COMMONWEALTH OF VIRGINIA
DEPARTMENT OF MINES, MINERALS, AND ENERGY
DIVISION OF MINERAL RESOURCES

GEOLOGY OF THE SIMEON QUADRANGLE, VIRGINIA

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EXPLANATION

al — alluvium

d — diabase

STRATIFIED ROCKS ON THE SOUTHEASTERN LIMB OF THE BLUE RIDGE ANTICLINORIUM

Everona Limestone: **O€e**, graphite slate with limestone interbeds; **ls**, limestone

ph — chlorite - white mica phyllite

sl — chlorite - white mica slate

qd — quartz diorite porphyry

fv — ferruginous metasandstone and metatuffaceous breccia

dv — dacitic metavolcanic rocks

mss — metasandstone

msp — metasiltsone and phyllite

Catoctin Formation: **€Zc**, metabasalt; **€Zca**, meta-arkose; **€Zcs**, phyllitic metasiltstone

ALLOCHTHONOUS ROCKS OF UNCERTAIN STRATIGRAPHIC POSITION (Buck Island thrust sheet)

€Zmg — metagraywacke

ss — metasandstone

ps — pinstriped metagraywacke

KEY

Contact

Faults:
Dashed where projected beneath alluvium

Normal fault: **U** - on upthrown side; **D** - on down thrown side.

D_1 thrust fault: open teeth on hanging wall

D_2 thrust fault: solid teeth on hanging wall

Thrust fault reactivated as normal fault

Folds:

Overturned antiform showing axial trace and direction of plunge

Overturned synform showing axial trace and direction of plunge

Trend and plunge of minor fold axis

Planar features:

Strike and dip of beds

Vertical beds

Horizontal beds

Strike and dip of metamorphic foliation

Vertical metamorphic foliation

Bedding and metamorphic foliation strike and dip in the same rock, location given by intersection of bedding tick with strike line

Strike and dip of joint surface

Other features:

Abundant vein quartz or siliceous breccia

Exposures of hyaloclastite pillow breccia in Catoctin metabasalt

Denotes superposed brittle and ductile shear fabric

Quarries:

s Slate quarry, abandoned

l Limestone quarry, abandoned

b Metabasalt quarry, abandoned

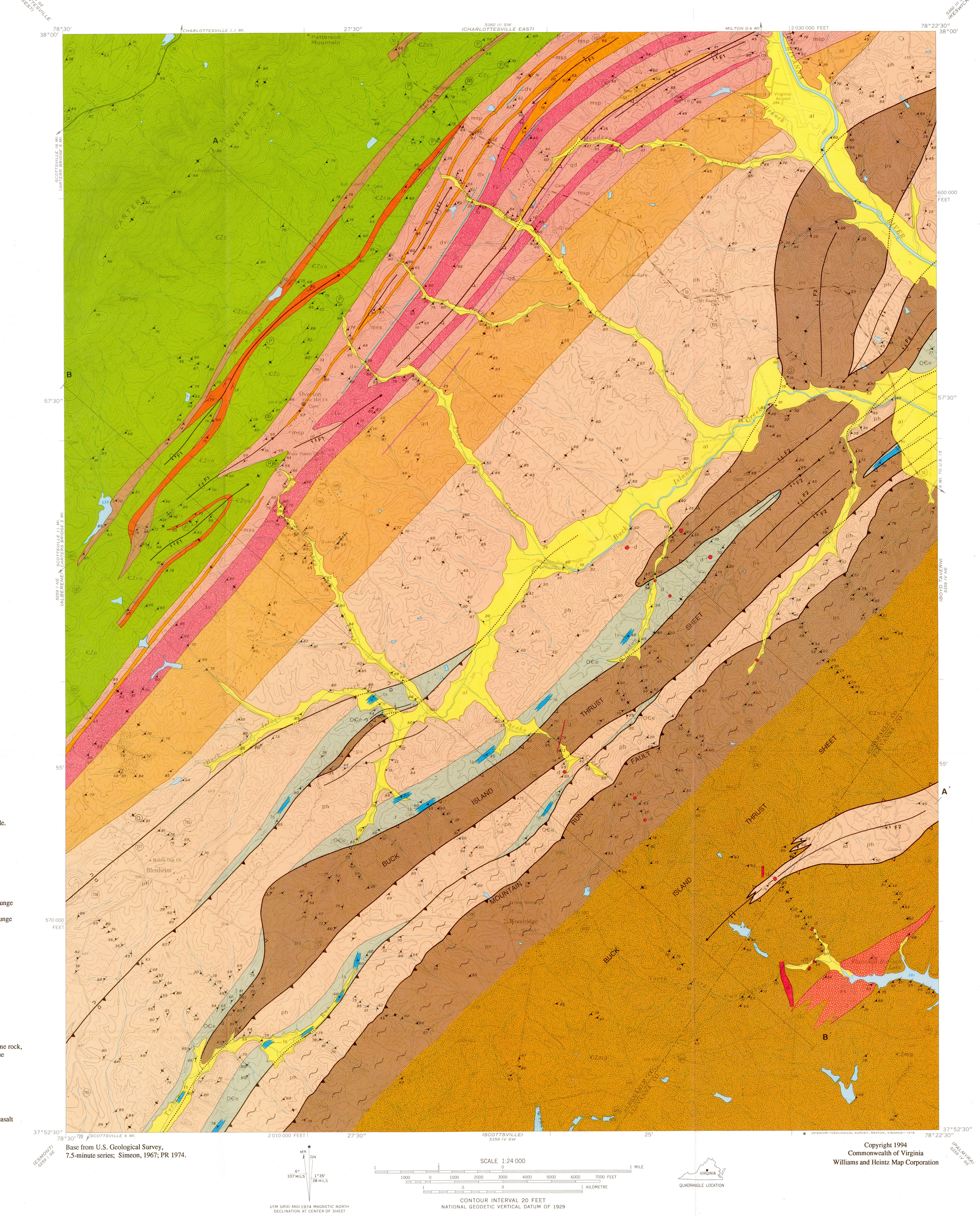
CROSS SECTIONS ONLY:

Fault

Bedding form lines

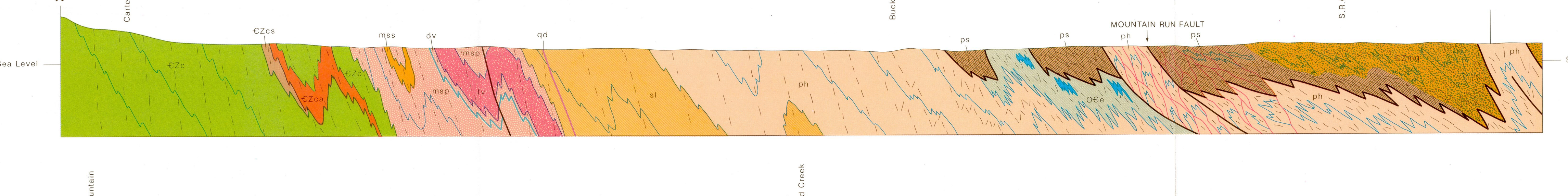
Metamorphic schistosity (D_1)

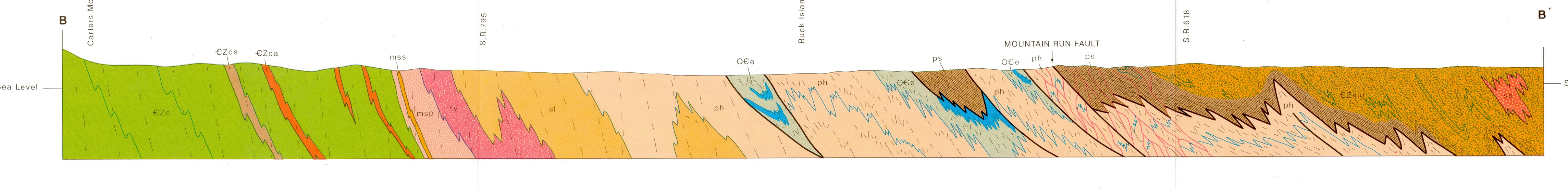
Brittle shears (D_2)



Base from U.S. Geological Survey, 7.5-minute series; Simeon, 1967; PR 1974.

INTERPRETIVE CROSS SECTIONS
1. No vertical exaggeration.
2. Surficial deposits not shown.
3. Subsurface units and structures interpreted from surface and nearby seismic data.





INTRODUCTION

The Simeon 7.5-minute quadrangle includes parts of southeastern Albemarle and westernmost Fluvanna Counties, in the western part of the Piedmont Physiographic Province of central Virginia. The quadrangle straddles a complex tectonic boundary between Late Precambrian- to Early Paleozoic(?)-age stratified rocks on the southeastern limb of the Blue Ridge anticlinorium, in the northwestern portion, and allochthonous Precambrian- or Cambrian(?)-age metagraywackes of uncertain stratigraphic affinity that occur to the southeast. The regional tectonic framework of this part of the Virginia Piedmont is discussed by Pavlides (1989), Glover and others (1989), Conley (1989), and Evans and Milici (1994).

The pre-Mesozoic-age rocks throughout Simeon quadrangle contain greenschist-facies mineral assemblages that crystallized during Paleozoic regional metamorphism. Primary features related to volcanism or sediment deposition are widely recognizable through this mild metamorphic overprint, making it possible to develop a stratigraphic framework consisting of fifteen map units. The Catoctin Formation and Everona Limestone are retained as formal names, following Nelson (1962) and Rossman (1991). The Catoctin is subdivided into three units, and the Everona, into two. Metamorphosed sedimentary and volcanic rocks stratigraphically above the Catoctin and below the Everona, which are mapped as Candler Formation on the Geologic Map of Virginia (Virginia Division of Mineral Resources, 1993), comprise seven lithostratigraphic units in this report. The lowermost units correspond to metagraywacke and meta-arkose lithologic units mapped by Rossman (1991) in nearby Keswick quadrangle; phyllite and slate units mapped in Simeon quadrangle are equivalent to "unit brb" of Rossman (1991). In the absence of detailed mapping between the Simeon quadrangle and the type locality of the Candler Formation at Candlers Mountain near Lynchburg, it is not clear what portion of the lithologic units here defined between the Catoctin Formation and the Everona Limestone are equivalent to the Candler Formation at the type locality.

Southwest of, and structurally above the Everona Limestone, three lithodemic units of uncertain regional correlation have been mapped in Simeon quadrangle. The rocks in these units likely are equivalent to rocks mapped as lithologic units in the Mine Run Complex by Rossman (1991), and are mapped as metagraywacke, quartzose schist, and melange lithodeme on the 1993 Geologic Map of Virginia.

DESCRIPTION OF MAP UNITS

al — **alluvium:** Unconsolidated fine- to coarse-grained or gravelly sand, silt, and clay, deposited in the flood plains of major drainages. Deposits adjacent to the Rivanna River occur in thicknesses of 16 feet (5 meters) or more.

d — **diabase:** Grayish-black (N 2) to olive-black (5Y 2/1), weathers olive-gray (5Y 4/1) to light brown (5YR 5/6), fine- to coarse-grained, massive, dense diabase; composed of plagioclase and augite in ophitic texture, with accessory magnetite. Olivine is present locally. Diabase occurs as dikes as much as 164 feet (50 meters) thick; where dikes have not been traced beyond a single outcrop, unit is shown as a colored circle on the map.

STRATIFIED ROCKS ON THE SOUTHEASTERN LIMB OF THE BLUE RIDGE ANTICLINORIUM

Everona limestone

O€e — **graphite slate with limestone interbeds:** Medium-gray (N 5) to grayish-black (N 2) pyrite-quartz-graphite slate; thinly-laminated in part, with laminae defined by graphite-rich and quartz-pyrite-rich domains. Chlorite, muscovite, and calcite are constituents of some slates. Weathered slates are characterized by light brown (5YR 5/6) pinstripes defined by goethite-quartz laminae. Most slate outcrops contain complex microfolds. Although limestone and calcareous mudstone (**ls**) generally overlie chlorite-white mica phyllite (**ph**) and underlie the principal belt of graphite slate, limestone beds also are present at higher stratigraphic levels within graphite slate.

ls — **limestone:** Medium- to medium-dark-gray (N 4 to N 5), thinly-laminated limestone and calcareous mudstone. Mudstone contains calcite, quartz, and graphite in graded, silty laminae 2 mm to 1 cm thick; muscovite, pyrite, and graphite are common accessory minerals. Limestone contains a penetrative slatey cleavage defined by graphite and muscovite; most limestone outcrops contain abundant small-scale folds, calcite-filled fractures, and microfaults. Limestone is exposed only where outcrop belts intersect stream bottoms; outcrop widths range from 1 to 328 feet (1 to 100 meters). Because of uncertainty as to how far individual limestone beds persist along strike, only areas of exposed limestone are indicated as such on the map. Limestone bedrock likely is present beneath cover along strike well beyond the limits of exposure.

The Everona Limestone was named by Jonas (1927) for exposures near Everona, Orange County, Virginia, about 25 miles northeast of Simeon. Jonas (1927) reports retrieving trilobite fragments from sandy beds adjacent to the Everona (graphite slates?), but these were so poorly preserved that E.O. Ulrich could not identify them, even with respect to genus. Recent attempts by N.H. Evans and R.C. Milici to extract conodonts from the Everona have so far proven fruitless.

Thin graded laminations in Everona limestone and slate imply transport by gravity flow below wave-base; presence of carbonate and a relative lack of siliciclastic detritus are consistent with a carbonate bank source area. Stabilization of pyrite and graphite are suggestive of reducing conditions (restricted circulation?) in the depositional basin. To the extent that facies correlations across the Blue Ridge anticlinorium are valid, it is plausible that the Everona was deposited outboard of a carbonate shelf that became stabilized along the North American continental margin in Middle Cambrian time, and is Early Paleozoic in age, although this age has not been verified.

The Everona was quarried at several localities along its outcrop belt during the 19th and early 20th centuries (Mack, 1965). For the most part, limestone was burned in local furnaces to produce lime for agricultural and construction purposes. A quarry west of State Highway 53 near Buck Island Creek produced aggregate for road construction during 1947 and 1948 (Nelson, 1962).

ph — **chlorite-white mica phyllite:** Greenish-gray (5GY 6/1) to shiny-dark-gray (N 4 to N 6), very-fine-grained chlorite-muscovite-quartz or chlorite-paragonite-quartz phyllite. Very-fine-grained quartz constitutes as much as 20 percent of the mode; zircon, tourmaline, magnetite, and graphite are accessory minerals. Chlorite porphyroblasts occur locally. The color of phyllites varies over a wide range with degree of weathering. Slightly weathered rocks are yellowish gray (5Y 7/2); with increasing weathering, the color changes from grayish orange pink (5YR 7/2) to pale red (10R 6/2 to 5R 6/2) to grayish red (5R 4/2 to 10R 4/2); deeply weathered phyllites are pale-grayish-orange (10R 8/4) to dark-yellowish-orange (10YR 6/6). X-ray diffraction work by R. C. Milici and S.S. Greenberg (unpublished data and manuscript map) indicates variation in the paragonite component of white micas within rocks mapped as chlorite-white mica phyllite (**ph**); this variation in paragonite component does not seem to manifest itself as a consistent variation in color or other observable feature that could be used in field mapping at a scale of 1:24,000.

Bedding generally is not visible in phyllite outcrops, and the rock contains a penetrative schistosity defined by chlorite and white mica. Crenulation cleavage is variably developed. Locally, the crenulation cleavage produces pencil structures where it intersects the metamorphic foliation at a high angle. Pencil structure is also developed where thin, silty laminae intersect the foliation at a high angle. Silty laminae locally outline tight, upright mesoscpoic folds in which the penetrative schistosity forms an axial-planar cleavage. The phyllite outcrop belt ranges from 0.62 to 1.24 miles (1 to 2 kilometers) in width. The unit is in stratigraphic continuity above chlorite-white mica slate (**sl**), with a gradational contact that appears to be related to decreasing quartz content in the transition from slate to phyllite, rather than decrease in metamorphic grade.

sl — **chlorite-white mica slate:** Medium-dark- to dark-gray (N 4 to N 3) chlorite-white mica slate and pencil slate. Weathered slates range in color from light greenish gray (5GY 7/1) to pale red (5R 6/2 to 10R 6/2) to reddish brown (10R 5/4 to 10R 3/4). Microcrystalline chlorite, muscovite, and flattened quartz define the penetrative slatey cleavage; tourmaline, zircon, graphite, and magnetite are accessory minerals. Many slates contain a weakly-developed crenulation cleavage. Slates locally contain actinolite- and chlorite-rich blebs that are wrapped by the slatey cleavage. Bedding, defined by very thin silty laminae, is visible in some exposures and locally outlines folds to which slatey cleavage is axial planar. Pencil slates occur where primary laminae and/or crenulation cleavage intersect the slatey cleavage at a high angle.

Slates are gradational with laminated metasiltstones (**msp**) in the northern part of the map area; southwest of Overton, slates appear to be conformable above ferruginous metasandstone and metatuffaceous breccia (**fv**). During the 18th and 19th centuries, slate was quarried for roofing material at several localities within the map area.

qd — **quartz diorite porphyry:** Medium-gray (N 5), weathers pale yellowish brown, metamorphosed porphyry contains prominant euhedral plagioclase, sanidine, quartz, and brown amphibole phenocrysts, in a microcrystalline groundmass of felty plagioclase, green amphibole, and muscovite. Plagioclase phenocrysts show little alteration in thin section; amphibole phenocrysts have alteration rims of pale-green amphibole and chlorite. Sanidine phenocrysts are thoroughly altered to white mica. Tiny metamict zircon or allanite crystals occur within some amphibole phenocrysts. Amphibole in the groundmass defines a weak foliation.

This unit occurs as a northeast-trending, steeply southeastward-dipping, dike-like mass as much as 50 feet (15 meters) thick that cuts at a low angle across slate (**sl**), metasiltstone and phyllite (**msp**), and ferruginous metasandstone and metatuffaceous breccia (**fv**) outcrop belts. The weakly-developed foliation in the quartz diorite porphyry is generally concordant with the foliation in adjacent rocks.

fv — **ferruginous metasandstone and metatuffaceous breccia:** Very-fine- to medium-grained, hematite-cemented quartz sandstones are dark-gray (N3), and weather to dusky-red (5R 3/4). Graded beds are as thick as 15 cm; detrital grains are almost entirely angular quartz, with minor plagioclase, tourmaline, and zircon. Metatuffaceous breccias are dark-greenish-gray (5GY 3/1) to medium-dark-gray (N 4) and weather dusky-red (5R 3/4). These are dense, hematite- and chlorite-cemented breccias containing angular, embayed, subhedral quartz and feldspar grains, 1- to 2-mm lenticular blebs of intergrown chlorite and actinolite, and 2-mm to 2-cm angular chips and fragments of opaque, iron-rich material that has an internal foliation (primary?) discordant to bedding and schistosity (S_1) in the enclosing rock. Ferruginous metasandstones and metatuffaceous breccias are interbedded with greenish-gray laminated metasiltstone and phyllite; discontinuous dacitic metavolcanic beds occur locally.

This unit is a distinctive, if heterogeneous, marker that occurs in outcrop belts as much as 1640 feet (500 meters) in width. Limited exposure precludes mapping out individual beds over long distances. In the southwestern part of the map area, the unit occurs stratigraphically beneath chlorite-muscovite-quartz slate (**sl**). Thin interbeds within the slate contain chlorite- and actinolite-rich fragmental material and resemble tuffaceous breccia, implying a gradational contact. In the northeastern portion of the map area, these rocks are within laminated metasiltstones and phyllites (**msp**).

dv — **dacitic metavolcanic rocks:** Dark-greenish-gray (5GY 4/1), very-fine-grained to aphanitic, well-indurated actinolite-plagioclase-quartz-chlorite metadacite; epidote, calcite, and magnetite are accessory minerals. The rock contains subhedral, embayed betaform-quartz and plagioclase phenocrysts locally; some outcrops contain vesicles filled with chlorite-actinolite-epidote intergrowths. These rocks are in outcrop widths as great as 65 feet (20 meters), within or subjacent to ferruginous metasandstone and metatuffaceous breccia (**fv**).

mss — **chlorite-quartz metasandstone:** Includes greenish-gray (5GY 5/1), fine- to medium-grained chlorite- and silica-cemented quartzose metasandstone that weathers light-brown (5YR 6/4), and grayish-green (10GY 5/2) laminated metasiltstone that weathers light-brown (5YR 6/4). Graded metasandstone beds are from 50 cm to 3 m thick; coarse-grained to pebbly beds are sparsely distributed. Detrital grains are predominantly quartz, with minor plagioclase, tourmaline, and zircon. Greenstone clasts are present locally in pebbly beds. Chlorite defines a faint metamorphic schistosity.

msp — **metasiltstone and phyllite:** Includes grayish-green (10GY 5/2) laminated chlorite-muscovite-quartz metasiltstone that weathers light-brown (5YR 6/4), and grayish-green (10GY 5/2) silty chlorite-muscovite phyllite. Graded laminations are 2 mm to 0.5 cm thick; the intersection of metamorphic schistosity, defined by chlorite and muscovite, with bedding, produces mullion and pencil structure locally. Southwest of the Simeon quadrangle, laminated, graded metasiltstone is in depositional contact above Catoctin metabasalt in an exposure along the Hardware River (Evans and Milici, 1994).

The thickness and abundance of metasandstone (**mss**), and the areal extent of laminated metasiltstone (**msp**), increase from southwest to northeast along strike across the Simeon quadrangle. These trends likely reflect, to some extent, primary depositional facies distribution, suggestive of a paleodepocenter (submarine fan complex?) in the northern part of the map area. Gentle dips in the cores of map-scale folds also contriubute to broader outcrop belts in the northern part of the quadrangle.

Catoctin Formation

€Zc — **metabasalt:** Dominantly grayish-green (5G 5/2) to dusky-yellow-green (5GY 5/2), fine-grained, massive to schistose quartz-albite-epidote-magnetite-chlorite-actinolite metabasalt that weathers olive-gray (5Y 3/2 to 5/2) to light-brown (5YR 5/6). Fine-grained saccharoidal segregations of epidote plus quartz are common. These are moderate-yellow-green (5GY 7/4) to grayish-yellow-green (5GY 7/2), and weather yellowish-gray (5Y 7/2) to dusky-yellow (5Y 6/4); segregations range in size from a few centimeters to a meter or more across. Lack of persistent marker beds and limited exposure make it difficult to map out structures within the northwestern outcrop belt of metabasalt.

Hyaloclastite pillow breccias are common along the southeastern margin of the outcrop belt; exposures where pillows and pillow breccias were identified are indicated on the map by (P). Pillows are ellipsoidal and flattened, generally on the order of 10 cenimeters in maximum dimension, but locally as much as 3 meters across (Kline and others, 1990); these features are delineated by concentrations of epidosite on the rims, and in the interstices between pillows. Pillow breccias consist of poorly-sorted assemblages of 1 cm- to 1 m-size ellipsoidal to angular clasts of metabasalt in a finer-grained metabasalt matrix.

Badger and Sinha (1988) obtained a Rb-Sr age of 570 +/- 36 Ma on a suite of Catoctin metabasalt samples from Afton Mountain, on the northwestern limb of the Blue Ridge anticlinorium about 25 miles (40 km) west of the Simeon quadrangle. Early Cambrian *Rusophycus* is reported stratigraphically above the Catoctin near the base of the Chilhowee Group, also on the northwest limb of the anticlinorium (Simpson and Sundberg, 1987). Age dating and fossils indicate that the Catoctin Formation is close to the Precambrian-Cambrian boundary. Catoctin metabasalt is presently being quarried for aggregate in Shadwell, just north of Simeon quadrangle. An abandoned greenstone quarry is located within the quadrangle, southwest of Overton.

€Zca — **meta-arkose:** Pale yellowish brown (10YR 5-6/2), medium- to coarse-grained, silica-cemented, arenaceous meta-arkose that weathers grayish orange (10YR 7/4) to light olive gray (5Y 7/1) occurs as interlayers in the metabasalts. These rocks contain spherical to ellipsoidal grains of quartz, perthitic feldspar, and plagioclase; interstital material includes polycrystalline quartz with sutured grain boundaries, and minor epidote, chlorite, and muscovite. Primary sedimentary structures are not visible; outcrop widths reach a maximum of 487 feet (150 meters). Arenaceous meta-arkose is interbedded with laminated metasiltstone and phyllite. Meta-arkoses are notably less micaceous than the chlorite-quartz metasandstones (**mss**) stratigraphically above the Catoctin Formation. Southeast of Simeon, a bed of arenaceous meta-arkose is in contact with laminated metasiltstones that overlie the Catoctin; this map pattern is indicative of some degree of erosional beveling at the top of the Catoctin.

€Zcs — **metasiltstone and phyllite:** Geenish-gray (5GY 6/1 to 7/1) laminated chlorite-muscovite-quartz metasiltstone and silty phyllite weathers grayish-orange (10YR 7/4) to light-brown (5YR 6/4), graded laminations are from 2 mm to 0.5 cm thick. These rocks are thin interbeds within Catoctin metabasalt, generally associated with arenaceous meta-arkose.

ROCKS OF UNCERTAIN STRATIGRAPHIC POSITION

€Zmg — **metagraywacke:** Light- to dark-greenish-gray (5GY 7/1 to 4/1) quartzose chlorite metagraywacke, weathers grayish-orange (10YR 7/4) to dark-yellowish-orange (10YR 6/6). Rocks in this unit are heterogeneous with respect to grain size, quartz content, thickness of primary bedforms, and severity of tectonic overprinting; fabrics range from phyllitic to schistose to gneissic. A typical fabric consists of lenticular granular laminae and beds 10- to 20 cm-long by 3 mm- to 1 cm-thick composed of silt- to medium-grained or, locally, coarse-grained quartz and feldspar detritus, in a matrix of finer-grained quartz, chlorite, and muscovite. Graded beds are preserved locally. Phyllitic metagraywackes are fine-grained, micaceous rocks that lack visible detrital grains, but contain thin, laterally discontinuous and contorted, quartz-rich laminations, giving the appearance of gneissic segregation layering. Widely-distributed, attenuated, intrafolial isoclinal folds, and a characteristic lozenge-shaped bedform, imply that primary bedding in the metagraywacke has been substantially transposed into the plane of metamorphic foliation.

Thin sections reveal that the principal detrital grains in the metagraywacke are quartz and plagioclase feldspar. These are ellipsoidal, and have a strong preferred orientation, with an elongation direction in the plane of penetrative schistosity. Quartz grains have undulatory extinction and sutured grain boundaries, with tails of elongate subgrains. Although matrix quartz is generally thoroughly recrystallized into trains of strain-free, polygonal subgrains in the plane of foliation, ribbon fabric, indicative of ductile shearing of quartz, is preserved locally.

Other detrital grains include zircon, tourmaline, magnetite, epidote, and titanite. Lithic fragments include felsic volcanic detritus (subhedral quartz and feldspar grains), granitic plutonic fragments (quartz-perthite-biotite intergrowths), and metamorphosed mafic igneous material (chlorite-actinolite-magnetite intergrowths, rock fragments containing felty plagioclase and amphibole laths). Metamorphosed mafic igneous rock fragments, including chlorite-amphibole schist and hornblende-plagioclase metagabbro, have been identified within the metagraywacke; these range in size from a few centimeters to several meters across. Mafic fragments and blocks contain a foliation that is generally concordant with the penetrative foliation of the enclosing metagraywacke. Block boundaries are sheared in some cases; in others, they appear to be strain-free. No contact metamorphic effects have been observed.

This unit is depicted on the 1993 Geologic Map of Virginia as being intruded by the Melrose granite in Campbell County, about 50 miles (80 km) along strike to the southwest of Simeon quadrangle. The Melrose has been dated at 515 Ma (U-Pb zircon; Sinha and others, 1989), indicating that the metagraywacke is is Cambrian in age, or older.

ss — **metasandstone:** Very-pale-orange (10YR 8/2), poorly-sorted, fine- to coarse-grained, sucrose metasandstone, weathers dark-yellowish-orange (10YR 6/6). Rocks contain plagioclase and quartz grains in a strongly-foliated, very-fine-grained quartz-muscovite matrix. Other detrital components identified in thin section include zircon and tourmaline, both highly fractured; felty intergrowths of chlorite and amphibole; and magnetite.

This unit is notably homogeneous and lacking in mesoscopic structures. In contrast, the surrounding rocks are intensely deformed schistose and gneissic quartz-mica metagraywackes that display complex mesoscopic folds, boudinage, and mylonite. Contact relations with adjacent rocks are poorly exposed.

ps — **pinstriped metagraywacke:** Light-greenish-gray (5GY 8/1) to light-gray (N 7), phyllitic, quartzose, chlorite-muscovite metagraywacke weathers grayish-orange (10YR 7/4). These rocks contain a distinctive "pinstriped" fabric defined by lenticular, silty, quartz-rich domains 2 mm to 1 cm thick and 2 cm to 10 cm in maximum dimension, within an anastomosing micaceous matrix (Figure 1). Silty domains display grain-size grading locally, although the fining-direction varies among silty domains within a single outcrop. This implies that rock fabric is a result of shearing and transposition of primary graded laminations and beds. Attenuated, intrafolial, isoclinal folds outlined by granular laminae are visible locally. Oriented chlorite and muscovite laths define a penetrative foliation that is axial planar to isoclinal fold noses, and in the plane of transposed primary laminations.

In the southeastern outcrop belt, schists and phyllites showing pinstripe texture are gradational with schistose, phyllitic, and gneissic metagraywacke (**€Zmg**); the metagraywackes contain similar mesoscopic and microscopic structural elements, but are generally coarser-grained and more heterogeneous with respect to fabric. The "pinstriped" schists and phyllites are characteristic of the Buck Island thrust sheet in the central part of Simeon quadrangle. These rocks are interpreted as tectonites formed by deformation of metagraywacke (**€Zmg**) in an early- to syn-metamorphic (D_1) fault zone.

STRUCTURAL GEOLOGY

The northwestern part of the Simeon quadrangle is situated on the upright southeastern limb of the Blue Ridge anticlinorium, a regional northeast-trending, northwest-verging structure that can be traced through central and northern Virginia into Maryland and Pennsylvania. In central Virginia, the southeastern limb of the anticlinorium is truncated along a zone of ductile and brittle faulting that includes the Mountain Run fault. In the central and southeastern part of the Simeon quadrangle, polydeformed metagraywackes (**€Zmg**) of uncertain stratigraphic affinity define an areally extensive structural block, the Buck Island thrust sheet, that was emplaced on Blue Ridge rocks during an early phase of contractional deformation, and was subsequently folded and imbricated along reverse faults including the Mountain Run fault.

Geologic structures across the map area formed during multiple episodes of tectonism that involved early- to syn-metamorphic (D_1) contractional deformation, post-metamorphic (D_2) contractional deformation, and late extensional faulting (D_3). The manner in which each episode is reflected in microscopic, mesoscopic, and map-scale structures varies from place to place across the map.

EARLY- TO SYN-METAMORPHIC (D_1) STRUCTURES

A penetrative schistosity (S_1) defined by preferred orientation of phyllosilicate minerals is pervasive in the southeastern Blue Ridge and western Piedmont. In phyllitic rocks, widespread across the Simeon quadrangle, S_1 is defined by chlorite and white mica; in greenstone metabasalts, the foliation is defined by preferred orientation of actinolite and chlorite. Where unaffected by D_2 or D_3 overprinting, the minerals defining S_1 are unstrained, and have crystallized in a preferred orientation relative to principal compressive stress during regional greenschist-facies metamorphism. In many exposures, the northeast-trending, commonly steeply southeastward-dipping S_1 foliation is the only recognizable fabric element; pre-metamorphic features such as bedding are rarely discernable. In many cases primary features are highlighted in sawed rock-slabs, revealing that during metamorphic recrystallization coinciding with D_1, strain was accomodated by mechanisms of shortening normal to bedding, by folding, and by ductile shearing. Intensity of D_1 strain increases dramatically from northwest to southeast across the map.

Map units in the northwestern part of the Simeon quadrangle contain distinctive marker units that outline outcrop- and map-scale F_1 folds. These folds are tight, and upright to slightly overturned to the northwest, with axes having subhorizontal to gentle northeastward plunge, and northeastward trend. In rare exposures of outcrop-scale F_1 folds, the metamorphic foliation is undisturbed, and within a few degrees of parallel to the plane of the axial surface. On the elongated limbs of map-scale F_1 folds, primary features such as pillow breccias, vesicles, and the finest-grained segments of graded laminations are flattened in the plane of S_1. Detrital quartz grains in chlorite-quartz metasandstones (**mss**) have undulatory extinction and sutured grain boundaries, with vague elongation in the plane of S_1.

To the southeast, slate (**sl**) and phyllite (**ph**) are largely devoid of recognizable primary layering or marker horizons; consequently, outcrop- and map-scale F_1 folds are likely present, but cannot be readily mapped. However, Everona limestone and slate do contain recognizable primary laminations, which define considerably greater microstructural complexity than observed in rocks stratigraphically below the Everona, which crop out to the northwest. The laminations outline tight to isoclinal, small-scale, intrafolial folds with axial surfaces parallel to S_1 slatey cleavage. These microstructures indicate that bedding (S_0) in the Everona has been substantially transposed into S_1. F_1 microfolds in the Everona are overprinted by later folds and small-scale faults; a rigorous geometric analysis to relate small-scale D_1 structures to larger-scale D1 structures has not been attempted, given limited exposures. However, in this area, the Everona is the highest stratigraphic unit that is exposed on the southeastern limb of the Blue Ridge anticlinorium, and is generally situated structurally beneath the Buck Island thrust sheet. F_1 microfolds in the Everona are interpreted to be related to emplacement of the Buck Island sheet during early- to syn-metamorphic (D_1) tectonism.

In the central part of the Simeon quadrangle, the Buck Island thrust sheet contains distinctive "pinstriped" phyllitic metagraywackes characterized by a penetrative mylonitic fabric in the plane of S_1 (Figure 1). These rocks constitute a mappable unit (**ps**) that has been structurally emplaced above Everona limestone and graphite slate (**O€e, ls**), and phyllite (**ph**), on a series of imbricate (D_2) fault-blocks. Outcrops and sawed slabs of "pinstriped" metagraywacke show primary laminations transposed into the plane of S_1 by shearing and attenuation of isoclinal microfolds. Small-scale, lenticular, granular, quartzose domains and sheared-out fold noses are sheathed by anastomosing micaceous folia. Examination of thin sections indicates that the primary fabric of the rock was disrupted by a combination of brittle and ductile processes. Ductile shearing accompanied metamorphic recrystallization in silty and clay-rich laminae. Micaceous domains contain tiny, asymmetric, lenticular grains of chlorite and muscovite, crystallographically aligned in S_1. Ellipsoidal micro-augen of plagioclase and quartz have pressure-shadows and asymmetric "tails". Quartz grains are monocrystalline and have recrystallized to an optically strain-free configuration; linear trains of tiny polygonal strain-free quartz grains occur within micaceous seams; ribbon fabric is locally preserved in the quartz. In coarser-grained, more quartz-rich laminae, mechanisms of small-scale folding and intergranular sliding were operative. Quartz-rich domains contain spherical to ellipsoidal detrital grains with asymmetric "tails" of finer-grained quartz, in a fine-grained, recrystallized quartz-chlorite matrix. The "pinstriped" metagraywackes are interpreted to be tectonites that formed during emplacement of the Buck Island thrust sheet.

On the hangingwall of the Mountain Run fault, where D_1 fault-rocks (**ps**) are brought up along a D_2 reverse fault, "pinstriped" metagraywackes are heavily overprinted by D_2 microshears (Figure 2). To the southeast, the "pinstriped" rocks are gradational with phyllitic, schistose, and gneissic metagraywackes (**€Zmg**). These rocks are more heterogeneous, and generally coarser-grained than the "pinstriped" metagraywackes, but transposition of primary layering into S_1 appears to be widespread in this unit throughout southeastern Simeon quadrangle and beyond.

D_1 microstructural sense-of-shear indicators are difficult to resolve in most places because of overprinting by later folds, faults, and related microstructures. In many situations, a subhorizontal, northeast-trending orientation of microfold axes, and angular relations between shear planes (S_1) and bedding indicate that tectonic transport to the northwest (present coordinates), although down-to-the-southeast transport is implied by some exposures. Evidence for D_1 lateral movement is not compelling. A large outlier or semi-klippe of "pinstriped" metagraywacke (**ps**) in the northeastern part of the quadrangle, and a tectonic window that exposes phyllite (**ph**) in fault contact beneath metagraywacke (**€Zmg**) in the southeastern sector are suggestive of substantial northwestward displacement of the Buck Island thrust sheet along a low-angle, southeastward-dipping fault. The association of D_1 tectonites with this fault, where exposed, has led to the interpretation that the Buck Island thrust sheet was emplaced during the D_1 deformational event.

POST-METAMORPHIC (D_2) STRUCTURES

Open kink folds and weakly developed crenulation cleavage commonly distrupt S_1 foliation in rocks in the northwestern part of the Simeon quadrangle, but map pattern and rock fabric are largely related to D_1 structures. In contrast, D_2 folds, faults, and related microstructures are major factors in determining map pattern and rock fabric in the central and southeastern parts of the map area.

In the central part of the Simeon quadrangle, a series of northeast-trending D_2 map-scale faults imbricate a "pseudostratigraphy" consisting of phyllite (**ph**), Everona limestone and slate (**O€e, ls**), and "pinstriped" metagraywacke (**ps**; D_1 tectonites on the Buck Island thrust sheet.) D_2 faults are associated with an easily recognizable phyllitic breccia in which micaceous fragments with preexisting metamorphic foliation (S_1) are folded, distended, fractured, and rotated amid an anastomosing mesh of microshears (Figure 2). D_2 tectonites are extensively developed on the hanging wall of the Mountain Run fault, as indicated on the map by a shear pattern. Chlorite-white mica phyllites (**ph**) commonly form either the footwall or the hanging wall of D_2 (and D_1) faults. This unit is well-suited, from a rheological standpoint, to serve as a glide surface for the development of a large-displacement, low-angle fault. D_1 tectonites are not well-developed (or readily apparent) in the phyllite adjacent to D_1 faults; however, the unit does display well-developed D_2 microfabrics in the vicinity of D_2 faults.

The imbricated rocks of the Buck Island thrust sheet and its footwall are folded by map-scale F_2 folds, some of which are probably genetically related to "blind" D_2 thrust faults. The F_2 folds are tight, northeastward-trending, northwestward-verging asymmetric structures with subhorizontal northeastward trending axes. Asymmetric outcrop-scale F_2 kink folds are common on the limbs of map-scale F_2 folds and adjacent to D_2 faults; these folds generally have northeast-trending, subhorizontal to gently-plunging axes. Kink folds are particularly well developed in thinly layered, "pinstriped" metagraywackes (**ps**).

EXTENSIONAL (D_3) STRUCTURES

A down-to-the-southeast extensional fault is demonstrable at a locality in the central part of Simeon quadrangle (Evans and Milici, 1994). In this outcrop, a southeastward-dipping extensional fault has offset previously sheared and folded "pinstriped" metagraywacke (**ps**) in the hanging wall relative to kinked and sheared Everona limestone and slate (**O€e, ls**) in the footwall. Structures in adjacent rock units (hanging wall anticline; footwall syncline) indicate that the fault is localized along an earlier reverse fault. The amount of down-to-the-southeast displacement on this fault cannot be determined on the basis of available exposures. However, the fault has been traced directly into the western border fault of the Scottsville Mesozoic basin, in an area located less than 3.2 miles (2 km) southwest of the Simeon quadrangle (Evans and Milici, 1994).

Models of subsurface geometry that are consistent with the geology in map view allow the possibility that other D_2 faults were reactivated as normal faults during the Mesozoic, producing down-dropped structural blocks and contributing to the complexity of the present-day map pattern. Notably, the Mountain Run fault is tracable directly into a normal fault that projects northeastward from the eastern side of the Scottsville basin (Evans and Milici, 1994). Definitive corroborative evidence for late extensional movement on the Mountain Run has not been found in this area, although the chaotic fabric of the tectonites associated with that fault could in part be a result of overprinting of D_1 and D_2 fabrics by microstructures related to late extensional faulting.

Outcrops of silicified phyllitic rocks, and of siliceous breccia consisting of white, amorphous quartz with angular fragments and blocks of quartz and phyllitic material occur at several localities within the map area; some, but not all coincide with the traces of D_2 faults. These features are similar to features in rocks described and attributed to Mesozoic extensional faulting by others (Conley and Drummond, 1965; Bourland, 1976; Kreisa, 1980).

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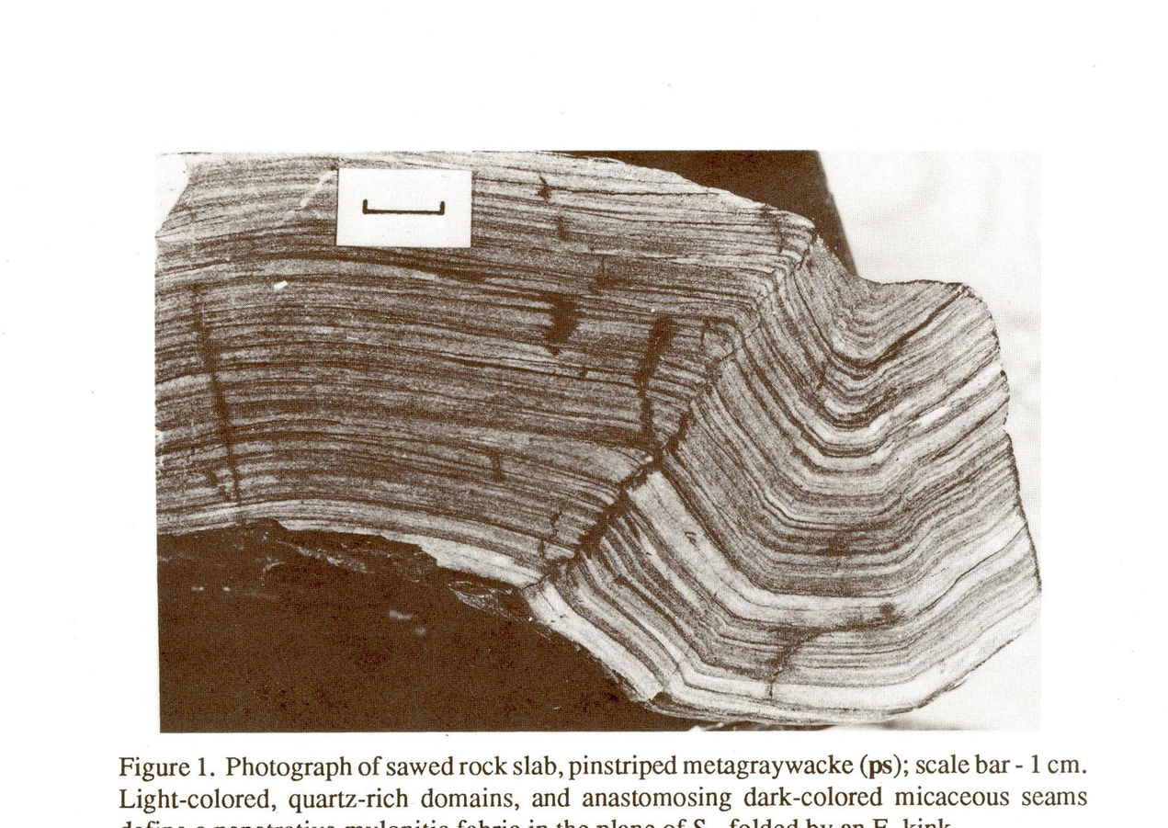

Figure 1. Photograph of sawed rock slab, pinstriped metagraywacke (ps); scale bar - 1 cm. Light-colored, quartz-rich domains, and anastomosing dark-colored micaceous seams define a penetrative mylonitic fabric in the plane of S_1, folded by an F_2 kink.

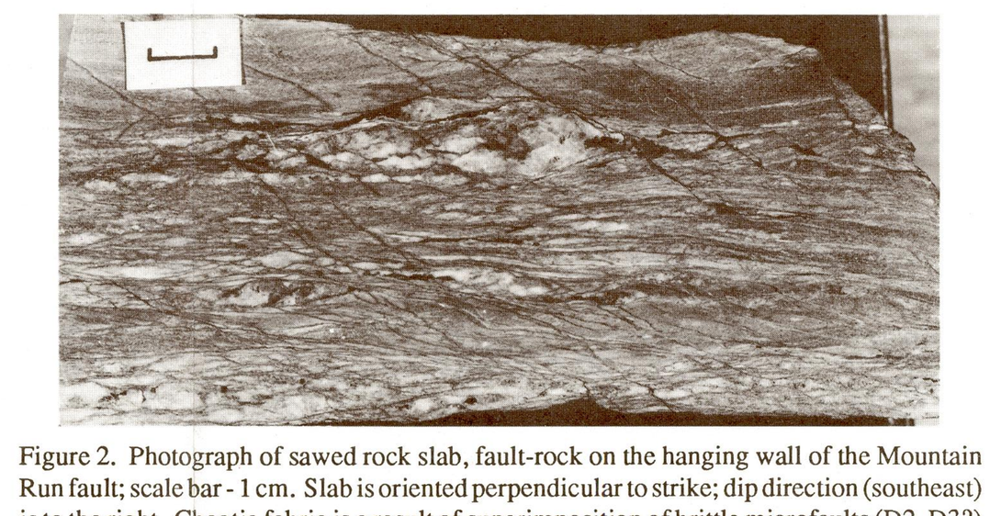

Figure 2. Photograph of sawed rock slab, fault-rock on the hanging wall of the Mountain Run fault; scale bar - 1 cm. Slab is oriented perpendicular to strike; dip direction (southeast) is to the right. Chaotic fabric is a result of superimposition of brittle microfaults (D2, D3?) on D1 mylonitic fabric. Brittle microstructures display both top-plate-to-the-northwest, and down-to-the-southeast shear-sense indicators.