossils represent. There are at least two possibilities.

The first is that these are sections of some sort of primitive plant which had a hollow or pithy stem; or possibly, a primitive echinoderm stem. More study on unweathered specimens, if they can be found, must be made before any positive identification can be attempted.

Although an accurate identification of these fossils would be desirable and helpful in the study of the ecology of Early Cambrian seas in this area, the major significance of these fossils is their use as a marker horizon in stratigraphic work. Although they have never been reported elsewhere, these fossils occur in all three major strike-belts of the Erwin in this area. This may indicate that they had considerable geographic distribution.

Shady Dolomite

Name and age. - The Shady Dolomite or Formation was named by Keith (1903) for exposures in Shady Valley, Johnson County, northeast Tennessee. It is Early Cambrian in age.

Distribution and thickness. - The Shady Dolomite crops out in a broad anticlinal pattern. The outcrop belt occurs at the base of Pond Mountain, strikes southwest along the base of the mountain, and swings to the east around the southwest end of the Glade Mountains. The Shady also crops out between each of the ridges in the Glade Mountains in a series of narrow belts that parallel the ridges. The Shady Dolomite underlies each of the valleys between these ridges.

No thickness can be determined for the Shady Dolomite in this area because the Shady Dolomite outcrop belts are bounded on one side by faults. Measured sections by King (1960) in northeasternmost Tennessee indicate that the Shady Dolomite has an approximate thickness of 1,000 feet.

Lithology. - The Shady Dolomite in the area is poorly exposed. At the base of the Shady Dolomite is a thin unit, not more than 30 to 40 feet thick, that consists of very coarse-grained sandstone and granule conglomerate which are carbonate-cemented. The clasts are well rounded. The carbonate cement was weathered away leaving a very porous sandstone which was subsequently recemented by iron and manganese oxides. Although this unit is poorly exposed, dark red to maroon float from the unit is quite common. Occurrence of float was the primary criterion for determining the Erwin-Shady contact. Above the basal sandstone is massive bedded, fine- to medium-crystalline, light- to medium-gray dolomite. About 600 feet north of McCarter Cemetery in the southeast corner of the area, about 75 feet above the base of the formation within the dolomite are large, angular, highly irregular masses of quartz. The quartz has an unusual texture. On a freshly broken surface the quartz, probably chert, appears to be crystalline. Some of the chert grades from white, coarsely crystalline silica on the outside to a dark-gray to black micro-crystalline chert.

Outcrops of the chert are rare, but in the soil cover over the Shady Dolomite chert is common.

The Shady Dolomite in this area contains a minor amount of blue-gray limestone interbedded with the typical dolomite. The limestone is very fine grained and weathers blue-gray.

The soil cover on the Shady Dolomite is of particular interest. It has been commonly, but incorrectly, called the "Shady residuum". The thick soil cover is characteristically a mahogany-red to yellow-clay which has, mixed with it, quartzite float from the Erwin ridges. It was originally thought that this soil cover was derived largely from the Shady Dolomite itself. This idea does not seem to be valid as there is not enough insoluble material in the Shady Dolomite to account for the total thickness of the cover. The dolomite is relatively pure except for the little chert. A more reasonable explanation is that the "residual" soil was derived in most part from the Rome and other formations which overlay the Shady Dolomite at one time. It is possible that, locally, a minor part of the "residuum" was derived from colluvial material from the Erwin ridges and from alluvial material deposited by the South Fork of the Holston River.

As the Shady Dolomite weathered away underneath, the soil cover was let down making room at the surface for further accumulation of material.

Rome Formation

Name and age. - The Rome Formation, Early Cambrian in age, was named by E. A. Smith, 1890, probably for exposures near Rome, Georgia.

Distribution and thickness. - The Rome Formation extends as a belt from 0.5 to 2.0 miles wide from the southwest corner to northeast corner of the area.

The Rome is a very incompetent unit and in almost every exposure it is folded into a series of very tight synclines and anticlines. Because of its structural complexity it was impossible to make an accurate measurement of the thickness of the Rome Formation. Butts (1940) has estimated that the Rome reaches a maximum thickness of at least 2,000 feet in southwest Virginia.

Lithology. - The Rome Formation consists of interbedded red, maroon, brown, and green shales, siltstones and fine-grained sandstones. These units range in thickness from a few inches to many feet. There are also minor beds of shaly dolomite and beds of black, massive, fine-grained dolomite up to four feet in thickness. Ripple marks and mudcracks are common in the shale.

Elbrook Dolomite

Name and age. - The Elbrook Dolomite was named by Stose (1906) from exposures in south-central Pennsylvania. The Elbrook Formation is mainly of Middle Cambrian age but does contain, at the top, fossiliferous beds which are Upper Cambrian.

Distribution and thickness. - The Elbrook Dolomite is the oldest formation that forms part of southwest-plunging Holston River Syncline. It has a roughly horseshoe-shaped outcrop pattern confined to the western half of the area. The Elbrook Dolomite is slightly more than 2,000 feet thick in this area. (See Geologic Section 1).

Lithology. - The Elbrook Dolomite consists largely of massive dolomite to thin-bedded argillaceous dolomite. The massive dolomite is irregularly interbedded with limestones. The lower 200 feet of the

Elbrook is the shaly dolomite and the remainder is interbedded limestones and dolomites with minor amounts of the shaly dolomite.

The limestones are commonly blue-gray, fine-grained, algal-matte types similar to the Maryville Limestone (See Geologic Section 1) member of the Elbrook.

The dolomites are fine- to medium-grained and light- to medium-gray. Some are shaly; some have vein carbonate. The Elbrook contains many stringers of black chert and an occasional Crypotozoan head. See Geologic Section I for a more detailed lithologic description.

There is much evidence of penecontemporaneous deformation in the Elbrook. There are numerous slump structures and micro-faults within the interbedded dolomites and limestones of the upper part of the formation.

One very interesting lithology that is not present in Geologic Section I, is the tectonic breccia or crush conglomerate that is found along the Rome-Elbrook contact and within the Elbrook Dolomite in several distinct zones along the northwest flank of the syncline occupied by the Elbrook beds.

These zones of brecciation are apparently a function of the lithology of the Elbrook and the angle of dip of the beds. On the southeast limb of the syncline in which the beds are vertical or nearly so, no brecciation occurs; however, on the northwest limb in which the beds have a lower angle of dip many zones of brecciation occur.

As pressure was applied to the sediments from the southeast the syncline began to form and eventually the southeast limb became overturned to the northwest while the northwest limb maintained a relatively low angle of dip making the beds more susceptible to movement between the beds. When this stage was reached the differential stress between the beds of the Elbrook was increased to a point where the weaker shaly beds ruptured and the slight movement between the beds resulted in what we not see as tectonic breccia within the beds.

Within the zones of brecciation, all gradations between relatively continuous masses of dolomite with the bedding still apparent to a well-rounded crush conglomerate are found. The large masses of dolomite with the bedding still apparent are shattered and cut with fractures. The fractures are filled with coarsely crystalline dolomite. With just a little more movement along this zone it is most probable that the masses would have fallen apart to form more breccia.

A typical exposure of this tectonic breccia is composed of thinly bedded, highly fractured dolomite mixed with a true crush conglomerate with individual clasts of dark-gray, buff-weathering dolomite up to 3 inches in maximum dimension in a matrix of dark-gray, finely granulated dolomite. The surfaces are commonly pockmarked as a result of large clasts weathering out.

The tectonic breccia was originally referred to by M. R. Campbell (1893) as stream-deposited conglomerate. His description was from exposures in the Elbrook Dolomite south of Peppers Ferry, along New River near Radford, Virginia.

Campbell (1925) revised his original name to breccia but his interpretation of these deposits was essentially the same.

Cooper (1939) made an extensive study of this type of breccia in association with the Max Meadows fault. He was the first to attribute the formation of the breccia to tectonic forces. Cooper (1940, 1946, 1959, 1961, 1964) in further study has emphasized the tectonic nature of this breccia.

Along those Rome-Elbrook contacts where brecciation occurs there may have been sufficient movement to have caused brecciation in beds that might not ordinarily have been susceptible to brecciation. However, where brecciation occurs within the Elbrook Dolomite itself, it may be stratigraphically controlled.

Conococheague Limestone

Name and age. - The Conococheague Limestone was named by Stose (1908) for exposures on Conococheague Creek in Franklin County, Pennsylvania. The Conococheague Limestone is Late Cambrian in age.

Distribution and thickness. - The Conococheague crops out in a roughly triangular pattern and occupies all the area of the Holston River syncline outlined by the upper contact of the Elbrook Dolomite. The next younger unit, the Chepultepec Limestone, is not exposed in the map area but is exposed farther southwest in the same syncline.

The full thickness of the Conococheague Limestone is not exposed in the map area. The actual total thickness may be greater than 2,000 feet.

Lithology. - The Conococheague Limestone is very similar to the

Elbrook Dolomite especially at the contact and for a hundred feet or so above the contact. The contact is gradational and except for the occurrence of sandstone in the Conococheague, the contact would be very difficult to recognize in this area. The lowest occurrence of sandstone is the basis for arbitrary determination of the Conococheague-Elbrook contact.

The Conococheague Limestone consists of interbedded fine-grained, blue-gray limestones and buff-weathering, light-gray, fine-grained dolomite. Locally, sandstone beds 1 to 2 feet thick occur at random through the sequence. In most places the sand occurs as 1 to 2 inch thick lenses of very limited lateral extent.

The sandstone was originally cemented with carbonate. The sandstone is the same blue-gray color as the limestone and it is difficult to distinguish from the surrounding limestone on freshly broken surfaces. Upon weathering the calcite is removed and the sand lenses stand out as ridges upon the outcrop. The color is changed to rusty-brown upon weathering and the sandstone becomes friable. The sandstone is fine- to medium-grained and some cross-bedding can be seen in weathered outcrops.

Some limestone beds contain thin argillaceous laminae which stand out as crinkly ribs on the surface of the exposures. The limestones also contain abundant algal structures. Associated with the algal structures are nodules of chert 4 to 5 inches in diameter which appear to be strung out along bedding surfaces. This type of chert was observed within 50 feet of the base of the formation. Other chert, mostly black and nodular, occurs higher in the formation. Much of the chert is oolitic.

There is much evidence of penecontemporaneous deformation in the Conococheague. Minor faults with displacement of a few inches and numerous slump features are evident in the lower parts of the formation.

The Chepultepec Limestone and Longview Limestone which overlie the Conococheague Limestone do not crop out in the area. They crop out further southwest in the Holston River syncline. The part of the Knox Dolomite Group which is exposed in the area could not be positively identified as to the specific formation, so it will be referred to as Knox Dolomite.

Ordovician System

Knox Dolomite

Name and age. - The Knox Dolomite was named by J. M. Safford in 1869 for exposures in Knox County, Tennessee. The Knox Dolomite, exposed in this area, is Early Ordovician in age.

Distribution and thickness. - The Knox Dolomite crops out at the northern limit of the map area in two belts that form the central portions of two anticlines, one of which runs parallel to the northeast-trending McMullin syncline and the other which forms a small south-trending anticlinal nose to the Marion dome.

Due to structural complications it was not possible to determine the thickness of the Knox Dolomite.

Lithology. - The Knox Dolomite consists of light-gray, massively bedded, fine- to medium-grained cherty dolomite which weathers brownish-gray. The outcrops are usually cross-hatched with minute fractures along which weathering has taken place more rapidly.

Chert is found in irregular masses. Where fresh it is light-gray and where weathered, white. It is abundant in the overlying soil cover.

Erosional Unconformity at the Top of the Knox Dolomite

The top of the Knox Dolomite is marked by the occurrence of an erosional break. At the end of Canadian time probable eustatic lowering of sea level exposed parts of the Knox surface to erosion. Local relief on this surface of disconformity of as much as 460 feet has been reported (Webb, 1959). When sea level was raised in Middle Ordovician time, chert and dolomite fragments were incorporated in the new sediments as clasts of a basal conglomerate in the lower areas on the surface of unconformity.

Directly overlying the surface of unconformity is a series of limestones collectively referred to as Middle Ordovician limestones.

Tumbez Formation

Name and age. - The Tumbez Formation was defined by B. N. Cooper (1925, p. 133) from a section 1 mile south of Tumbez, Russell County, Virginia. The Tumbez belongs to the Marmor Stage (Cooper, G. A. 1956, pt. 1, Chart 1).

Distribution and thickness. - The Tumbez Formation occurs sporadically along the Knox-Middle Ordovician surface which is exposed just south of McMullin. The belt of Middle Ordovician limestones, of which the Tumbez is a part, strikes essentially east-west. The Tumbez ranges in thickness from a feather edge to approximately 30 feet. It only occupies erosional troughs or depressions in the Knox.

Lithology. - The Tumbez includes in this area an unusual black, impure dolomitic sandstone, heavily laden with pyrite. The unit is 3 to 4 feet thick and crops out over a distance of approximately 65 feet. The unit may be the oldest Middle Ordovician unit yet discovered overlying the surface of unconformity.

The unit is very fossiliferous. There are few whole specimens but the unit is abundantly sprinkled with broken brachiopod shells. The fossils are poorly preserved inarticulate Lingula brachiopods. Some of the fossils are covered with a thin layer of pyrite. Above the basal unit are beds of pink calcarenites which are primarily composed of fossil fragments and numerous well-preserved specimens of two brachiopods, Rostricellula pristina and Mimella nucleus. Above these beds is about 20 feet of buff- to rusty-weathering, fine-grained, fossiliferous, argillaceous, magnesian limestone.

Mosheim Limestone

Name and age. - The Mosheim Limestone was named by Ulrich (1911) from Mosheim, a station on the Southern Railway 7 miles northwest of Greeneville, Greene County, Tennessee. The Mosheim Limestone belongs to the Marmor Stage (Cooper G. A., 1956, pt. 1, Chart 1).

Distribution and thickness. - The Mosheim Limestone overlies the Tumbez Formation and occurs in the same belt of Middle Ordovician limestones. It ranges from 5 to 50 feet thick.

Lithology. - The Mosheim Limestone is a dove-gray calcilutite. Locally, the formation contains abundant *Maclurites*, a large marine gastropod. Some incomplete specimens of a large straight cephalopod are also present.

The Mosheim is characteristically thick bedded and toward the base contains detrital chert derived from the underlying Knox Dolomite.

Giesler Limestone

Name and age. - The Giesler Limestone was named by B. N. Cooper (1961, p. 35) for exposures just west of the junction of Routes 80 and 745 in Washington County, Virginia, near Giesler Mill. The Giesler is equivalent to the Upper Lenoir. It is Middle to Late Marmor age. (Cooper, G. A., 1956, pt. 1, Chart 1).

Distribution and thickness. - The distribution of the Giesler Limestone is the same as the underlying Mosheim and Tumbez. The Giesler is approximately 100 feet thick.

Lithology. - The Giesler consists of dark-gray to black, fine- to medium-grained silty limestones. The unit also contains light-gray, very fine-grained to medium-grained limestones which on a weathered surface resemble the Mosheim Limestone, but they are coarser grained and more impure.

Arline Limestone

Name and age. - The Arline Limestone was named by G. A. Cooper and B. N. Cooper (Cooper and Cooper, 1956, pt. 1, pp. 41-43) for exposures along Gallagher Creek, two miles southwest of Arline, Loudown County, 20 miles southwest of Knoxville, Tennessee. The age of the Arline is considered by G. A. Cooper (1956, pt. 1, Chart 1) to belong to the earliest Porterfield stage.

Distribution and thickness. - The distribution of the Arline is the same as the underlying Middle Ordovician limestones. It is about 50 feet thick.

Lithology. - The Arline Limestone is composed of dark-gray to black, silty, impure limestone. It is fine- to medium-grained crystalline limestone. The unit is irregularly bedded and weathers into thin slabs or irregular cobbles.

Rich Valley Formation

Name and age. - The Rich Valley Formation was named by B. N. Cooper and G. A. Cooper (G. A. Cooper, 1956, pp. 86-87) from exposures in Rich Valley, south of Porterfield Quarry, Smyth County, Virginia.

Distribution and thickness. - The Rich Valley Formation crops out in several localities, all of which are located north of the Seven Springs Fault. The largest outcrop area is in a shallow basinal structure which includes McMullin. Around this basin are several minor erosional remnants which are completely surrounded by Middle Ordovician limestones. East of McMullin the Rich Valley Formation forms the center of a syncline plunging northeast. To the west next to the Seven Springs fault it crops out again in the center of an overturned syncline which plunges north. No thickness could be determined in this area, but the formation is probably about 850 feet thick (B.N. Cooper, 1936).

Lithology. - The Rich Valley Formation is composed of a series of black graptolitic shales which weather brown. In places, there are black, thin-bedded, fine-grained limestones or very calcareous shales present. The formation is highly fractured and folded. It weathers dark- to medium-brown and in some exposures the rock breaks up into elongate fragments formed by intense fracturing.

Structural Geology

The major portion of the area (Plate I) lies in what is called by Cooper (1936) the Glade-Pond Mountain shingle block. This shingle or thrust block is bounded on the north by the Seven Springs thrust fault. The major structural features of the block in the map area are the Holston River syncline which plunges to the southwest and the Glade-Pond Mountain anticlinorium which plunges to the northeast. Both of these structures nose out within this area.

North of the Seven Springs thrust fault is the Saltville thrust block bounded on the northwest by the Saltville fault.

Structures in the Saltville Fault Block

The structures in the Saltville block which are exposed in this area consist of a series of small synclines and anticlines. Except for the McMullin syncline these structures are unnamed. The trends of these folds do not follow the regional trend. They are minor structures on the southern flank of the Marion dome and are probably local adjustments to forces which formed the Marion dome.

<u>McMullin Syncline</u>. - The structure of greatest magnitude in this part of the Saltville block is the McMullin syncline. The syncline follows the regional trend which is northeastward. It is asymmetrical, northeast-plunging, and overturned to the northwest. Rich Valley shale forms the center of the syncline with Middle Ordovician limestones surrounding the Rich Valley shale.

<u>Other Synclines</u>. - West of the nose of the McMullin syncline is a broad synclinal structure. This fold is very open and its odd outline is probably due to erosion of flat-lying or gently dipping beds. The center of the structure is underlain by Rich Valley shale which is surrounded by Middle Ordovician limestones.

At the northwestern limit of the Seven Springs fault in this area is another minor overturned syncline which has Rich Valley shale at the center surrounded by Middle Ordovician limestone. The syncline plunges almost exactly north.

<u>Anticlines</u>. - A broad, open, southwest-plunging anticline which has Knox Dolomite cropping out in the center occurs west of the drive-in-theater along U. S. Route 11 southwest of the prison camp.

Another anticline occurs adjacent to the McMullin syncline on the southeast. The anticline is overturned to the northwest and trends northeast. The anticline has Knox Dolomite exposed at the center and Middle Ordovician limestones well exposed on the northwest limb. Except in one small area southeast of McMullin, the southeast limb of the anticline is covered by a fault slice of Conococheague Limestone which is caught under the Seven Springs thrust fault. At this place the slice of Conococheague is eroded back far enough to expose the Middle Ordovician limestones of the southeast limb. The anticline with the adjacent McMullin syncline may have been formed as a result of the Conococheague fault slice and the overlying Glade-Pond Mountain thrust block overriding these beds.

Seven Springs Thrust Fault

The surface of the Seven Springs thrust fault is overlain by Elbrook Dolomite. The Elbrook is thrust over beds as young as Middle Ordovician. In this area, however, a large fault slice of Conococheague Limestone underlies the Elbrook for most of the length of the fault trace. The Conococheague slice is thrust over Middle Ordovician rocks and the Knox Dolomite.

Possibly the Seven Springs fault block originally covered part of what is now the Marion dome which lies to the north of the fault trace. The rocks of the Saltville block lie north of a large embayment in the Glade-Pond Mountain thrust block.

The Glade-Pond Mountain block probably overrode the Marion dome in an early stage of its development. The dome was then raised higher causing the overlying rocks to be fractured and folded and subject to more rapid erosion. Erosion has exposed the portion of the Saltville block which is now exposed in this area. The formation in the Glade-Pond Mountain block on the southwest flank of the Marion dome strike directly into the trace of the Seven Springs fault and are terminated by the fault. This could only have occurred if the fault plane itself were curved, not by folding of the fault plane around the dome but by having the fault plane change its position and cut across beds higher in the moving block. The curve in the fault plane is probably a result of the fault block coming in contact with the Marion dome. This writer believes the dome acted as a buttress against which the Glade-Pond Mountain thrust block met considerable resistance to its northwest movement. The block met less resistance southwest and northeast of the dome and the beds advanced more readily.

Structures in the Glade-Pond Mountain Thrust Block

The major structures south of the Seven Springs thrust fault are the Holston River syncline and the Glade Mountain anticlinorium.

Holston River syncline. - The Holston River syncline, a broad asymmetrical fold which plunges southwest, has vertical or near vertical to slightly overturned beds along its southeast limb. The angle of dip along the southeast limb increases southwestward from the nose of the structure. Overturning to the northwest reflects a southeast direction of primary stress in many cases.

The Holston River syncline is defined almost entirely by Conococheague Limestone which is entirely surrounded by the older Elbrook Dolomite. The older Rome crops out on the southeast limb of the structure and at the nose seems to start its swing around to form part of the northwest limb where the syncline apparently loses its southwest plunge to become a non-plunging syncline trending northeast.

The Glade-Pond Mountain anticlinorium. - The Glade-Pond Mountain anticlinorium in this area consists of five anticlinal ridges composed of Erwin sandstone surrounded by Shady Dolomite. The anticlinal ridges strike northeast and plunge southwest under Shady Dolomite. The Shady Dolomite plunges to the southwest under the Rome Formation.

The anticlinal ridges are all broken on their northwest limbs by reverse faults. During the formation of the major anticline a series of small anticlinal folds formed on the southeast limb of the anticline. As pressure from the southeast continued, the smaller anticlines eventually broke along their northwest limbs forming reverse faults.

It is not possible to measure the dip of the reverse faults. There is at least one outlier of the Erwin Formation to the northwest of Pond Mountain which appears to be a landslide block. The attitude of the beds within the outlier are almost at right angles to the beds on Pond Mountain. The block probably broke away from Pond Mountain and moved downslope, rotating as it moved. There is no good evidence on which to base an estimation of the dip of the faults which occur on the northwest sides of the mountain ridges. However, it may be assumed that since all these ridges are similar in structure, their bounding faults may also have a similar attitude. Since the contact lines V only slightly in the direction of dip this would seem to indicate that the faults have a rather high angle of dip. (See Structure sections A-A', B-B', Plate 1).

At the southwest ends of the ridges there is evidence that they were originally southwest plunging anticlines. The basal Shady sandstone unit which gives rise to conspicuous float can be traced along the southeast slopes of all the ridges and around the ends in the case of Pond Mountain and a small unnamed ridge at the southeast corner of the map. The evidence for these ridges being anticlinal is best shown on the southeast side and around the southwest end of Pond Mountain. The basal Shady sandstone is easily traced as float and occasional outcrop along the southeast side of the ridge. It can be traced around the end and for about 2,000 feet along the northwest side of the ridge but is not exposed further to the northeast because the Erwin sandstone has been thrust over it.

Within 2,000 feet of the end along the northwest side of Pond Mountain the basal Shady sandstone disappears, presumably into the subsurface under the Erwin sandstone.

Since the nose of the anticline is preserved and the rest of the northwest flank faulted, it is evident that the movement along the more northeasterly part of the fault was greater than further southwest. Assuming that the primary deforming force was directed in general from the southeast, then the deforming force had to be greater to the northeast or some local conditions kept the more southwesterly portions of these blocks from moving forward. If the Marion Dome had been present before the faulting took place, then it could have acted as a buttress impeding the northwest movement of the block. Farther to the northeast the movement was not impeded as much and greater displacement occurred in that direction.

<u>Other Faults in the Glade-Pond Mountain anticlinorium</u>. - There are three other minor faults in this structure which do not fit into the

general picture of anticlinal folds cut by faults. The first of these is a small normal fault on the north side of Rich Mountain just below Paint Creek. The next is a nearly-east striking reverse fault that cuts Dunford Ridge. The fault occurred during the early stages of the formation of Dunford Ridge. As the anticline and subsequent fault on the northwest side of the ridge was forming, this cross fault developed. The part of the ridge northeast of the fault was not subject to as much displacement as Dunford Ridge proper. Both parts of the ridge were displaced to the northwest.

The trace of a reverse fault is exposed in Possum Hollow on Barton Mountain. Possum Hollow was probably formed as a result of a zone of weakness caused by this fault. It is confined to the Erwin Formation and repeats a part of the section. Miller (1944) in his map of this area has indicated the presence of several faults for which the writer could find no evidence. He also mapped several thin quartzite units in the Erwin Formation which the writer was not able to find. The exposures on the Erwin ridges of the Glade Mountains are relatively poor and so thin units as those mapped by Miller cannot be traced and mapped.

Local Domal Structure in the Rome Formation

In the Rome Formation about 1 mile southeast of Holston Mill is an elongate zone which contains float of many different rock types, most of which are various forms of chert.

The majority of the chert float is of a peculiar type which has been described in the transition zone between the Rome Formations and the Shady Dolomite. Also large concentric banded chert nodules that resemble Cryptozoon structures are relatively abundant.

The structure is an erosional inlier in the Rome which exposes the transitional zone indicating the proximity of the Shady Dolomite to the surface.

The inlier is the result of eroding through a small asymmetrical anticline which involves both the Rome Formation and Shady Dolomite.

Along Roland Creek the Shady Dolomite dips at about 25° northwest under the Rome. There are no outcrops in the inlier and the identification of transitional Rome was made on the similarity of chert types and structural relationships.

Rome-Elbrook Contact. - The Rome-Elbrook contact is of structural interest. Along this contact are two cross faults which may indicate some differential movement. Northeast from the cross-fault west of Horseshoe Bend there has been significant movement between the Rome and Elbrook. The Rome has been thrust to the northwest over the Elbrook Dolomite. This is evidenced by a narrowing of the Elbrook outcrop belt to the northeast even though the dip is lower in this area than to the southwest where it is vertical or near vertical.

There are also outcrops of fault breccia along the contact northeast of Horseshoe Bend. Southwest of Horseshoe Bend there is very little breccia.

If the amount of fault breccia may be used as an indication of the amount of movement along a fault, then there is increasing movement northeast from Horseshoe Bend and little or none southwest from that point.

Geologic History

The oldest rocks exposed in this area are those of the Erwin Formation. It was deposited during Early Cambrian time. The unit, predominantly sandstone, was probably deposited in a relatively shallow near-shore environment. This is indicated by the presence of ripple marks and mud cracks on some bed within the formation.

There is evidence within the Erwin Formation that even as early as Lower Cambrian time some deformation was taking place within the basin of deposition. Below the uppermost conglomeratic sandstone of the Erwin is a series of silty, micaceous shale beds. Clay galls, presumably from this series of shale beds, are present in the overlying sandstone indicating that the shaly beds must have been exposed to erosion. The debris was incorporated into the overlying sediment because of a rapid influx of coarser clastic material.

The change from sandstone sedimentation of the Erwin to carbonate sedimentation of the Shady is gradational. The transition is recorded as a bed of dolomite-cemented sandstone approximately 40 feet thick. The transition zone is overlain by a thick sequence of massive-bedded dolomite.

With the beginning of Rome deposition, large amounts of clastic material were once again deposited in the Lower Cambrian sea. A thick red soil had probably developed on the source area. The red soil is the probable source for the red color characteristic of the Rome Formation.

Ripple marks and mud cracks in the shale and sandstone indicate that the majority of the sediment was deposited in shallow water and that some areas were subject to occasional drying.

Middle Cambrian time is represented by the Elbrook Dolomite composed of limestones and dolomites which are argillaceous or interbedded with shale. Influx of minor amounts of fine-grained clastic material continued although more abundantly at some times than others.

Late Cambrian time is represented by the Conococheague Formation. This interbedded limestone and dolomite formation contains sandstone beds and lenses. Essentially the same conditions prevailed in the basin of deposition as during the time the Elbrook was being deposited. The major difference is that the Conococheague Limestone has much more limestone and thin lenses and beds of fine- to medium-grained sandstone.

The Conococheague Limestone is the youngest Cambrian unit exposed in this area. The next younger unit exposed in this area is the Knox Dolomite of Lower Ordovician age. The Chepultepec Limestone and Longview Limestone which were deposited between the Conococheague and the upper Knox units are present farther southwest in the Holston River syncline but do not crop out in this area. The Knox Dolomite contains little or no clastic material.

After the deposition of the Knox, lowering of sea level, probably eustatic, left the beds exposed to subaerial erosion. The surface of unconformity attained relief of up to 460 feet (Webb, 1959). As the sea returned in Middle Ordovician time the valleys on this surface were first to be filled with water and to become sites of deposition. Debris from the highs was washed into the lows and formed the first sediments of Middle Ordovician time.

These beds are locally reddish-brown and sandy and contain clasts of detrital chert, derived from the underlying Knox. As the sea continued to encroach upon this surface the highs were washed clean and as the water deepened, the high parts of the surface of erosion were overlain by beds of fine-grained, high calcium limestones. The series of basal Middle Ordovician limestones may pinch out against the high areas on the surface of unconformity.

Above the basal units a relatively thin succession of limestones was deposited. The become more impure toward the top.

The last episode of sedimentation recorded in this area was the deposition of black graptolitic shale of the Rich Valley Formation of Middle Ordovician time. The shale was deposited in a reducing environment.

The age of deformation in the Appalachians has long been a subject for discussion. It is well established that sedimentation and some deformation occurred simultaneously. In the area discussed in this report, especially in the Conococheague Limestone, Elbrook Dolomite and Middle Ordovician limestones there are micro-faults and slump structures that bear this out.

The inception of the major folds was probably early in the depositional history of the area and the later tectonic forces which acted from the southeast served to amplify them into the structures exposed today.

The episode of major tectonic activity which resulted in the folds and thrust faults probably started very early but did not reach its fullest expression until after the deposition of the Mississippian formations which occur to the north of the area. The Mississippian formations are involved in the faulting and folding.

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APPENDIX

SECTION OF ELBROOK FORMATION
(Strike: N. 41 E.; dip vert to 80° NW.)
Measured by B. N. Cooper and writer

		(Feet)
Conococheague Formation (upper 220 feet exposed)		
Elbrook Formation (2,037 feet)		
1.	Limestone, blue-gray, algal-matte type, with intercalations of fine grained, medium-gray dolomite; interval very poorly exposed; top contact fairly closely established.	190
2.	Limestone, dark-blue-gray, thick bedded, partly algal-matte limestones that are strongly magnesian	165
3.	Dolomite, thin bedded, medium-gray, some slightly shaly	75
4.	Dolomite and limestone, some millimeter-laminated, weathers shaly	100
5.	Dolomite, fine-grained, gray, straticulate, has very hackly fracture	80
6.	Covered	98
7.	Limestone, algal-matte type, magnesian, blue-gray with buff-weathering dolomite partings (very irregular); several thin zones of intercalated dolomite of gray to black color; minor chert in a few layers	109
8.	Same as above	98

9.	Limestone and dolomite: about two-thirds of interval are straticulate gray dolomite with penecontemporaneous slump faults or micro-faults; remainder of interval consists of blue-gray, algal-matter-type limestones that are rather strongly magnesian	90
10.	Limestone, blue-gray, algal-matter type (Maryville) with intercalated zones of very fine-grained gray dolomite; few beds of blocky, tabular, magnesian limestone, heavily sprinkled with vein carbonate	98
11.	Same as above	69
12.	Dolomite, light-gray, very shaly and silty; decalcifies to shale of buff color; chips are tabular to paper thin; no sign of any crackling or brecciation or rotational dismemberment of the beds	423
13.	Dolomite, buff-gray to blue-gray, weathered, very shaly as in overlying unit	140
14.	Dolomite, dark blue-gray, medium grained, looks like Honaker dolomites, some vein carbonate	77
15.	Dolomite, mixture of platy-weathering, gray type and blue-gray, thick-bedded type	215
16.	Dolomite, dark blue-gray, brecciated (autobrecciated)	10

Rome Formation (several hundred feet exposed)

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GEOLOGY OF THE ADWOLF-THOMAS
BRIDGE AREA, VIRGINIA

by

L. J. Aiken

ABSTRACT

The Adwolf-Thomas Bridge area of Smyth County, Virginia is underlain by Paleozoic rocks that crop out in northwest-trending belts. The formations that are considered in this study include in ascending stratigraphic order, the Erwin Formation, Shady Dolomite, Rome Formation, Elbrook Formation and Conococheague of Cambrian age and the uppermost Knox Dolomite, Tumbez Formation, Mosheim Formation, Giesler Limestone, Arline Limestone and Rich Valley Formation of Ordovician age.

The area is structurally complex. The southeast dipping Seven Springs thrust brings Late Cambrian rocks of the hanging wall into contact with rocks as young as Middle Ordovician age in the Saltville thrust block.

The Holston River syncline and the Glade-Pond Mountain anticlinorium form the area southeast of the Seven Springs fault. The Holston River syncline is an asymmetrical, southweat-plunging syncline in rocks of Cambrian age. The Glade-Pond Mountain anticlinorium is also confined to rocks of Cambrian age and is complicated by a series of small anticlines which have been broken on their northeast limbs by southeast dipping reverse faults.

Sands and carbonates were the predominant sediments deposited in Cambrian and Early Ordovician time. In Middle Ordovician time, both

carbonates and clayey muds were deposited. As no Silurian or younger Paleozoic sediments are present, it is not known when sedimentation ended.

Deformation, perhaps in part contemporaneous with sedimentation, appears to have been climaxed in Mississippian time after sediments of this age were deposited in the area considerably to the north of the area discussed in this report (Butts 1940).

GEOLOGIC MAP AND SECTIONS OF THE ADWOLF-THOMAS BRIDGE AREA, SMYTH COUNTY, VIRGINIA

BY
LEWIS J. AIKEN
1967

EXPLANATION

ORDOVICIAN

- Orv — RICH VALLEY FORMATION
- Ols — MIDDLE ORDOVICIAN LIMESTONES: Arline, Geisler, Mosheim, and Tumbez Formations
- Ok — KNOX DOLOMITE

CAMBRIAN

- €c — CONOCOCHEAGUE LIMESTONE
- €el — ELBROOK DOLOMITE
- €r — ROME FORMATION
- €sh — SHADY DOLOMITE with basal sandstone
- €e — ERWIN FORMATION

Reverse Fault
T on upper plate
Strike and dip of beds
Horizontal beds
Overturned beds
Contact lines, dashed where inferred or approximately located

Scale 1:24000

0 1 2 Miles

Contour Interval 20 Feet