STRUCTURAL ANALYSIS OF THE CENTRAL APPALACHIANS, WESTERN VIRGINIA

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STRUCTURAL SETTING OF THE CENTRAL APPALACHIANS, WESTERN VIRGINIA

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INTRODUCTION

The Appalachian Mountain system is subdivided into northern, central, and southern parts. The southern and central portions of the Appalachians are comprised of four morpho-tectonic provinces each of which extends northeast-southwest along the trend of the orogen. Each province is characterized by distinctive bedrock geology which is expressed in the physiography, and is closely related to both bedrock structure and composition. From the internal to external portions of the Southern and Central Appalachians, these provinces are the Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau. The Piedmont and Blue Ridge are composed mainly of igneous and metamorphic rocks some of which were metamorphosed long before the beginning of Appalachian orogenesis. The unmetamorphosed sedimentary cover on this crystalline basement is exposed in the Valley and Ridge and Appalachian Plateau provinces.

The 1990 Keck structural research projects were located within the Blue Ridge and Valley and Ridge Provinces. They were concerned with the relationships between microscopic and mesoscopic features and the larger regional structures of which they are a part. The participants in this project were Paul Bowyer from Wooster College, Derek Brooks from Carleton College, Duncan Cox from Whitman College, Laurie Grigg from Colorado College, Philip Pearce from Trinity College, Alex Sessions from Williams College, and Christina Vosen from Carleton College. Sam Root from Wooster College, Ed Beutner from Franklin and Marshall College, and I shared the task of trying to provide encouragement, advice, and sympathy as needed.

BLUE RIDGE PROVINCE

The Blue Ridge is a large north-plunging anticlinorium comprised of a basement core consisting mainly of Precambrian crystalline rocks covered by a sedimentary veneer. This veneer consist of metasedimentary rocks on the southeastern flank of the core and by unmetamorphosed sedimentary rocks on the northwestern flank. In recent years the basement of the Blue Ridge has been interpreted as being comprised of two massifs known as the Pedlar and Lovingston massifs. All of the Pedlar massif and major portions of the Lovingston massif are composed of Precambrian, high grade metamorphic rocks. Some Paleozoic intrusions occur in the Lovingston massif. The Lovingston massif may also contain some late Precambrian / early Paleozoic metasedimentary rocks. The Precambrian, high grade rocks in the Blue Ridge were affected by Grenville age (1 billion +/-) metamorphism. These older portions of the Blue Ridge generally appear to have behaved as brittle materials during the late Paleozoic orogeny, the Alleghanian Orogeny, that affected the region. In western Virginia, effects, if any, of early and middle Paleozoic orogenesis remain obscure.

Both the Pedlar and Lovingston massifs contain charnokites and other granulite facies metamorphic rocks. They differ in that the Lovingston also contains lower grade metamorphic rocks and at least portions of the Lovingston massif are thought to have been metamorphosed at shallower levels in the crust. As evidence of this, some of the rocks in the Lovingston massif contain biotite which is generally not present in the Pedlar massif.

The contact between these two massifs is a fault zone characterized by large scale ductile deformation. Known as the Rockfish Valley ductile deformation zone, this zone is ten kilometers or more wide. Alex Sessions and Laurie Grigg studied portions of the zone in an effort to resolve some of the complexities of its deformational history.

NORTHWESTERN FLANK OF THE BLUE RIDGE

The contact between the Blue Ridge crystalline basement and its cover is a major nonconformity. In some places, the top surface of the basement beneath the cover is deeply weathered. In other places, fresh basement rock is covered by sedimentary rocks. The basal sedimentary rocks belong to two units, the Catoctin Formation and the basal member of the Chilhowee Group, known as the Unicoi Formation. The Catoctin Formation is comprised of metavolcanic rocks including prominent greenstones lava flows some of which were extruded under or into water. Coarse sandstones and pebble conglomerates containing feldspar are also present in the Catoctin. Dating of the metabasalts in the Catoctin has yielded ages ranging from 900 to 700 ma. The primary distinction between the Catoctin and the Unicoi formations is the presence of thick greenstones in the Catoctin. Ash beds and some greenstones are also present in some rocks that have been mapped as Unicoi.

Along most of the boundary between the Blue Ridge and the Valley and Ridge in the Central Appalachians, the sedimentary cover lies in a conformable sequence over the Blue Ridge basement. The cover rocks are strongly folded and are locally cut by tear faults and thrusts with minor stratigraphic throw, but they are unbroken by major thrust faults. When the Alleghanian Orogeny took place late in the Paleozoic Era, the Blue Ridge massifs were transported to the northwest. In the northern part of the Central Applachians, major thrust faults are not present along the northwestern flank of the Blue Ridge. Apparently the rocks now exposed in the Blue Ridge were transported mainly on a thrust fault that now crops out as the North Mountain thrust, the trace of which is located in the western part of the Great Valley of Virginia.

South of the gap formed by the James River where it cuts across the Blue Ridge, major thrust faults lie along the boundary between the Blue Ridge and the Paleozoic cover. Generally, these faults are located within the Chilhowee and in some places between the Precambrian basement and its cover. In our study area, a thrust, known as the Blue Ridge fault, lies in this position. Two members of our group, Duncan Cox and Derek Brooks, undertook investigations of a portion of this northwestern flank of the Blue Ridge in an area southwest of the James River Gap.

FOLDS AND FAULTS OF THE VALLEY AND RIDGE

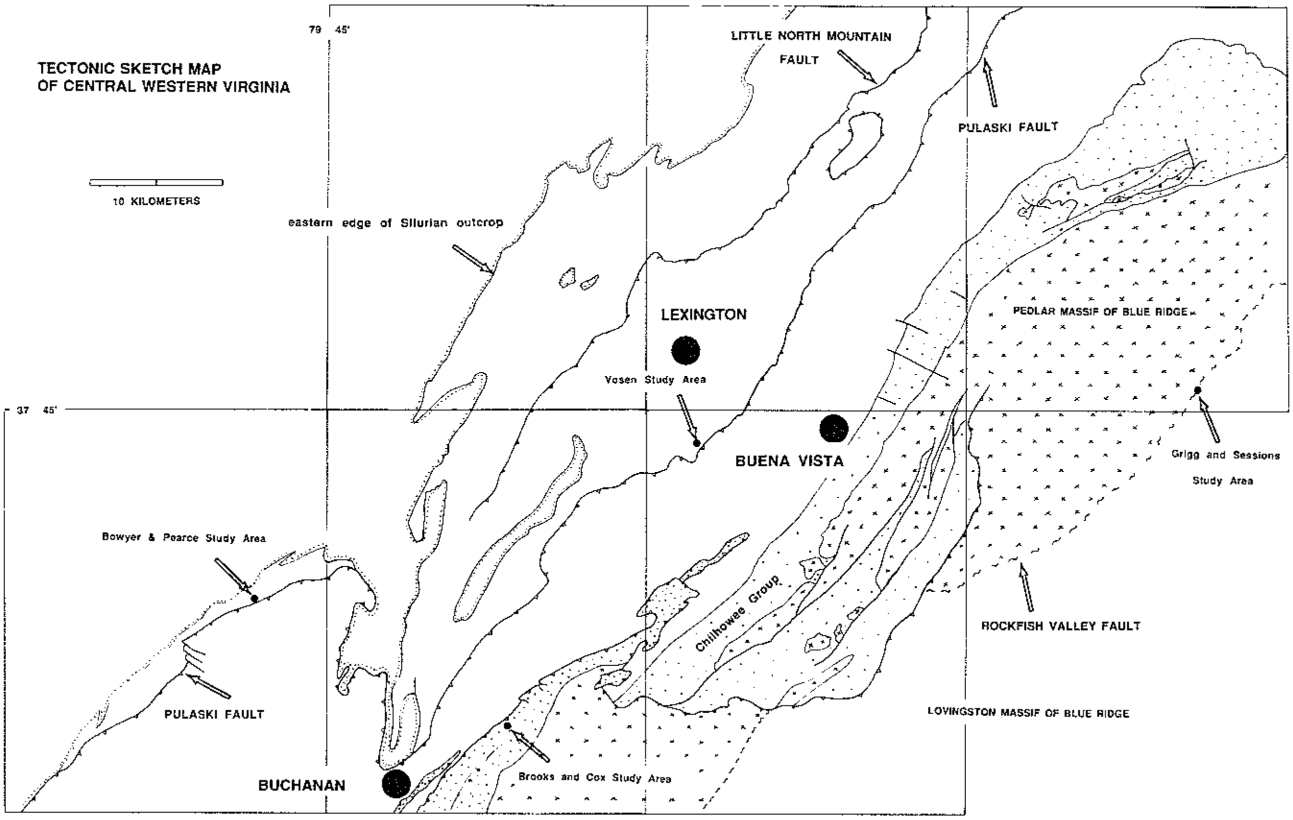
In central Virginia, strata ranging in age from lower Cambrian to middle Devonian lie within the eastern part of the Valley and Ridge. This stratigraphic sequence, approximately 6 kilometers thick, contains two sections of coarse quartz-rich, clastic, ridge-forming rocks, the Chilhowee Group and the Silurian Tuscarora, Rose Hill, and Keefer sandstones. The balance of the sequence is composed mainly of carbonates and shales. The Chilhowee clastic rocks are resistant to erosion and underlie many of the topographic highs along the Blue Ridge flank. These rocks are not exposed northwest of the Blue Ridge flank. The Silurian clastic rocks are also resistant and form many of the ridges in the Valley and Ridge province. The Great Valley of Virginia is underlain by carbonate and shale parts of the section that lie between the Chilhowee and Silurian clastic rocks. All of these rocks are strongly folded in Virginia.

In northern Virginia, the North Mountain fault was the plane on which much of the displacement toward the northwest occurred. Near Staunton Virginia, a second major thrust, the Pulaski thrust, appears in the Great Valley, and at far south as Lexington, these two major thrusts run parallel to one another. A third major thrust, the Blue Ridge thrust, located within the core of the Blue Ridge is also parallel to the North Mountain and Pulaski thrusts for a short distance. Near Lexington, major changes occur in this system of thrusts. The North Mountain thrust dies out, and just south of the gap formed where the James River cuts across the northwestern flank of the Blue Ridge, the trace of the Blue Ridge fault cuts up in the section and becomes a prominent fault along the flank of the Blue Ridge. Farther south, through much of Virginia, the Blue Ridge and Pulaski faults are major planes of northwestward transport.

Along much of its length, the Pulaski fault carries lower Cambrian shales and platy dolomites on the northwestern edge of hanging wall. These are in thrust contact with rocks that range in age from upper Ordovician (a stratigraphic throw of about 1500 meters) to middle Devonian (a stratigraphic throw of about 2500 meters).

Christina Vosen elected to decipher the structure of some of the rocks in the middle Ordovician Edinburg Formation on the footwall and a short distance northwest of the trace of the Pulaski thrust near Buffalo Creek. Paul Bowyer and Philip Pearce worked on unraveling a complex portion of the leading edge of the Pulaski thrust near Eagle Rock Gap.

TECTONIC SKETCH MAP OF CENTRAL WESTERN VIRGINIA



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Structural Analysis of Eagle Rock Gap
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Introduction

Eagle Rock gap is a water gap formed by the James River in Botetourt county, west-central Virginia. It is located on the eastern margin of the Valley and Ridge Province of the Appalachians. Immediately to the east is the Great Valley of Virginia. The gap consists of two ridges which are held up by sub-vertical ridge forming Silurian sandstones. The ridges are laterally extensive for approximately 5km on both sides of the gap. The gap exposes Upper Ordovician through Lower Devonian strata, exposed units are: Martinsburg shale, Tuscarora quartzite, Rose Hill sandstone/shale, Keefer sandstone, Eagle Rock sandstone (a new name used for Upper Silurian units), Tonoloway limestone, and Oriskany sandstone. This sequence in exposed for 800m along the gap, which is oriented nearly perpendicular to strike. All deformation at Eagle Rock is attributed to the Alleghanian orogeny (Fig. 1).

The primary structure of the gap consists of a large NW dipping fault (refered to in this study as the Eagle Rock fault) which duplicates the section. This fault is on the limb of a large third-order SE verging syncline. This structure is in a region where principal stress was from the SE, thus most major faults would be expected to dip SE.

Eagle Rock is located near the western edge of the Pulaski thrust sheet. The Pulaski is a series of complex Alleghanian thrusts with a minimum total displacement on the order of 100km. The thrust originates southeast of Eagle Rock and propagates upward from depth on a series of decollements and ramps. Uncertainty surrounds the exact relation of the thrust to Eagle Rock, however it is agreed that Eagle Rock is a marginal feature of it.

The purpose of the study is to present a geometric model to explain the evolution of the Eagle Rock structure, with emphasis on the NW dipping Eagle Rock fault which duplicates the Silurian strata.

Previous Models

Several differing models have been presented to explain the Eagle Rock structure. This in itself illustrates the elusiveness of the structures origin. Foremost among the differences in previous descriptions is the displacement sense of the Eagle Rock fault. This fault has been interpreted as both a normal and reverse fault.

McGuire (1970) mapped Eagle Rock as a foot wall block of the Pulaski thrust. In this model, the Eagle Rock fault is formed early in the deformation by a slumping mechanism with normal fault displacement. The structure was then rotated toward the NW by branches of the Pulaski thrust. This rotation resulted in the sigmoidal folding and rotated the Eagle Rock fault to it current NW dipping orientation (Fig. 2).

Bartholomew (1982) suggests a similar geometry. In this model the major branch of the Pulaski thrust is shown as running under the gap, thus placing the structure on the hanging wall. As in the earlier interpretation, the Eagle Rock is believed to be a normal fault (Fig. 3.).

Most recently Spencer (1989) described Eagle Rock as a backthrust structure. This requires that the Eagle Rock is a reverse fault. Spencer suggests that a backthrust developed on the Pulaski when it encountered resistance to its NW movement (Fig. 4).

Data

This study is based on data and observations collected in the gap, as well as reference to the previous descriptions, reference to other described occurrences of foreland dipping faults, and with reference to the local geologic map (McGuire, 1970).

Folds analyzed at Eagle Rock consist of the large synclinal hinge in the Keefer and several smaller folds in the Rose Hill. A number of small sigmoidal kink folds in the more shaly layers of the Rose Hill are interpreted as early formed features, forming in sub-horizontal beds. Axial surfaces of these folds strike