

GEOLOGY OF THE GLENVAR AREA,
" ROANOKE COUNTY, VIRGINIA

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INTRODUCTION

Location of Area

The Glenvar area is in the Roanoke Valley, Roanoke County, Virginia (Figure 1). The area mapped is bounded on the north by the crest of Fort Lewis Mountain, on the west by the Roanoke-Montgomery County line, on the south by the lower part of Poor Mountain, and on the east by $80^{\circ}06'30''$ west longitude. The area lies within the Valley and Ridge Province of the Southern Appalachians with the exception of Poor Mountain which is in the Blue Ridge Province.

U.S. Highway 11 traverses the area from northeast to southwest and Interstate 81 extends from the eastern border of the area to a point approximately two miles southwest of Glenvar. Construction, currently underway, will extend Interstate Route 81 across the area essentially parallel to U.S. Highway 11.

Several state and private roads lead northwest and southeast from U.S. Highway 11 but most of these roads terminate either at the base of Fort Lewis Mountain to the north or Poor Mountain to the south. Only the Smith Gap fire trail provides access to the crest of Fort Lewis Mountain, and only State Route 612 reaches the crest of Poor Mountain. The only other access to these mountainous portions of the area is by foot.

Purpose of Investigation

The purpose of this investigation was to interpret the structural development of the area. In order to do this, the areal geology was mapped at a scale of 1:24,000.

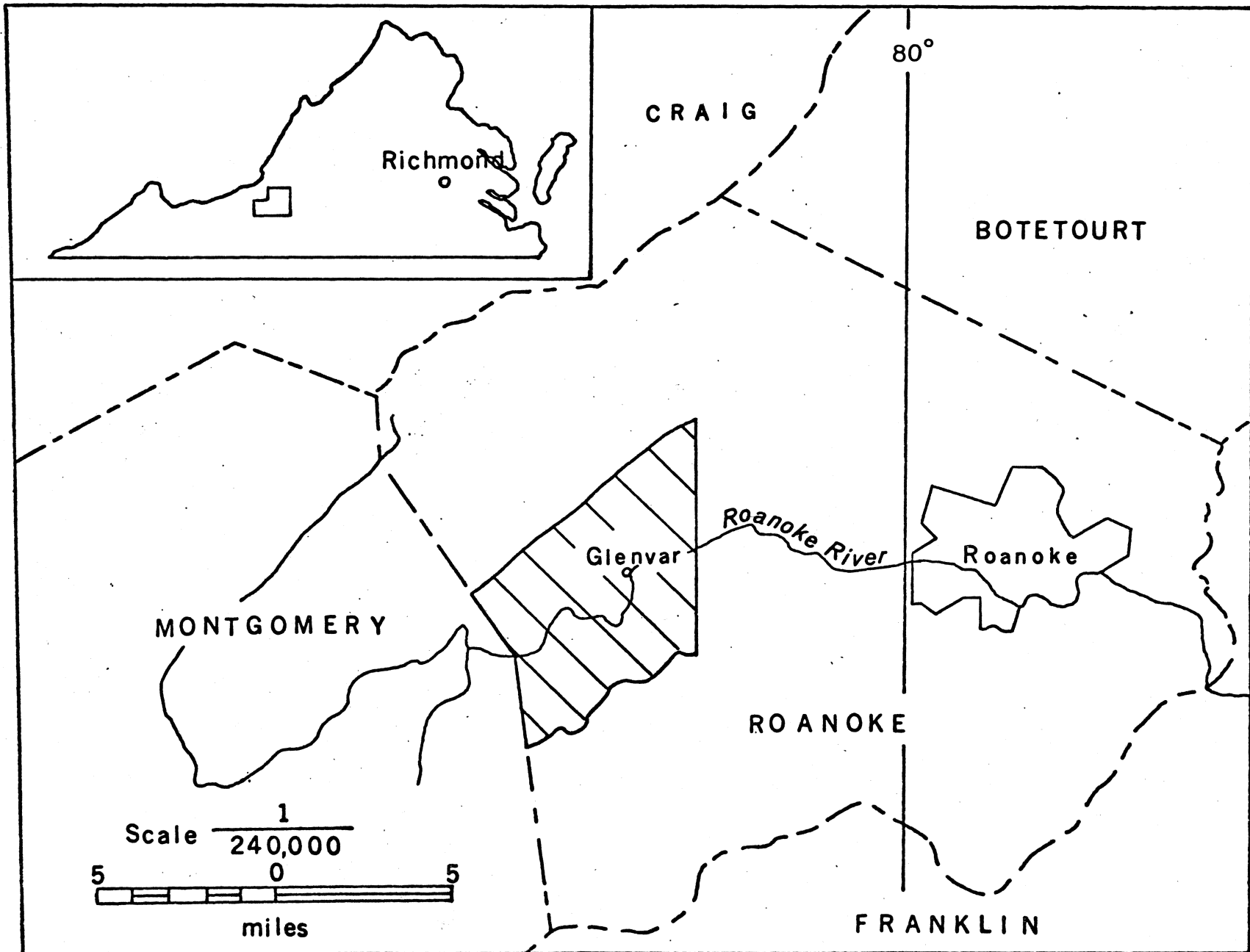


Figure 1. Index Map of the Glenvar Area, Virginia

Particular attention was focused on the arcuate body of rocks along the base of Fort Lewis Mountain between Stypes Branch and the western border of the area (Plate 1).

Mapping was done on aerial photographs and portions of topographic maps of the Glenvar, Salem, Elliston and Bent Mountain 7-1/2 minute quadrangles, published by the United States Geological Survey in 1963. All measurements, unless indicated otherwise, were made by means of tape and Brunton Compass.

Previous Work

Woodward (1932) included the entire Glenvar area in his 1:125,000 scale map of the Roanoke area. The area is also included by Butts (1933) in his map of the Appalachian Valley of Virginia published at a scale of 1:250,000. Barlow (1936) mapped all but the extreme southwestern corner of the Glenvar area for his report on the geology of the Salem area. His map is to a scale of 1:62,500. Edwards (1959) included the entire area of this report on his map, to a scale of 1:30,680. Recent work in the Catawba syncline was done by Hazlett (1968) and Amato (1968), who mapped areas to the northeast of the Glenvar area and by Eubank (1967) who mapped an area to the east. Tillman and Lowry (1968) discussed the structure and Paleozoic history of the Catawba (Salem) syncline. The area described by Shufflebarger (1953) adjoins and slightly overlaps the Glenvar area along its southern boundary. Dietrich (1954) mapped the area adjoining the Glenvar area on the southwest.

Geographic Features

The entire valley and adjacent mountains are drained by the Roanoke River, which flows from southwest to northeast through the central portion of the area. The course of the river is very sinuous and for the most part bears no relation to geologic structure. The river drops approximately 140 feet between the point at which it enters the area and the point at which it leaves. Several minor tributaries flow into the Roanoke River from the slopes of Fort Lewis Mountain to the north and Poor Mountain to the south.

Relief in the area is slightly more than 2,200 feet. The lowest point is on the Roanoke River at the eastern margin of the area where the elevation is 1,020 feet. Less than four miles away near the radio towers above Big Bear Rock Gap, the crest of Fort Lewis Mountain is 3,260 feet above sea level. A mile beyond the southern boundary of the map, Poor Mountain in the Blue Ridge Province rises to an elevation of 3,784 feet. Within the valley of the Roanoke River the local relief is moderate, approximately 680 feet.

The topography is distinctly linear and parallel to the general northeastern structural trend. This is evident not only in the two mountains that border the Roanoke Valley on the north and south, but even in the broad, rolling valley itself. Only the narrow flood plain of the Roanoke River is sufficiently alluviated to obscure the dominant structural trend.

The mountainous areas are densely forested and so is part of the valley floor. Near U.S. Highway 11 the cleared portions of the valley floor are suburban housing developments; elsewhere they are pasture

land. Only the flood plain portion of the valley supports farms of any size.

Exposures are common along roads, streams and railroads, but outcrops are rare in woods or open fields away from streams. Two quarries, both in the Cambrian Elbrook Formation, provide additional exposure. Alluvium and colluvium cover much of the area along the base of Fort Lewis and Poor mountains and the flood plain of the Roanoke River. A rather detailed description of these surficial deposits is given by Edwards (1959).

STRATIGRAPHY

General Statement

The rocks cropping out in the Glenvar area are entirely sedimentary and range in age from Early Cambrian to Early Mississippian. The oldest rocks in the area are exposed along the base of Poor Mountain, where the Lower Cambrian Unicoi Formation has been thrust northward upon the younger Lower and Middle Cambrian Rome Formation. The Rome Formation underlies the rolling portion of the Roanoke Valley approximately as far north as the Roanoke River, where it in turn has been thrust to the northwest upon the Elbrook Formation of Middle and Late Cambrian age. The subdued topography of this northern portion of the valley is developed on the Elbrook Formation. Devonian shale and sandstone capped by the Lower Mississippian Price Formation form the bulk of Fort Lewis Mountain, but the belt of foothills at the base of this mountain between State Routes 777 and 778 are developed on a section ranging in age from Late Cambrian to Middle Devonian. Included in this belt, much reduced in thickness, are Knox Dolomite, Effna Limestone and the Liberty Hall, Bays and Martinsburg formations, all of Ordovician age; Silurian sandstone; and Devonian age Huntersville Chert, Ridgeley Sandstone and Millboro Shale.

Cambrian System

Unicoi Formation - The Unicoi Formation of Early Cambrian age was named by Campbell (1899) for exposures in Unicoi County, Tennessee. The Unicoi crops out along the base of Poor Mountain, at the southern margin of the area mapped, where the Unicoi has been thrust toward the northwest upon the Rome Formation. Only that portion of the Unicoi that lies directly adjacent to the fault has been examined by the writer. Shufflebarger (1953) described the Unicoi Formation in some detail.

The conglomerate and arkosic sandstones of the Unicoi are the only portion of the formation cropping out within the mapped area. These sandstones and conglomerates are exposed in stream cuts 0.15 mile south of the Y.M.C.A. Camp on State Route 649. Excellent exposures of the sandstones, conglomerates and overlying basalts are found along State Route 612 1.1 miles south of the Wabun Bible Chapel. Shufflebarger (1953) has shown this basalt to be the lower basalt of the Unicoi Formation.

The Unicoi Formation consists of green to greenish gray, thick-bedded, impure sandstones and conglomerates and greenish-gray basalts. The conglomerates are dominantly quartzose but some contain appreciable feldspar. Some of the quartz pebbles are as much as 0.75 inch in diameter. Both the conglomerates and sandstones show pronounced pressure effects including crushing and pressure welding. The basalts contain appreciable chlorite and locally are amygdaloidal.

Rome Formation - The Rome Formation of Early Cambrian age was named by Hayes (1891) for exposures near Rome, Georgia. It crops out

in the Glenvar area from the base of Poor Mountain roughly as far northeast as the Roanoke River. The Rome is bounded on the southeast by the Blue Ridge fault and on the northwest by the Max Meadows fault. The Shady Dolomite, which normally underlies the Rome does not crop out in the area, but the fact that it crops out in a re-entrant in the Blue Ridge fault near Roanoke (Woodward, 1932) indicates that it is probably present beneath the Blue Ridge thrust sheet. The Erwin Quartzite and Hampton Shale, which normally underlie the Shady Dolomite and overlie the Unicoi Formation, do not crop out in the Glenvar area, but they do crop out higher on Poor Mountain.

The Rome consists of red, reddish brown and green shales and siltstones and thin- to medium-bedded dolomites. Some gray and black thickly bedded dolomites are present as well. The formation is intensely folded and faulted. The axial planes of the folds and the fault planes dip consistently to the southeast. Several breccia zones are present within the Rome. An excellent exposure of breccia occurs along the Norfolk and Western Railroad cut between Wabun and Riverside. Along this same cut a thickly bedded dolomite unit nearly 60 feet thick is well exposed. This unit is nearly identical in appearance to many of the dolomites in the overlying Elbrook Formation. This may indicate that it is high in the Rome Formation not far below the contact with the Elbrook Formation. Woodward (1932) estimates the Rome Formation to be at least 900 feet thick in this area.

The only fossil found in the formation is Olenellus romensis Resser and Howell (Butts, 1940). This Early Cambrian trilobite occurs in dolomitic siltstones exposed along State Route 639 0.15 mile east of Beamer Cemetery.

Elbrook Formation - The Elbrook Formation of Middle and Late Cambrian age was named by Stose (1906) for exposures in a quarry near the town of Elbrook, Franklin County, Pennsylvania. The formation crops out in a belt as much as 1.75 miles wide between the Roanoke River and the base of Fort Lewis Mountain where it forms the lowest, flattest portion of the valley floor. The Elbrook is bounded on the southeast by the Max Meadows fault and on the northwest by the Salem fault.

The Elbrook consists of blue to blue-gray, medium- to thin-bedded, fine-grained dolomites, argillaceous dolomites and green dolomitic shales. White chert occurs in connection with poorly defined algal structures in a road cut along U.S. Highway 11 0.12 mile northeast of Riverside.

The formation is cut by numerous faults and shear zones, particularly near the Salem fault where the more thickly bedded dolomites are cut by calcite-filled fractures and the shales are virtually converted into fault gouge. An excellent exposure of fault breccia occurs in the stream 10 yards north of the old gravel quarry along Stypes Branch, where the Elbrook is brought into contact with the Knox Dolomite across the Salem fault to the northwest. Tectonic breccia is also well exposed in a recently developed quarry on State Route 778 0.1 mile north of the point where the telephone line crosses this road. Such brecciated zones are not confined to the portions of the Elbrook adjoining the Max Meadows and Salem faults, but occur sporadically throughout the formation.

With the exception of several algal structures, no fossils were found in the Elbrook. Though natural exposures of the formation are

present along the Roanoke River and within Dixie Caverns, the formation is better exposed along road cuts on U.S. Highway 11 and at the quarries on State Route 778 and 0.55 mile northeast of Riverside.

Ordovician System

Knox Dolomite Group - The Knox Dolomite of Late Cambrian and Early Ordovician age was named by Safford (1869) for exposures in Knox County, Tennessee. The Knox outcrop belt is bounded on the southwest by the Salem fault along which the older Elbrook formation has been thrust northwestward upon the Knox. The Knox is overlain unconformably by the Effna Limestone, or where the Effna is absent, by the Liberty Hall Formation. The upper contact of the Knox is a prominent unconformity with a minimum of 30 feet of the relief as indicated by discontinuous channel fills of Effna in the Glenvar area.

Approximately 300 feet of Knox Dolomite is exposed in Stypes Branch. The portion of the Knox adjacent to the Salem fault is highly brecciated. This brecciation has obscured the bedding and the weathered outcrops have a massive appearance. The formation consists for the most part of medium-gray, thick-bedded, fine-grained dolomite with minor amounts of black chert at certain horizons.

In Stypes Branch, approximately 60 feet below the upper contact of the Knox Dolomite a medium-gray, thick-bedded, finely crystalline limestone crops out in the stream bank. The presence of gastropods, presumably Lecanospira, in characteristic lithology indicates that this unit is the Longview Limestone of Early Ordovician age. Therefore, the Knox Dolomite exposed in the Glenvar area probably belongs entirely to the upper part of the Knox Dolomite of Early Ordovician age. The thickest section of Knox in the Glenvar area occurs along the first drainage southwest of Stypes Branch, where the formation is approximately 500 feet thick. Neither the unconformity at the top of the Knox Dolomite nor Longview Limestone are exposed in this stream.

Effna Limestone - The Effna Limestone of Middle Ordovician age was named by Cooper (1944) for exposures near Effna, Bland County, Virginia. Edwards (1959) applied the name Effna to the light gray, fossiliferous calcarenite exposed in Stypes Branch because it is lithologically and faunally similar to the type Effna. The same formation crops out in the stream beside the Smith Gap fire trail. At both localities the Effna disconformably overlies the Knox Dolomite, and the black shales of the Liberty Hall Formation overlie the Effna.

In Stypes Branch the Effna occupies a channel developed on the Knox. There is 15 feet of Effna Limestone on the northeast bank of the stream and three feet on the southwest bank. These two exposures are no more than 15 feet apart which indicates clearly the marked irregularity of the erosion surface. Angular clasts of reworked Knox Dolomite, up to two feet in maximum dimension, along with subangular clasts of black chert, as much as three inches across, mark the contact of the Effna with the underlying Knox in Stypes Branch.

In the stream beside the Smith Gap fire trail the Effna is poorly exposed. The formation is approximately 10 feet thick and consists of light gray calcarenite. The unconformity below the Effna is covered at this locality. No other exposures of the Effna occur in the Glenvar area. It is absent in the stream beside State Route 778 and in the first drainage northwest of Stypes Branch; it may be absent elsewhere.

Liberty Hall Formation - The Liberty Hall Formation of Middle Ordovician age was first named by Campbell (1905) for exposures near the historic ruin of that name at Lexington, Virginia. The formation crops out along the southeastern base of Fort Lewis Mountain. It overlies the

Knox Dolomite disconformably except where Effna Limestone is present. The Liberty Hall is overlain by the Bays Formation.

Along Stypes Branch (Plate 2) the black fissile shale of the lowest part of the Liberty Hall Formation is 45 feet thick. No other part of the formation is present at this exposure, but farther southwest along the Smith Gap fire trail (Plate 2) the black shale is overlain by thinly bedded argillaceous dolomite and calcareous siltstones and shales. The black shale is 70 feet thick and the overlying dolomitic beds are 110 feet thick, which gives the Liberty Hall Formation a total thickness of 180 feet, the maximum thickness present in the map area. The black shales in both localities contain an abundant graptolite fauna including the following genera: Nemagraptus, Climacograptus, and Dicellograptus. These fossils were all found in the lower 10 feet of the black shale, just above the Liberty Hall-Effna contact. No fossils were found in the dolomitic beds.

The absence of the upper dolomitic portion of the Liberty Hall Formation along Stypes Branch together with pronounced disruption of the black shale at the contact with the Bays Formation clearly indicates that the upper portion of the Liberty Hall is deleted by faulting. However, as discussed later, faulting does not account for the systematic thinning of each and every formation cropping out along the southeast limb of the Catawba syncline. Woodward (1932) gives a thickness of 970 feet for the Athens Shale on the northwest limb of the Catawba syncline, east of Catawba. The name Liberty Hall Formation has since replaced the name Athens Shale.

Bays Formation - The Bays Formation of Middle Ordovician age was

named by Keith (1895) for exposures in the Bays Mountains, Hawkins and Greene counties, Tennessee. The Bays Formation crops out continuously in the belt of foothills along the southeastern base of Fort Lewis Mountain where it forms minor ridges.

The formation overlies the Liberty Hall Formation and is transitional with the overlying Martinsburg. Along Stypes Branch the black shales of the lower part of the Liberty Hall are in fault contact with the Bays and along the Smith Gap fire trail the Bays is thrust upon the Martinsburg (See Plate 2, sections D-D' and F-F').

The formation is composed of coarse- to fine-grained, thick- to medium-bedded, impure sandstones and siltstones. In contrast with the Bays in other areas, the sandstones and siltstones are dominantly greenish-gray rather than red, although some red beds are present.

The thickness of the Bays differs greatly from place to place. The Bays is deleted entirely by faulting in the first stream valley northeast of Stypes Branch, reaches a thickness of 53 feet at Stypes Branch, and is more than 60 feet in the first stream valley southwest of Stypes Branch. The thickest section of Bays in the Glenvar area is along the Smith Gap fire trail where the formation is 85 feet thick. Only 0.75 mile farther southwest the Bays is barely 10 feet thick.

Martinsburg Formation - The Martinsburg Formation of Middle and Late Ordovician age was named by Geiger and Keith (1891) for exposures near Martinsburg, West Virginia. The formation crops out in a narrow belt approximately 2.75 miles in length along the southeastern base of Fort Lewis Mountain and along the minor normal fault at the Montgomery County line. The Martinsburg overlies the Bays Formation and is overlain unconformably by the Tuscarora Sandstone.

In Stypes Branch the Martinsburg Formation consists of 70 feet of alternating beds of medium gray, buff-weathering calcareous shales and medium gray, medium-bedded shell limestones. The Martinsburg beds exposed in the drainages northeast and southwest of Stypes Branch, in the stream beside the Smith Gap fire trail, and in the stream beside State Route 778 are similar in appearance to that cropping out in Stypes Branch.

The Martinsburg Formation exposed along the normal fault at the Montgomery County line consists of alternating limestones and shales, similar to those described above, overlain by thick-bedded, brown and greenish gray, impure sandstones and siltstones of the upper part of the formation. These sandstones and siltstones contain Lingula and Byssonychia, both of which are known to be abundant in the upper part of the Martinsburg. The Orthorhynchula zone in the Upper Martinsburg was not identified.

The thickness of the Martinsburg ranges from 197 feet at the Montgomery County line to 30 feet along the Smith Gap fire trail. In the latter exposure pronounced brecciation at the Martinsburg-Bays contact clearly indicates that a portion of the Martinsburg has been deleted by faulting. The absence of the lithology characteristic of the upper Martinsburg confirms this belief. Butts (1940) gives a thickness of 1,300 feet for the Martinsburg Formation on the northwest limb of the Catawba syncline near the town of Catawba.

Silurian System

Tuscarora Sandstone - The Tuscarora Sandstone of Early Silurian age was first named by Darton (1896) for exposures on Tuscarora Mountain, Juniata and Perry counties, Pennsylvania. The Tuscarora crops out sporadically along the southeast base of Fort Lewis Mountain between State Routes 777 and 778 and again in connection with the normal fault along the Montgomery-Roanoke County line approximately two miles west of Riverside.

The Tuscarora Sandstone overlies the Upper Martinsburg disconformably, and is overlain disconformably by the Ridgeley Sandstone of Early Devonian age. The Upper Ordovician Juniata Formation, which overlies the Upper Martinsburg in belts northwest of the Pulaski fault, is absent in the Glenvar area, as it is throughout the Catawba syncline (Tillman, 1963). The Rose Hill Formation and the "Keefer" Sandstone, present above the Tuscarora in most of the Catawba syncline, are not present in the map area. The Upper Silurian Tonoloway Limestone and the Keyser Formation, poorly represented or absent in the syncline (Tillman, 1963), are apparently absent in the Glenvar area. Throughout most of the area the Tuscarora is in fault contact with the Devonian Millboro Shale, and the lower Martinsburg is thrust upon the Tuscarora.

The Tuscarora Sandstone is a light gray, thick-bedded, medium- to coarse-grained orthoquartzite. The Tuscarora in the map area is coarser than elsewhere in the Catawba syncline. A basal conglomerate, well exposed along the normal fault at the Montgomery County line, contains rounded to subrounded pebbles of vein quartz as much as two inches

in greatest dimension. Both the conglomerate and the sandstone are well indurated. The rock has a massive appearance. The Tuscarora Sandstone reaches a maximum thickness of approximately 40 feet on the ridge 0.2 mile southwest of the first drainage southwest of Stypes Branch.

Devonian System

Ridgeley Sandstone - The Ridgeley Sandstone of Early Devonian age was named by Swartz (1913) for exposures near Ridgeley, West Virginia. The formation is exposed only in the first drainage southwest of Stypes Branch where a minor normal fault brings the Ridgeley and the overlying Huntersville Chert to the surface between the Martinsburg Formation and the Tuscarora Sandstone. The scale of the geologic map (Plate 1) does not permit this outcrop to be shown. The structure section along this drainage (Plate 2) shows the structural setting.

The Ridgeley Sandstone is a reddish-brown, medium- to thick-bedded, medium-grained, ferruginous sandstone. No fossils were found in the Ridgeley in the area mapped, but lithologically similar rocks, also occurring beneath the Huntersville Chert, are exposed farther west near the nose of the Catawba syncline (Eubank, 1968). These rocks contain brachiopods of Oriskany age, according to Tillman (Tillman and Lowry, 1968).

Huntersville Chert - The Lower Devonian Huntersville Chert was named by Price (1929) for exposures near Huntersville, West Virginia. The only place in the Glenvar area where the formation crops out is in the first drainage southwest of Stypes Branch. At this locality it overlies the Ridgeley Sandstone and is bounded above by a normal fault (Plate 2, Section E-E').

In the map area the Huntersville is a dark gray to black, nodular chert impregnated with secondary limonite. On the northwestern limb of the Catawba syncline glauconitic sandstones and cherty shales also occur

in the Huntersville Chert. On the northwestern limb of the Catawba syncline, along State Highway 311, the Huntersville Chert is 18 feet thick (Tillman, 1963).

No fossils were found in the Huntersville in the map area, but a similar chert unit occurs between the Ridgeley Sandstone and the Needmore Shale farther to the northwest. The Needmore Shale is not present in the Glenvar area, but its presence locally east of the area near Hanging Rock (Amato, oral communication, August 15, 1967) and west of the area 1.2 miles east-northeast of Fagg (Eubank, oral communication, August 15, 1967) indicates that it is probably omitted by faulting in the Glenvar area.

Millboro Shale - The Millboro Shale of Middle Devonian age was named by Butts (1940) for exposures near Millboro Springs, Bath County, Virginia. The formation crops out within the foothills along the base of Fort Lewis Mountain.

Throughout the Glenvar area the Tuscarora Sandstone or, where the Tuscarora is absent, the Martinsburg Formation has been thrust northward upon the Millboro Shale. The Needmore Shale, which normally underlies the Millboro Shale, is absent in the map area. Nichols (1959) reports that the Mason Cove Shale, which is equivalent to the Needmore, is 50 feet thick along the southeastern slope of Catawba Mountain on the northwestern flank of the Catawba syncline.

The Millboro becomes progressively more sandy upward and grades into the overlying Brallier Formation. The contact was placed below a 4-foot unit of thick-bedded, brown sandstone. The thickness of the Millboro Shale in the Glenvar area ranges from a maximum of approximately

380 feet along the Smith Gap fire trail to less than 80 feet along Stypes Branch. Woodward (1932) gives a maximum thickness of about 500 feet for the Romney Shale in the Roanoke area. The Romney Shale is equivalent to the Millboro Shale.

The Millboro is a black, fissile shale with locally abundant limestone concretions. A large septarian nodule, three feet across, is exposed in the stream which flows beside the Smith Gap fire trail. Some sandstones and siltstones are present and become more abundant toward the upper contact. No fossils were found in the Millboro Shale.

Brallier Formation - The Brallier Formation of Late Devonian age was named by Butts (1918) for exposures near Brallier Station in Bedford County, Pennsylvania. The Brallier crops out on the slopes of Fort Lewis Mountain where it grades downward into the Millboro Shale and upward into the Chemung Formation.

The Brallier is well exposed along the Smith Gap fire trail where it consists of greenish gray, medium- to thin-bedded sandstones and greenish gray shales and siltstones. Woodward (1932) gives the thickness of the Brallier in the Roanoke area as 2,000 to 3,000 feet, but no more than 1,000 feet are present in the Glenvar area. Woodward's (1932) map does not show the Brallier Formation and the entire biconvex belt of Ordovician, Silurian and Devonian formations in the Glenvar area. This explains why his estimate of the thickness of this formation does not apply to the Glenvar area. The overlying Chemung Formation is not differentiated from the Brallier Formation on the accompanying geologic map (Plate 1).

Chemung Formation - The Chemung Formation of Late Devonian age was named by Hall (1839) for exposures near the town of Chemung,

Chemung County, New York. The formation crops out on the upper slope of Fort Lewis Mountain. The Chemung grades into the Brallier Formation below and is overlain by the Lower Mississippian Price Formation.

The Chemung is well exposed along the Smith Gap fire trail where it consists of brown, reddish brown and greenish, medium- to thin-bedded sandstones, siltstones and shales. At this locality and along Stypes Branch several excellent exposures of large-scale cross bedding occur. An exposure of reddish brown sandstone 3-1/2 feet thick consists entirely of a single set of cross-beds. This exposure is located along the Smith Gap fire trail, northwest of the axis of the Catawba syncline. The bed is right side up and indicates current movement from the southeast toward the northwest.

The maximum thickness of the Chemung in the Glenvar area is 600 feet. Woodward (1932) gives a minimum thickness of 1,000 feet for the Chemung Formation in the Roanoke area and states that there may be as much as 2,500 feet of Chemung. Woodward's estimate of the thickness of this formation should be considered a maximum for the Catawba syncline. It does not apply to the Glenvar area because his geologic map is in error in this area. He incorrectly shows the Chemung Formation to extend from the Salem fault to the Mississippian Price Formation. As previously noted, the Chemung Formation is not differentiated from the underlying Brallier Formation on the accompanying geologic map.

Several well preserved brachiopods were collected from the Chemung Formation at the two fossil localities along the road on the crest of Fort Lewis Mountain (Plate 1). G. Arthur Cooper (written communication, March 11, 1968) said concerning the specimens from locality B:

I would say that they are either Frasnian=Chemung or possibly lower Fammenian=Cassadaga. The large spiriferoids are probably the genus Cyrtospirifer, related to disjunctus, which look like types that occur in the Fammenian, but they are accompanied by a spiriferoid with a strong median septum suggesting Spirifer mesacostalis, which is more characteristic of the Chemung.

The occurrence of Frasnian of lower Fammenian fossils within 50 feet stratigraphically of the base of the Price Formation indicates that the Fammenian is represented sparsely or not at all or possibly that the lowest Price in this area is upper Fammenian rather than lower Mississippian.

Mississippian System

Price Formation - The Price Formation of Early Mississippian age was named by Campbell (1894) for exposures on Price Mountain, Montgomery County, Virginia. The Price crops out continuously on the slopes of Fort Lewis Mountain from the eastern boundary of the map to the spur east of Stypes Branch and in four isolated remnants west of Stypes Branch. It is the youngest bedrock formation in the area.

The basal unit of the Price is a light gray, quartz-pebble conglomerate and conglomeratic sandstone. Woodward (1932) called the basal conglomerate of the Price Formation the Ingles Conglomerate, but the name has since been changed to the Cloyd Conglomerate (Butts, 1940). Along the fire trail on top of Fort Lewis Mountain the Cloyd contains light gray, subrounded pebbles of vein quartz as much as one inch in diameter. The Cloyd Member is about 20 feet thick at this locality.

The coarsest conglomerate in the Price crops out along Paint Bank Creek about 3,200 feet upstream from the transmission line, which is shown on the map. The conglomerate exposed here contains pebbles and cobbles of vein quartz, sandstone and chert up to six inches in maximum dimension. The grains are subangular to subrounded and range in size from fine sand to cobbles. Many of the vein quartz pebbles are clear but some are milky or smoky. Both dark colored and white chert are present but neither are distinctive enough in hand specimen to identify their source. Some of the sandstone pebbles are dense and vitric but others show distinct grain boundaries visible to the unaided eye.

Above the Cloyd Member the Price Formation consists of medium to

dark gray, medium-bedded subgraywacke and massive quartz pebble conglomerates and conglomeratic sandstones. A single exposure of claystone containing wood fragments, crinoid stem plates and abundant secondary iron oxide occurs about 75 feet northeast of the last house of Paint Bank Hollow.

The Price Formation is approximately 420 feet thick along Paint Bank Creek. Woodward (1932) states that only the lower beds of the Price Formation are present on Fort Lewis Mountain. The complete section in the Blacksburg-Pulaski area ranges from 500 to 800 feet in thickness (Cooper, 1961).

STRUCTURAL GEOLOGY

General Statement

The rocks of the Glenvar area are entirely allochthonous. The area is divided into four structural units (Figure 2). From northwest to southeast these units are: the Pulaski fault block, the Salem fault block which includes the entire Elbrook outcrop belt, the Max Meadows fault block, which includes the Rome outcrop belt, and the Blue Ridge fault block, which includes the Unicoi Formation and the crystalline rocks of the Blue Ridge.

The Pulaski Fault Block

The Catawba syncline belongs to the Pulaski fault block. This entire block has been displaced horizontally a minimum of eight miles (Bauerlein, 1966). The syncline occupies the portion of the Glenvar area between the Salem fault and the northwestern boundary of the area (Plate 1). The normal northwestern limb of the syncline forms the crest of Fort Lewis Mountain; the overturned southeastern limb, which forms the lower southeastern portion of the mountain and the adjoining foothills, is cut off by the Salem fault. Within the area the outcropping rocks involved in this fold range from the Knox Dolomite of Early Ordovician age to the Price Formation of Early Mississippian age.

The axis of the syncline is within the Brallier and Chemung outcrop belt, approximately 1.5 miles southeast of the crest of Fort Lewis Mountain. The axial trace (Plate 1) is essentially parallel to the crest of the mountain. Because of extensive minor faulting the structure of the overturned limb is not uniform; however, on the average, the

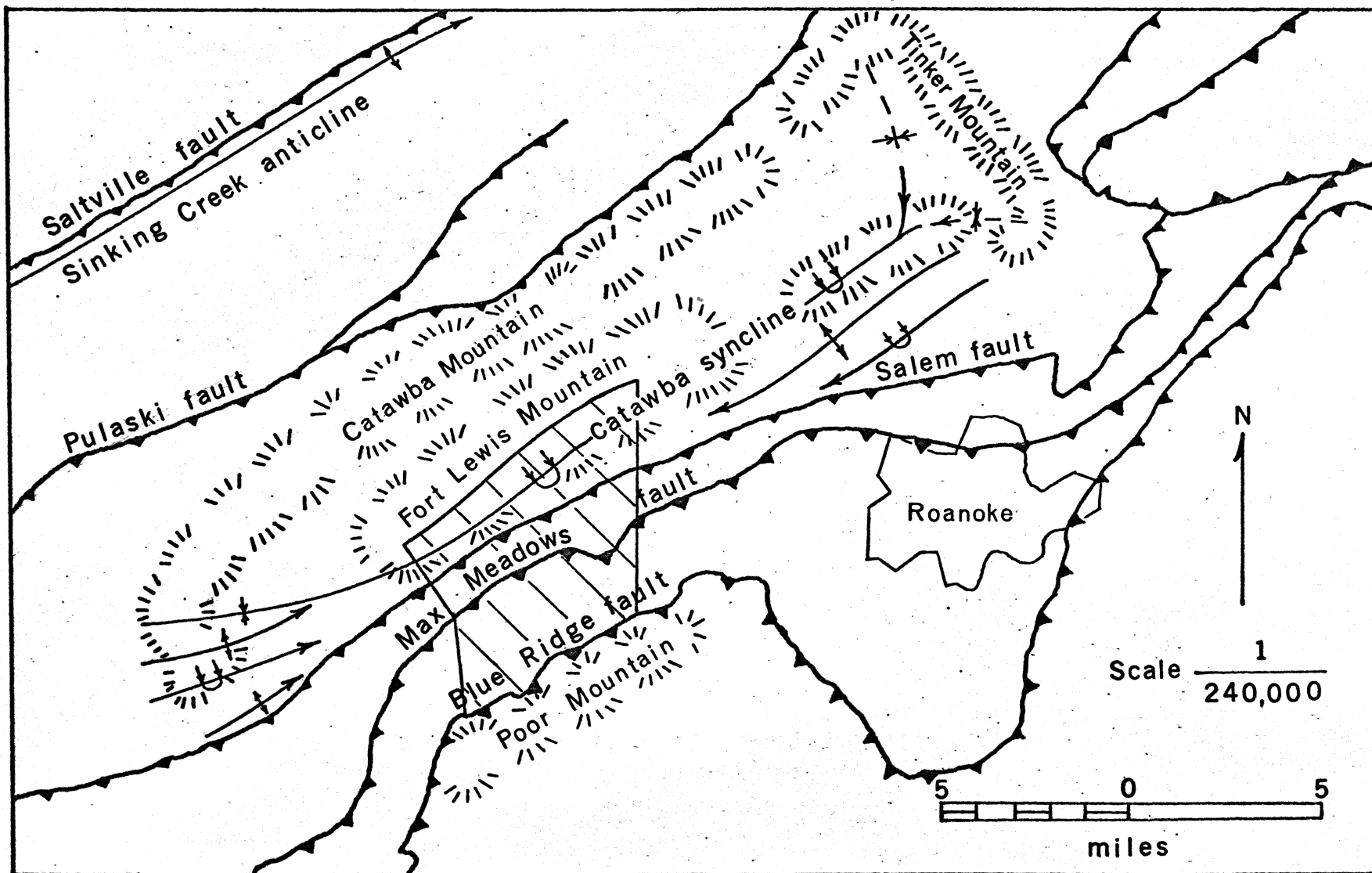


Figure 2. Structural Index Map of the Glenvar and Surrounding Area, Virginia

strike of the beds ranges from N.50-55°E. and the dip ranges from 30° to 35° southeast. The beds have been rotated through an angle of at least 150° from their initial horizontal position. Considering this, most of the units show remarkably little brecciation or drag folding.

Prior to the work of Edwards (1959) no published report indicated the presence of the biconvex body of Ordovician, Silurian, and Devonian rocks which form the belt of foothills at the base of Fort Lewis Mountain. Edwards concluded that the abnormal thinness of many of the formations in the overturned limb of the Catawba syncline is due to either non-deposition or erosion prior to deposition of the superjacent unit. Although this is probably true to some extent, the writer concludes that small-scale thrust faulting accounts for much of the reduction in thickness of some of the units.

A careful examination of any single exposure of these rocks of the overturned southeastern flank shows that each formation is substantially thinner here than on the normal northwestern flank. This would suggest primary thinning for it is difficult to conceive of systematic deletion of portions of each and every formation by faulting. However, on comparing the same formation in the six traverses shown in the structure sections (Plate 2) several interesting facts become apparent. First, the thickness of each formation ranges greatly along strike. Secondly, different portions of the formations are absent in different places. Thirdly, the Tuscarora Sandstone, the Ridgeley Sandstone and the Huntersville Chert are completely absent in some exposures but present in others and the Needmore Shale is absent in all exposures.

These differences take place over short distances; thinning and brecciation become more pronounced where this outcrop belt terminates against the Salem fault. Furthermore, the formations in this belt are lithologically similar to the same formations elsewhere in the Catawba syncline, and there is nothing to indicate that they were deposited under a set of unusual conditions that might account for their irregular distribution except for the Effna Limestone which lies on the erosion surface developed on the Knox Dolomite. In view of these considerations the writer concludes that the Tuscarora-Millboro contact and the lower Martinsburg-Tuscarora contact are minor thrust faults. Furthermore, the Liberty Hall-Bays contact in Stypes Branch and the Bays-Martinsburg contact on the Smith Gap fire trail are also faults.

The amount of stratigraphic displacement involved in these faults is difficult to ascertain because there is no way to be sure how thick the formations were initially. There is little doubt that the displacement is much greater toward the ends of the outcrop belt than in the center. In any case, the present thickness of the formations in this area is not conclusive proof of primary thinning. Not only are the rocks thinned tectonically but there is no way of knowing if the present position of these rocks, relative to the trough of the syncline, is the same as it was during deposition.

The outcrop of the portion of the overturned limb of the Catawba syncline lying along the Roanoke-Montgomery County line shows a somewhat different structural setting (Plate 1 and Plate 2, Section H-H'). Construction of Interstate Highway 81 in this area has provided new exposures which require a re-interpretation of this structure. Movement on

the Salem fault has brought the Elbrook Formation into contact with the lower part of the Martinsburg of the overturned limb of the Catawba syncline. The lower part of the Martinsburg is in turn thrust upon sandstones of the upper part of the Martinsburg. However, the Tuscarora overlies the upper Martinsburg disconformably. This is the only place in the Glenvar area where the Tuscarora Sandstone is exposed in depositional contact with any other formation either above or below it, and therefore, the only evidence for the stratigraphic omission of the Upper Ordovician Juniata Sandstone. The Tuscarora is in fault contact with the Millboro along the county line as it is throughout the area. No Huntersville Chert, Ridgeley Sandstone or Needmore Shale is present.

The repetition of Millboro Shale in this structure is due to displacement along a northwest dipping normal fault and not to folding, as Edwards (1959) thought. This fault closely resembles the normal fault exposing the pre-Millboro Devonian rocks along the first drainage southwest of Stypes Branch.

The small thrusts of the biconvex body of rocks of the southeastern flank are clearly related to movement on the Salem fault as evidenced by increased displacement and brecciation along these faults on approaching the Salem fault. This together with the fact that the Salem fault has brought the Elbrook Formation into contact with the Brallier Formation both northeast and southwest of the biconvex body of rocks suggests that the smaller faults were formed in response to the same forces that produced the Salem fault and were essentially contemporaneous with it.

Salem Fault

The Salem fault, named by Campbell (1925), is a southeast-dipping thrust fault which in the Glenvar area brings the Middle and Upper Cambrian Elbrook Formation into contact with rocks ranging in age from Early Ordovician to Late Devonian (Plates 1 and 2). Throughout the area the rocks of the footwall block northwest of the fault are part of the overturned southeast limb of the Catawba syncline, and dips range from 30° to 35° southeast. Amato (1968) determined the dip of the fault to be 38° based on well data obtained near Hanging Rock east of the Glenvar area. Algal structures in the Elbrook formation of the hanging wall in the Dixie Caverns area indicate the beds are right side up. Hence the Elbrook strata of the hanging wall do not represent a portion of the overturned limb of the syncline.

The arcuate nature of the Salem fault trace is not solely a reflection of topography but also reflects the initial nonplanar surface of the fault. The biconvex body of rocks at the base of Fort Lewis Mountain is part of a structural depression in the overturned limb of the Catawba syncline. This depression has caused the Millboro and older formations of the overturned limb to crop out northwest of the Salem fault. Northeast and southwest of the biconvex body of rocks these formations are concealed beneath the Salem fault block. Amato (1968) and Hazlett (1968) have mapped an overturned anticline southeast of the Catawba syncline. This anticline, the Green Ridge anticline, has not been traced into the Glenvar area. The biconvex body of rocks may represent a remnant of a more strongly overturned portion of this anticline.

This structural depression is believed to have been formed prior to movement on the Salem fault, and this implies that the southeastern limb of the Catawba syncline was overturned prior to Salem faulting. Overturning of the southeastern flank may have been slow as suggested by excellent preservation of graptolites in the severely inverted black shale of the lower part of the Liberty Hall Formation along Stypes Branch.

Structures in the Salem Fault Block

Lack of good exposures makes it impossible to map in detail the structure of the Elbrook Formation. Only a general picture of the mode of deformation can be obtained. Though extensive drag folding has crumpled the more thinly bedded units, the more thickly bedded dolomites dip consistently to the southeast from 30 to 35 degrees. Drag folds in the Elbrook are exposed along the tracks of the Norfolk and Western Railway 0.6 mile north of Wabun and along State Highway 11 0.2 mile north of Riverside. Sedimentary features show that except in minor local folds the Elbrook is right side up. Algal structures in the quarry 0.55 mile northeast of Riverside and in the road cut along U.S. Highway 11 0.2 mile north of Riverside are all right side up.

Brecciated zones are quite common in the formation, but the absence of recognizable horizons in the Elbrook prevents an accurate estimate of the amount of displacement.

Max Meadows Fault

The name Max Meadows fault was first used by Cooper (1939) for a fault marking the contact between the Rome and Elbrook formations near

Max Meadows, Wythe County, Virginia. Dietrich (1954) used the name Christiansburg fault for the Rome-Elbrook fault contact near Christiansburg, Virginia, but subsequent work by Hergenroder (1957) has shown the equivalence of the Christiansburg and Max Meadows faults.

Woodward (1935) and Butts (1940) showed the Elbrook in normal sedimentary contact with the Rome, but Edwards (1959) correctly indicated the contact as a thrust fault. Along the prominent bluff half a mile east of Dixie Caverns both formations dip steeply to the southeast, and the stratigraphically older Rome clearly overlies the Elbrook. Both sedimentary structures and cleavage-bedding relationships show that except in small local folds, both formations are right side up. Thus the Rome must be thrust over the Elbrook.

The sinuosity of the trace of the Max Meadows fault indicates a low angle fault. The reentrant at Wabun strongly suggests that the fault dips no more than 20° . Brecciation along this fault is not nearly so pronounced as it is southwest of the Glenvar area. In fact there is considerably more breccia within the Rome Formation than along the Rome-Elbrook contact.

Structures in the Max Meadows Fault Block

The Rome Formation is extensively deformed throughout the width of its outcrop. Numerous tight folds, all overturned or asymmetrical to the northwest, and southeast dipping reverse faults dominate the structure. The axes of the folds in general parallel the Blue Ridge. Some attempt has been made to map the larger folds (Plate 1), but it is difficult to trace such folds between road cuts. It is interesting to note that most of the larger folds are synclines and that the intervening anticlines are apparently omitted by faults.

The overall structure of the Rome outcrop belt has been interpreted as a syncline (Barlow, 1936) and an anticline (Woodward, 1932). Both interpretations are based on the erroneous belief that the Rome is in normal contact with the Elbrook. This writer has seen no indication of either structure and believes that the Rome simply dips southeastward beneath the Blue Ridge.

Blue Ridge Fault

The Blue Ridge fault is a southeast dipping thrust fault. The sinuous fault trace indicates a nearly horizontal attitude. Within the area the fault has brought the Lower Cambrian Unicoi Formation over the younger Lower and Middle Cambrian Rome Formation. Exposures of breccia mark the outcrop of the fault, particularly along Dry Branch. Woodward (1942), who first named the fault, proposed a minimum horizontal displacement of 9 miles. The name Blue Ridge Fault is used in this report, as it was used by Woodward (1942), to refer to the fault along which the rocks of the Lower Cambrian Chilhowee Group are thrust northwest over the Lower and Middle Cambrian Rome Formation. The fault called the Blue Ridge Fault in this report is called the Poor Mountain Fault by Dietrich (1954).

Though outcrops of the fault itself are rare, the prominent break in slope at the base of Poor Mountain reveals the position of the fault. The fault can be located approximately along most of the deep stream valleys of Poor Mountain, but it cannot be traced out of these valleys and around the intervening spurs where appreciable amounts of slide rock or alluvium obscure the trace of the fault.

The Blue Ridge Fault Block

Only the leading edge of the Blue Ridge fault block was included in the map area. Only the Unicoi Formation is present between the Blue Ridge Fault and the southeastern border of the map area. The Unicoi is right side up and dips, on the average, 10° southeast. Shufflebarger (1953) mapped the portion of the Blue Ridge thrust sheet adjacent to the Glenvar area.

STRUCTURAL EVOLUTION

The Knox Erosion Surface

The prominent unconformity above the Knox is well displayed in the Glenvar area. Not only is early Middle Ordovician time represented solely by the Effna Limestone, but in places even this formation is missing, and the Liberty Hall Formation directly overlies the Knox. Cooper (1964) states that the magnitude of this unconformity depends on its structural position and offers this as evidence that folding was initiated prior to this time. If this is so, then the magnitude of the unconformity along the foothill belt suggests that the southeast limb of the Catawba syncline was structurally high during early Middle Ordovician time.

In areas both northeast and southwest of the Glenvar area the overturned limb of the Catawba syncline is also the northwest limb of a preserved adjacent anticline. Although both limbs of this anticline are exposed northeast of the Glenvar area, the southeast limb in the Glenvar area has been removed by the Salem fault. The prominent unconformity above the Knox indicates that this anticline, only partially represented in the area of this study, was a structural high as far back as Middle Ordovician time. Cooper (1964) points out that near the trough of the Catawba syncline the unconformity is essentially absent and concludes that this structure was at least beginning to form at this time. This constitutes the first suggestion of Paleozoic deformation within the Glenvar area.

Continued Development of the Catawba Syncline

As was pointed out previously, the writer cannot draw any conclusions regarding the original thickness of the units of the southeast limb of the Catawba syncline with the exception of the Effna Limestone. The presence of numerous faults would make such estimates subject to large errors. However, unfaulted sections on the northwest limb of the syncline indicate a thickening of the various units toward the trough of the Catawba syncline. Thus the structure continued to form, though not without interruption, at least to Early Mississippian time.

The Late Silurian-Early Devonian Unconformity

Tillman (1963) has pointed out that Upper Silurian and Lower Devonian formations present elsewhere in the Southern Appalachians are absent in the Catawba syncline. He concluded that at several times during the Late Silurian and Early Devonian the Catawba syncline was a positive area.

Again, faulting of the southeast limb of the Catawba syncline makes an evaluation of this hypothesis within the mapped area difficult. The Upper Silurian and Lower Devonian formations older than the Ridgeley Sandstone are missing in the Glenvar area, but the horizon of the unconformity is a fault, and it cannot be determined whether these formations are omitted by the fault or by an unconformity. Evidence from adjoining areas strongly suggests the latter.

Early Mississippian Uplift of the Blue Ridge Anticlinorium

The large clasts present in the Price Formation especially at its base indicate contemporaneous uplift of a crystalline source area. The proximity of the Blue Ridge suggests that it may have been the source of the vein quartz clasts and possibly the sandstone clasts. Petrographic study may reveal the origin of the chert clasts. Eubank (1968) found conglomeratic beds near Fagg in rocks correlative with the Early Devonian Ridgeley Sandstone. He concluded that the quartz and impure sandstone clasts were derived from the Blue Ridge and that the chert was probably derived from impure Paleozoic limestone.

Origin and Emplacement of the Pulaski, Salem, Max Meadows and Blue Ridge Fault Blocks

The Catawba syncline of the Pulaski fault block has been displaced horizontally a distance of from 8 to 10 miles (Woodward, 1932). The syncline, prior to its displacement, was probably the first downwarp northwest of the Blue Ridge anticlinorium and was separated from the Blacksburg synclinorium (Cooper, 1961) by the Read Mountain anticline (Hazlett, 1968) which is not exposed in the Glenvar area. This anticline is exposed in a window in the Elbrook Formation near Roanoke (Woodward, 1932).

The Elbrook of the northwestern flank of the Catawba syncline crops out along the sole of the Pulaski fault (Woodward, 1932). Bauerlein (1966) suggested that the Elbrook forms the sole of the Pulaski fault beneath the southwestern portion of the Catawba syncline. He also states that the Pulaski fault of the northwestern flank is only 700

feet below the upper contact of the Elbrook. This indicates that the upper portion of the Elbrook forms the sole of the Pulaski fault and that the remainder of the formation was left behind during emplacement of the Pulaski fault block.

The Elbrook also crops out along the sole of the Salem fault in the Glenvar area and apparently dips essentially parallel to the fault. This suggests that the Elbrook also forms the sole of the Salem fault block and therefore implies that the faults may merge at depth. The writer could not determine which portion of the Elbrook is present in the Salem fault block of the Glenvar area.

The Elbrook of the Salem block and the Rome of the Max Meadows block are both dominantly right side up and apparently dip homoclinally southeast. Along the Max Meadows fault the Rome is thrust directly upon the Elbrook and along the Blue Ridge fault the Precambrian crystalline rocks or the Lower Cambrian rocks of the Chilhowee Group of the Blue Ridge are thrust directly upon the Rome. The formations normally overlying the Rome and Elbrook must somehow have been removed prior to or during faulting.

Lowry (1964) postulates that the Pulaski, Salem and Blue Ridge faults are genetically related and that the three structural blocks of the Glenvar area northwest of the Blue Ridge fault were one. He suggests that the Blue Ridge fault developed initially in the basement of the Blue Ridge anticlinorium and then broke upward along the base of the Rome. As the mass approached the anticline southeast of the Blacksburg synclinorium, the incompetent lower and middle portion of the Elbrook and the underlying Rome broke from the sole of the fault

and were left behind to be overridden by the Lower Cambrian Chilhowee Group and the Precambrian crystalline rocks of the Blue Ridge block. The Pulaski block moved down the southeast flank of the Blacksburg synclinorium until the buttressing effect of the northwest flank of the synclinorium prevented further movement. Continued compression caused overturning of the southeast flank of the Catawba syncline and finally broke the sole of the Pulaski fault to form the Salem (and Max Meadows) faults. Any Elbrook which remained overlying the Rome of the Max Meadows block has since been removed by erosion. Hazlett (1968) and Amato (1968) postulate a similar tectonic history.

If this proposal be correct, the Salem fault merges with the Pulaski fault and the Max Meadows fault merges with the Blue Ridge fault, presumably at the base of the Max Meadows block. Pulaski faulting is interpreted as a continuation of Blue Ridge faulting at a higher, incompetent horizon.

The formations once overlying the Rome of the Max Meadows fault block and those overlying the Elbrook of the Salem fault block could have been removed by erosion prior to faulting. If the Salem and Max Meadows blocks were originally rooted high on the northwestern flank of the Blue Ridge anticlinorium, erosion could have removed the overlying formations, exposing Rome and Elbrook at the surface. Then subsequent imbrication could have brought the Rome over the Elbrook giving the rocks their present southeast dip. However, the Shady which normally underlies the Rome is not present beneath the Rome in the window near Bonsack in Roanoke County (Hazlett, 1968). Instead beds as young as lower Martinsburg are exposed in this window. If the Shady is also

missing beneath the Rome in the Glenvar area, then the Rome and Elbrook were detached from the underlying Shady prior to emplacement of the Salem and Max Meadows blocks. Also, if the Rome in the Glenvar area is thrust upon rocks as old as the lower Martinsburg, as it is in the window near Bonsack, then the formations once overlying the lower Martinsburg were removed prior to or during emplacement of the Salem and Max Meadows blocks.

As an alternative, it is postulated that the Blue Ridge fault developed in the basement and then broke upward to an incompetent horizon above the middle portion of the Elbrook. The entire mass was pushed to the northwest, but as the block passed over the anticline southeast of the Blacksburg synclorium the Pulaski block broke loose and began to slide to the northwest. The removal of the Pulaski block caused the Rome and Elbrook on the northwest flank of the Blue Ridge anticlinorium to be detached from the underlying Shady and slide to the northwest. Either the Elbrook broke loose from the Rome and then the Rome broke loose from the Shady, or the Rome and Elbrook broke loose as a unit and the Rome was detached during sliding. The removal of the formations younger than Martinsburg from the window near Bonsack had already been accomplished by the advance of the Pulaski block. Continued advance of the Blue Ridge block thrust the Rome over the Elbrook. Finally the Blue Ridge block overrode the Rome.

If this alternative proposal be correct, then the Pulaski fault represents a continuation of Blue Ridge faulting at an incompetent horizon in the Elbrook, but the Salem and Max Meadows blocks are only detached plates emplaced subsequent to Pulaski faulting.

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GEOLOGY OF THE GLENVAR AREA
ROANOKE COUNTY, VIRGINIA

by

Donald James Murphy

ABSTRACT

Most of the Glenvar area, Roanoke County, Virginia, is in the Valley and Ridge Province of the Southern Appalachians. Poor Mountain of the Southern Appalachians is in the Blue Ridge Province. The area is underlain by rocks ranging in age from the Early Cambrian Unicoi Formation to the Early Mississippian Price Formation. All the rocks are allochthonous and constitute an imbricate structure the thrusts of which dip southeast.

The four structural units which make up the area are, from northwest to southeast, the Pulaski fault block, the Salem fault block, the Max Meadows fault block, and the Blue Ridge fault block.

The structure of the Pulaski fault block is dominated by the Catawba syncline. The normal northwestern limb of the syncline forms the crest of Fort Lewis Mountain and the overturned southeast limb forms the biconvex body of rocks along the base of the mountain. The southeastern limb is abnormally thin due to both stratigraphic omission and deletion by faulting of formations or portions of formation, which are present on the northwestern limb.

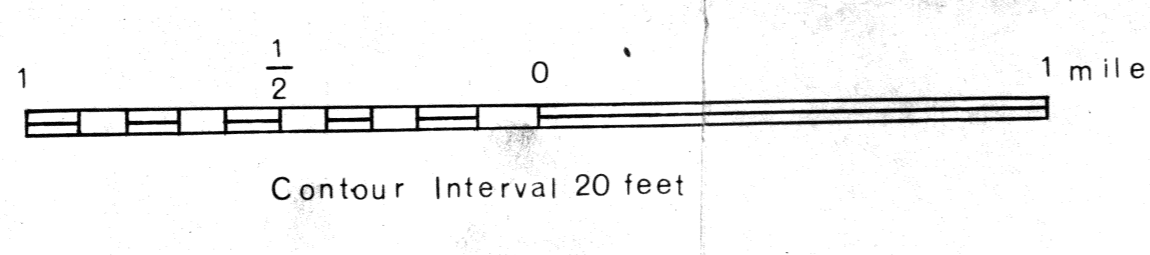
The Salem fault block within the area is made up entirely of the Cambrian Elbrook Formation and the Max Meadows fault block is made up entirely of the Cambrian Rome Formation. Southeast-dipping thrust faults and drag folds, overturned to asymmetric to the northwest, dominate the structure of both fault blocks.

The Cambrian Unicoi Formation crops out along the northwestern edge of the Blue Ridge fault block. Adjacent to the fault the Unicoi dips gently southeast.

It is suggested that Blue Ridge fault developed in the basement and then broke upward to the base of the Rome Formation. As the mass moved northwestward, the Rome and the lower and middle Elbrook broke loose and were overridden by the Blue Ridge block. Continued compression overturned the southeastern limb of the Catawba syncline and finally caused the Salem and Max Meadows faults.

GEOLOGIC MAP AND STRUCTURE SECTIONS OF THE GLENVAR AREA, ROANOKE COUNTY, VIRGINIA

263
295



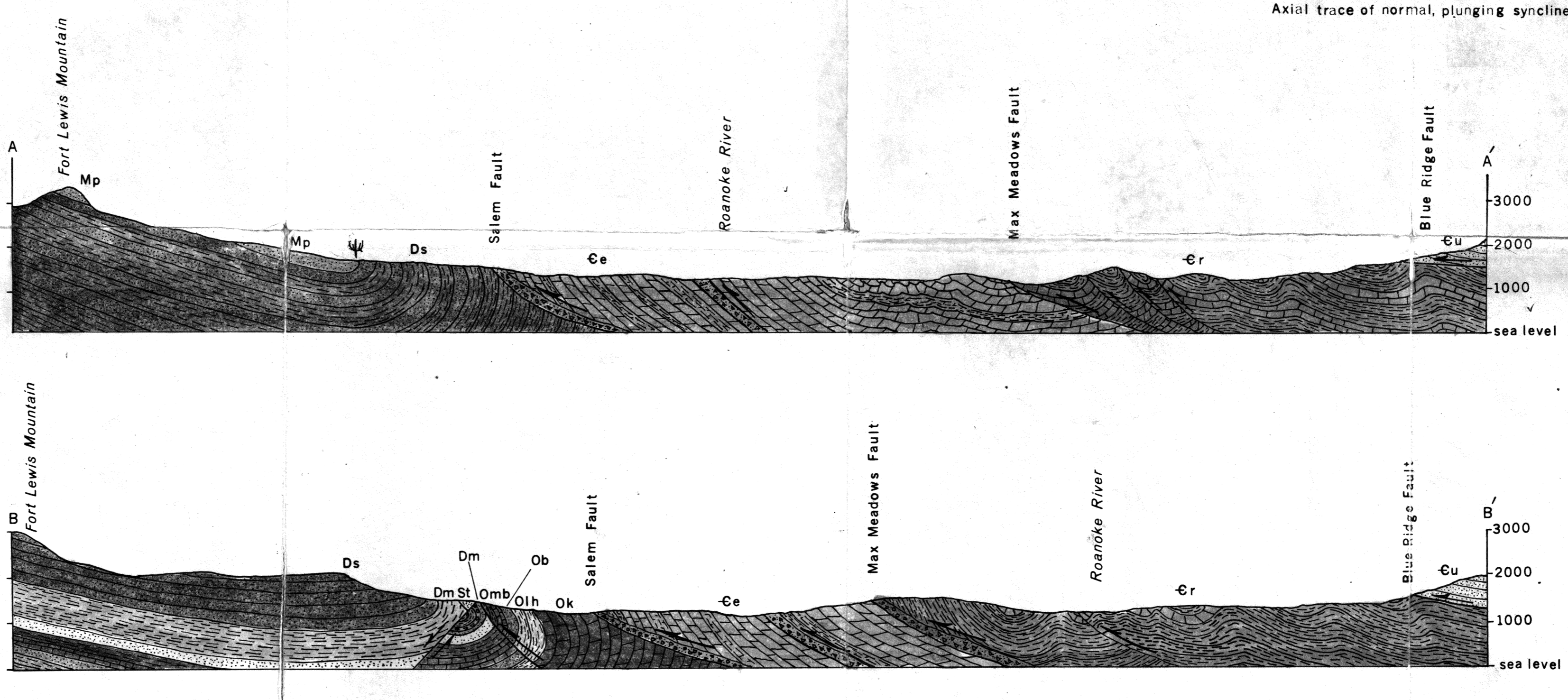
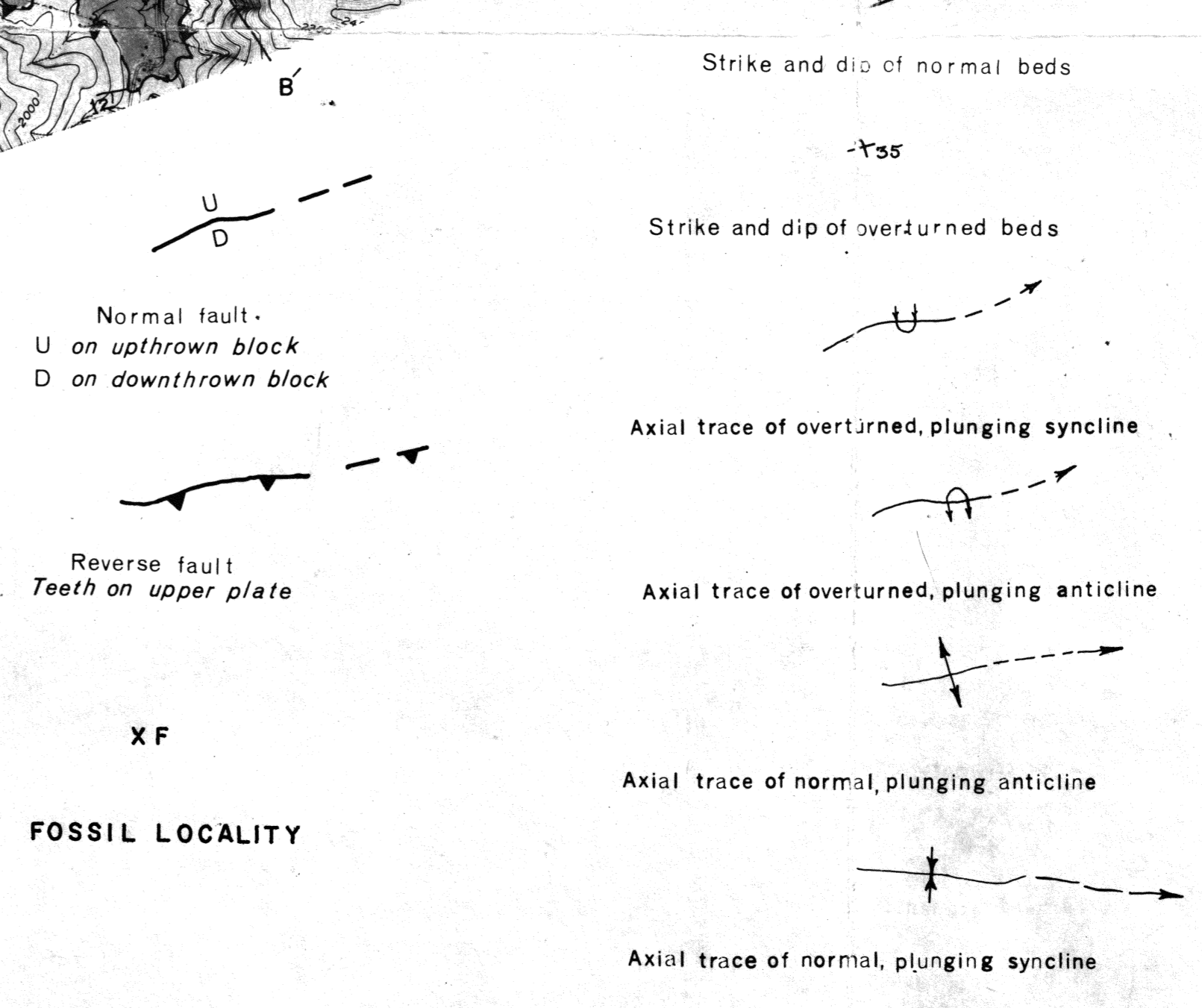
37°15'
MAGNETIC NORTH
TRUE NORTH
mean declination
1963

Base from U.S. Geological Survey
maps of the
Bent Mountain, Elliston
Glenvar and Salem
7 1/2 minute quadrangles

Geology by Donald J. Murphy
1968

EXPLANATION

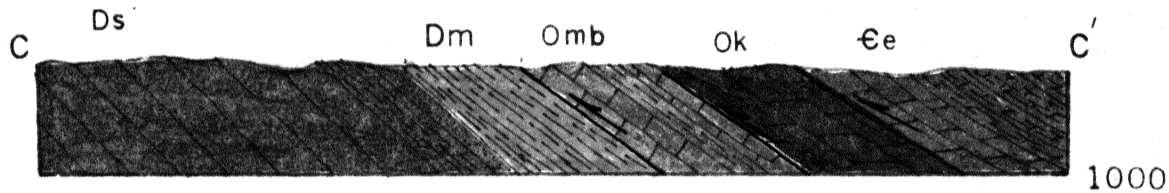
PL LASKI FAULT BLOCK	MISSISSIPPIAN
Price Formation	
Devonian Sandstone Chumung Formation and Brellier Formation	DEVONIAN
Millboro Shale locally includes huntersville Chert and ridgeley Sandstone	
UNCONFORMITY	SILURIAN
Tuscarora Sandstone	
UNCONFORMITY	ORDOVICIAN
Martinsburg Formation	
Bays Formation	
Liberty Hall Formation	ORDOVICIAN
UNCONFORMITY	
Effna Limestone	ORDOVICIAN
Knox Dolomite includes Longview Limestone	
SALEM FAULT BLOCK	MIDDLE AND UPPER CAMBRIAN
Elbrook Formation	
MAX MEADOWS FAULT BLOCK	LOWER CAMBRIAN
Rome Formation	
BLUE RIDGE FAULT BLOCK	LOWER CAMBRIAN
Unicoi Formation	



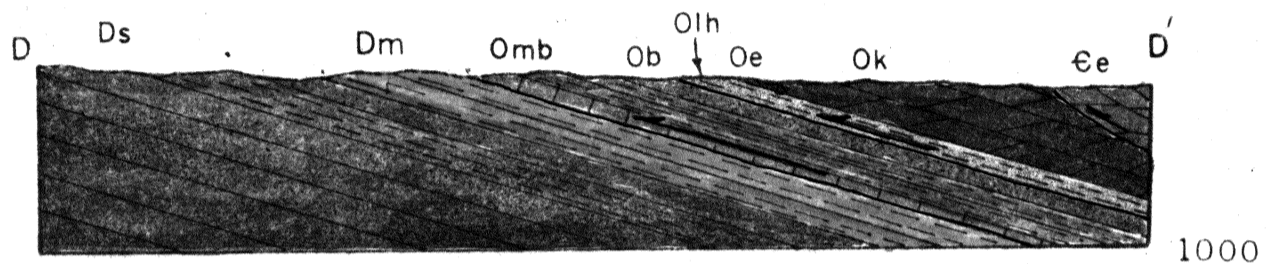
FOSSIL LOCALITY

STRUCTURE SECTIONS OF THE SOUTHEAST FLANK OF THE CATAWBA SYNCLINE

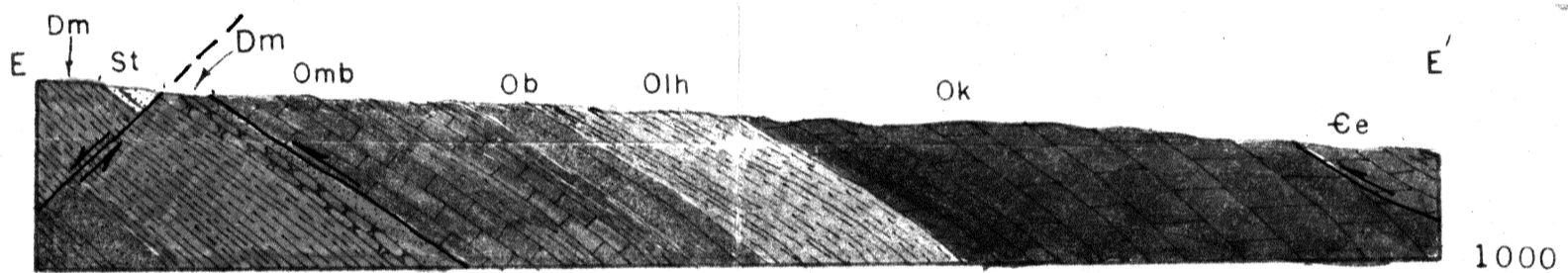
SEE PLATE 1 FOR EXPLANATION OF SYMBOLS



SECTION ALONG FIRST DRAINAGE NORTHEAST
OF STYPES BRANCH

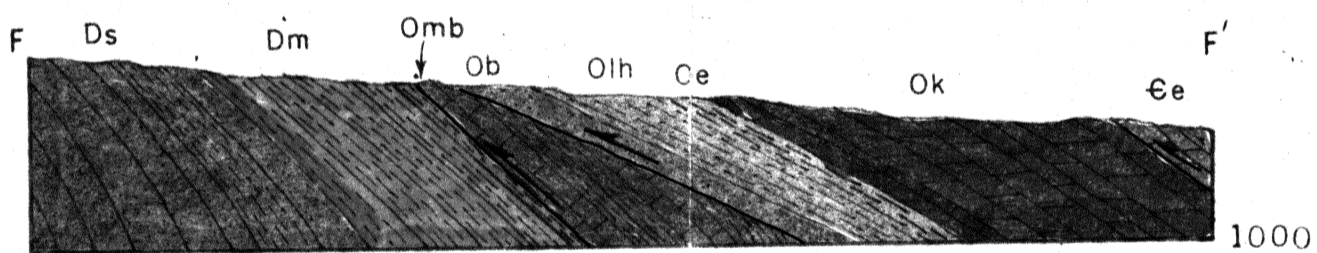


SECTION ALONG STYPES BRANCH

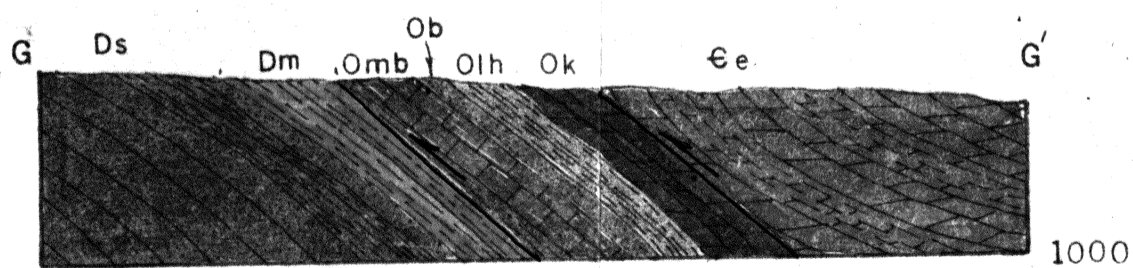


SECTION ALONG FIRST DRAINAGE SOUTHWEST OF STYPES BRANCH

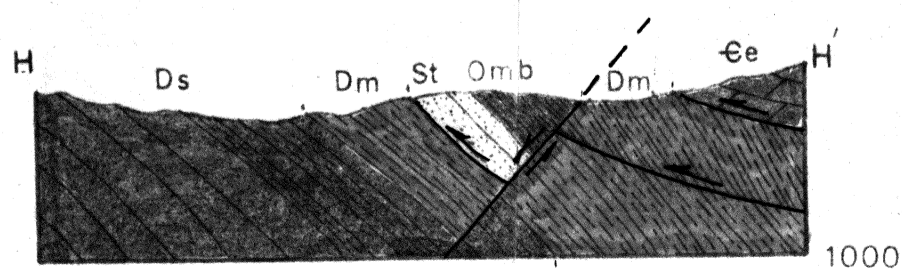
COINCIDES WITH LINE OF SECTION B-B', PLATE 1



SECTION ALONG SMITH GAP FIRE TRAIL



SECTION ALONG STATE ROUTE 778



SECTION 300 YARDS WEST OF MONTGOMERY COUNTY LINE

