VIRGINIA DIVISION OF MINERAL RESOURCES PUBLICATION 34

GEOLOGY OF THE ROANOKE AND STEWARTSVILLE QUADRANGLES, VIRGINIA

Mervin J. Bartholomew

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

Robert C. Milici, Commissioner of Mineral Resources and State Geologist

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FRONT COVER: Fold showing slightly fanned, axial plane, slaty cleavage in a loose block of Liberty Hall mudstone at Reference Locality 20, Deer Creek, Roanoke quadrangle.

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COMMONWEALTH OF VIRGINIA

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GEOLOGY OF THE ROANOKE AND STEWARTSVILLE QUADRANGLES, VIRGINIA

By
Mervin J. Bartholomew

ABSTRACT

The Stewartsville and Roanoke 7.5-minute quadrangles, encompassing an area of about 119 square miles (309 square km), are located in the Blue Ridge and Valley and Ridge physiographic provinces in Bedford, Botetourt, and Roanoke counties and the City of Roanoke in southwestern Virginia. The Blue Ridge fault, a prominent northeast-trending structural feature characterized by brittle deformation, forms a natural boundary between the crystalline rocks of the Blue Ridge province and the sedimentary rocks of the Valley and Ridge. Along a prominent fault in the Blue Ridge characterized by ductile deformation, the Rockfish Valley fault, relatively lower grade granulite gneisses of the Lovingston massif were thrust westward over somewhat higher grade granulite gneisses of the Pedlar massif. The oldest rock of the Lovingston massif is layered gray gneiss, which was intruded by the Horsepen Mountain suite during Grenville orogenesis and by material now represented by granite gneiss in latest Precambrian time. The oldest rock in the Pedlar massif is strongly layered granulite gneiss; this rock mass was intruded successively by materials now represented by porphyroblastic granulite gneiss, massive granulite gneiss, and leucocratic granulite gneiss. These Grenville-aged intrusive rocks and the country rock were invaded by small dikes of mafic to felsic composition. Rocks of the Pedlar massif are overlain nonconformably by rocks of the Weverton Formation (Chilhowie Group) adjacent to the Rockfish Valley fault.

The major faults in the Valley and Ridge of the area are the Salem, Green Ridge, Pulaski and Saltville thrust faults. Rocks of Cambrian age (Rome and Elbrook formations) in the Salem thrust sheet overlie those of Cambrian to Silurian age in the Green Ridge thrust sheet, and these rocks lie above the Ordovician to Mississippian rocks of the Salem synclinorium. These two thrust sheets and the synclinorium lie above the Pulaski fault and are, therefore, part of the Pulaksi thrust sheet, which is structurally higher than the Saltville thrust sheet. Small portions of the rocks from the Saltville thrust sheet have been brought to the surface in tectonic slivers that breached the overlying thrust sheet along the Salem thrust fault as at the Read Mountain-Coyner Mountain area and in the Bonsack window. A tectonic sliver derived from the Green Ridge thrust sheet forms the Glade Creek window.

Clay materials are produced from two sites in the Rome Formation within the Stewartsville quadrangle: one is a source of brick clay, the other is used for light-weight aggregate. Limestone and dolomite is produced from a quarry in Ordovician rocks in the Roanoke quadrangle. Past mining and prospecting was for phosphate (from nelsonite), sulfides, iron and manganese, and for building and crushed stone.

INTRODUCTION

The Stewartsville and Roanoke 7.5-minute quadrangles are located in Bedford, Botetourt and Roanoke counties and in the City of Roanoke in southwestern Virginia (Figure 1). The map area is about

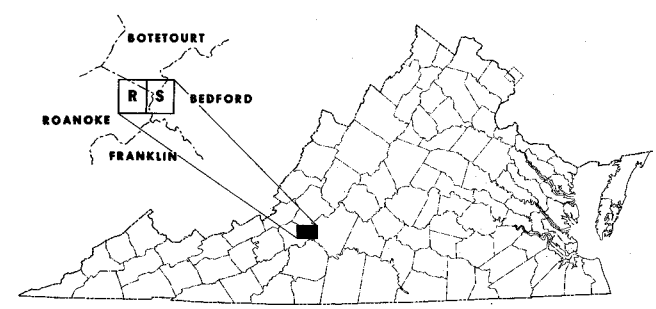

Figure 1. Index map for Roanoke (R) and Stewartsville (S) quadrangles.

119 square miles (309 sq km) and is bounded by 37° 15′00″ and 37° 22′30″ north latitudes and 79° 45′00″ and 80° 00′00″ west longitudes. Approximately three-fourths of the Stewartsville quadrangle and one-eighth of the Roanoke quadrangle are in the Blue Ridge province and the remainder of both areas is in the Valley and Ridge province. Elevations range from less than 820 feet (250 m) along the Roanoke River in the southwestern part of the Stewartsville quadrangle to more than 2520 feet (768 m) on top of Greens Knob near the center of the Stewartsville quadrangle. The Blue Ridge, which trends northeastward across the Stewartsville quadrangle, and Read and Coyner mountains, which are along the northern part of the common boundary between the quadrangles, are the most prominent topographic features. The Blue Ridge Parkway transects the western portion of the Stewartsville

quadrangle in a north-south direction. The entire region is drained by Roanoke River and its tributaries. Interstate Highways 81 and 581, respectively, cross the Roanoke quadrangle in a northeasterly and a southerly direction from their junction in the northwestern portion of the Roanoke quadrangle. U.S. highways 11, 220 and 460 and State Highway 24 as well as numerous state roads and city streets provide access to most areas. The Stewartsville quadrangle was mapped by M. J. Bartholomew between August 1977 and January 1978 and the Roanoke quadrangle between March and August 1979. Field work by W. H. Hazlett, Jr. was done as part of his Ph.D. dissertation (1968) completed at Virginia Polytechnic Institute and State University.

Numbers preceded by "R" or "F" in parentheses (R-) or (F-) correspond, respectively, to rock sample and fossil sample localities. These samples and thin sections from the rock samples are on file in the repository of the Virginia Division of Mineral Resources where they are available for examination.

Additional information on the geology of the Roanoke and Stewartsville quadrangles was obtained from maps done on different bases by Andrews (1952) and Chen (1960) and field notes of Charles Butts. Fossil identifications were by C. G. Tillman; A. P. Schultz helped collect specimens with numbers F-953 to F-956. Cataclastic rock nomenclature is after Higgins (1971).

STRATIGRAPHIC COLUMN

CENOZOIC

Quaternary

Alluvium: **al**, light-gray to light-brown, unconsolidated, stratified floodplain deposits of sand, silt and clay with beds and lenses of gravel, pebbles and cobbles. **f**, younger fan deposits, light-gray to medium-brown, unconsolidated, unstratified, poorly sorted, angular to subrounded boulders, cobbles, and pebbles in an unsorted matrix of sand, silt and clay. Deposits commonly reworked by fluvial processes and laterally gradational with older fan and terrace deposits as well as alluvium. Thickness is 0-20 feet (0.61 m).

Ancient alluvium: **td**, terrace deposits, dark-brown to dark-reddish-brown, unconsolidated, stratified deposits of older alluvial detritus above floodplains. **of**, older fan deposits, dark-brown to dark-reddish-brown, unconsolidated, unstratified to poorly stratified material formed by mass wasting processes and extensively reworked by fluvial processes. Deposits commonly dissected by streams. Thickness is 0-50 feet (0-15.3 m). The anomalous topographic high, Round Hill, apparently represents a 100-foot- (30.5-m-) thick remnant of a formerly extensive fan deposit derived primarily from Late Precambrian-Early Cambrian (Chilhowee) metasedimentary rocks of the Blue Ridge thrust sheet to the south. Up to 15 feet (4.6 m) of saprolite, containing blocks of quartzite, was observed on the southeast flank of Round Hill in a house excavation. Likewise, angular to well-rounded quartzite cobbles (R-8441) were observed resting directly on mudstone of the Rome Formation at the base of the hill. North of Glade Creek the deposits, which originated in the mountainous areas of both the Read Mountain-Coyner Mountain area (Figures 2 and 3) and the Blue Ridge in the adjacent Villamont quadrangle, once formed a series of coalescing fans. Thickness is 0-50 feet (0-15.3 m).

Tufa: **tu**, stratified deposit of light- to medium-gray, consolidated, angular to subrounded clasts of dolomite, limestone and chert in an unsorted matrix of similar material with calcareous cement. Thickness is 0-20 feet (0-6.1 m).

Talus deposits: **ta**, unconsolidated, unsorted boulder fields composed of 1- to 6-foot (0.3- to 1.8- m) angular blocks of orthoquartzite, quartz sandstone and quartzose conglomerate derived from nearby Devonian/Silurian strata. Thickness is 0-30 feet (0-9.2 m).

PALEOZOIC

Mississippian

Price Formation (lower member): **Mprl**, primarily medium-gray, fine- to medium-grained, platy, well-layered or cross-bedded, feldspathic and/or micaceous lithic standstone grading downward into cyclic sequences of medium-gray, medium- to coarse-grained conglomeratic sandstone with lenses of conglomerate; fine- to medium-grained lithic sandstone interbedded with siltstone; medium-gray mudstone interbedded with siltstone; and maroon mudstone and siltstone. About 200 feet (61 m) of the basal portion of the lower member is exposed in the Roanoke quadrangle. The member is generally overlain by a thin (1-3 feet; 0.3-0.9 m), light-brown, sandy soil.

Devonian

Chemung Formation: **Dch**, primarily medium-gray, fine- to medium-grained, platy, well-layered or cross-bedded, feldspathic and/or micaceous sandstones interbedded with dark-gray siltstones and mudstones. Mudstone layers are common in the lower part of it and increase toward the base to form 80% of the lower part of the unit. At the base of the formation, sandstones form 20- to 30-foot (6.1- to 9.2-m) resistant ledges. The base of the lowest prominent ledge was selected as the contact with the

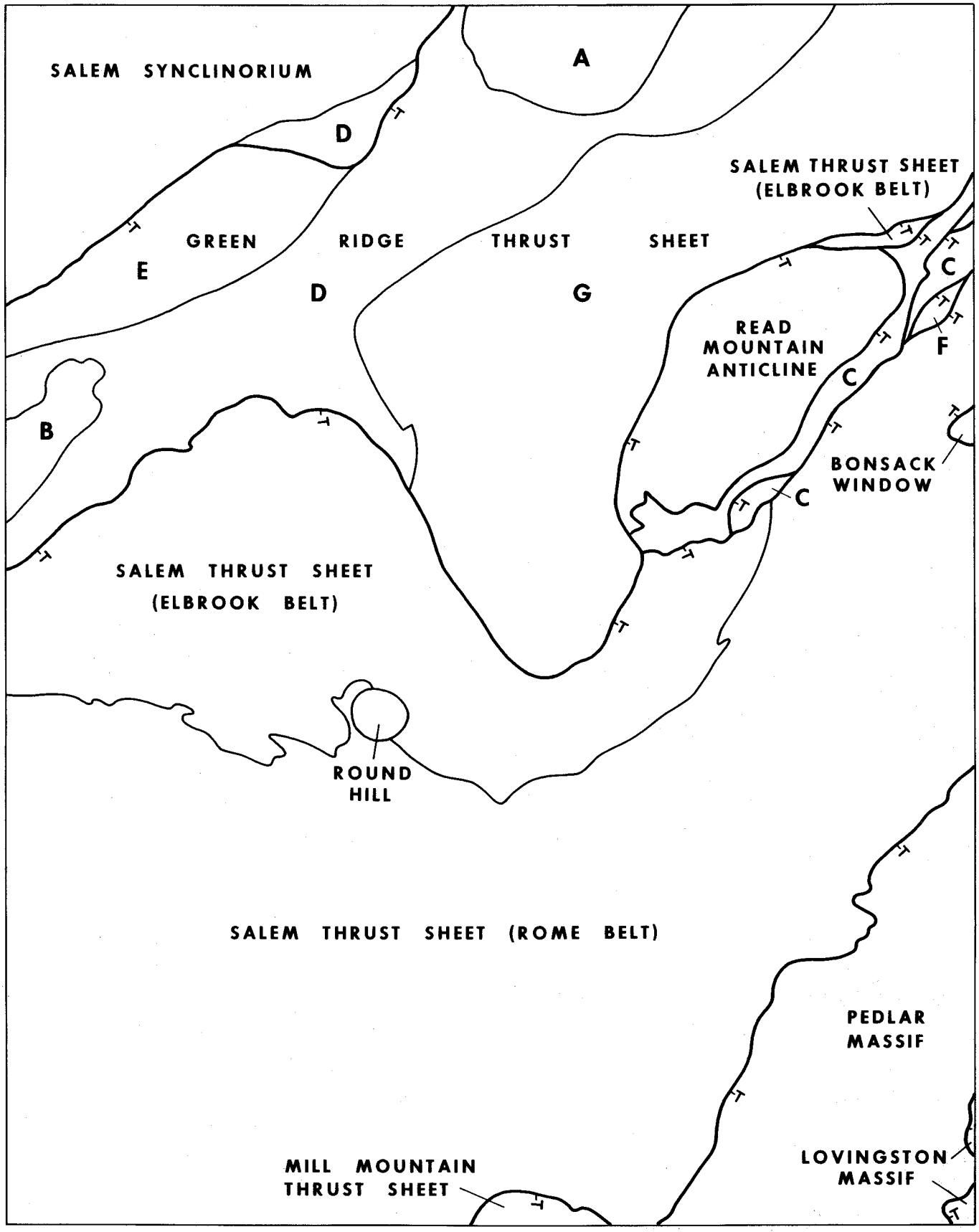

Figure 2. Major structural features of the Roanoke quadrangle. Heavy lines are faults; T is on upper sheet. Letter symbols are: A, Tinker Mountain; B, Kingston region of Green Ridge thrust sheet; C and F, fault slices around Read Mountain-Coyner Mountain structure; D, areas underlain by Liberty Hall shale, Green Ridge thrust sheet; E and G, Cambrian/Ordovician carbonate rocks.

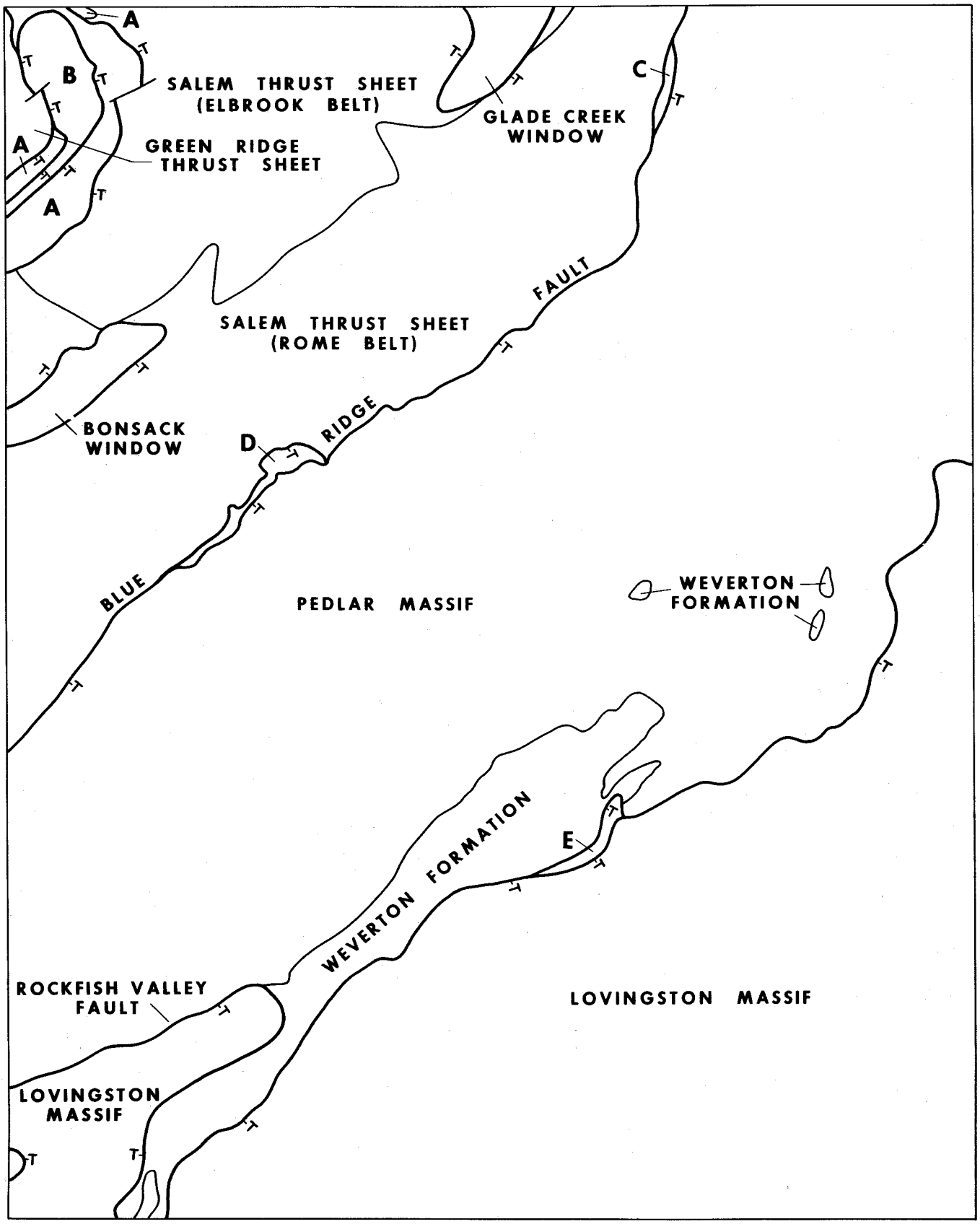

Figure 3. Major structural features of the Stewartsville quadrangle. Heavy lines are faults; T is on upper block. Letter symbols are: A and B, Coyner Mountain tectonic slices; C, D, E, tectonic slices.

underlying Brallier Formation. This contact is identical with that picked by Amato (1974) and Hazlett (1968); but is stratigraphically lower than the contact chosen by McGuire (1976). *Tylothyris mesacostalis* (F-959), which ranges from Late Devonian to Mississippian, is in the upper portion of the Chemung. Thickness is about 1000 feet (305 m). The formation is generally overlain by a thin (1-3 feet; 0.3-0.9 m), light-brown, sandy soil.

Brallier Formation: **Db**, interbedded sequence of 2-to 6- inch- (5.1- to 15.2-cm-) thick beds of dark-gray to black mudstones, medium-gray siltstones, and medium-gray, fine-grained, commonly cross-bedded sandstones. The base of the formation was placed at the lowest occurrence of prominent sandstones and siltstones. Thickness is about 2000 feet (610 m), but decreases dramatically southwestward into the adjacent Salem quadrangle (Amato, 1974) due to tectonic thinning. The formation is commonly covered by a thin (1-3 feet; 0.3-0.9 m), light- to medium-brown, sandy soil.

Millboro Formation: **Dm**, dark-gray to black, thinly bedded, fissile mudstone. It contains disseminated sulfides and is sparsely fossiliferous; Butts' field notes indicate that he found specimens of *Styliolina* at REFERENCE LOCALITY 1. Because of tectonic thinning, the observable thickness is only about 300 feet (91.5 m). A thin (0-3 feet; 0-0.9 m) light- to medium-brown, clayey soil generally develops over this unit, but near exposures of adjacent chert and sandstones, the mudstone may be concealed by a 0 to 6-foot (0-1.8 m) veneer of colluvium derived from the chert and sandstone.

Huntersville chert (Salem synclinorium; Figure 2): **Dh**, interbedded sequences of 6- to 12- inch (0.15- to 0.3- cm) beds of dark-gray, fine-gray, fine-grained chert separated by 0.5- to 1- cm lenses of dark-gray to black mudstone. The chert beds are irregularly bedded to somewhat nodular tabular lenses 1- to 4-cm thick with black, shaly partings. Unit thickness is about 20 feet (6.1 m) near abandoned quarry 38.

Lower Devonian and Upper Silurian rocks

(Read and Coyner mountains, Figures 2 and 3): **DS**, interbedded light-gray, medium- to coarse-grained quartzose sandstones in 5- to 40-foot (1.5- to 12.2- m) ledges (Figure 4) separated by 10- to 40-foot (3.1-to 12.2- m) intervals composed of thinly bedded, dark-gray to black mudstone, siltstone and fine-grained friable sandstone (Figure 5). The uppermost 20-foot (6.1- m) sandstone ledge of this unit on Read Mountain is sparsely fossiliferous and contains poorly preserved brachiopods and crinoid stems (F-960) similar to those found in approximately the same stratigraphic interval on Coyner Mountain.

Figure 4. Typical undivided Lower Devonian/Upper Silurian strata exposed at REFERENCE LOCALITY 19, on the southern flank of Read Mountain. Contact with Devonian Millboro shale is to left of 2-foot quartzite ledge on left side of borrow pit.

Figure 5. Close-up of interbedded sandstones and siltstone between quartzite ledges at borrow pit in Figure 4.

The faunal assemblage is suggestive of that commonly found in the Keyser Formation; preservation of fossils is generally poor. The assemblage consists of numerous fenestellid bryozoans (F-953), a calymenid trilobite (F-954), a *Coenites*-like coral (F-955) as well as other corals, brachiopods and crinod stems (F-956). Within the upper 50 feet (15.3 m) extensive replacement of sandstone by hematite, limonite and manganese is common. The contact with the underlying Keefer Formation was placed

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Lower Devonian and Upper Silurian rocks

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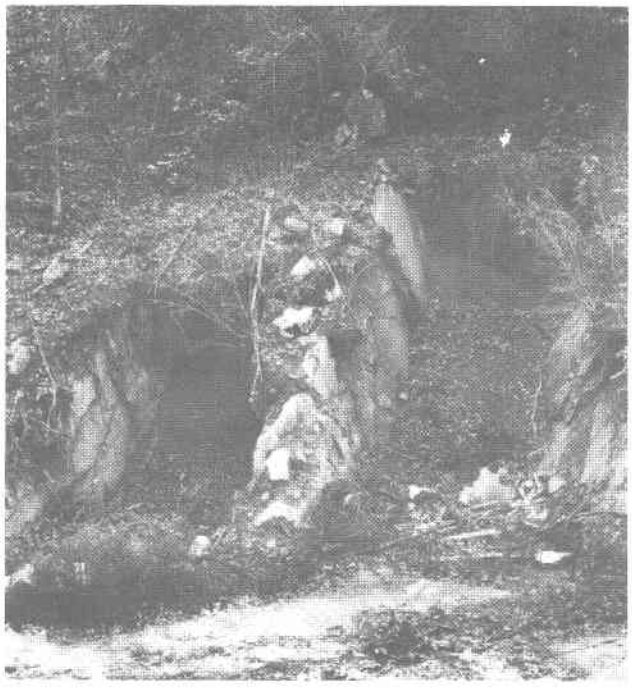

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at the base of the lowest occurrence of the easily weathered mud and siltstone. Thickness varies from about 100 to 600 feet (30.5 m-183 m). A very thin, light-gray, sandy soil locally covers small parts of outcrops.

Silurian

Keefer Formation: **Ske**, predominantly light-gray to white, medium- to coarse-grained quartzose sandstone interbedded with 5- to 20-foot (1.5- to 6.1- m) beds of light-gray to white, fine-grained orthoquartzite and quartz-pebble conglomerate. Discontinuous 5- to 10-foot (1.5- to 3.1.1- m) lenses of ferruginous sandstone occur locally. Thickness is 300 feet (91.5 m) near abandoned quarry 38 in the Salem synclinorium, about 200 feet (61 m) in the Green Ridge thrust sheet, where the Keefer lies disconformably on the Martinsburg Formation, and about 500 feet (153 m) in the Read-Coyner Mountain area. Locally, small parts of outcrops are covered by very thin, light-gray, sandy soil.

Rose Hill Formation (Read Mountain and Coyner Mountain area): **Sr**, interbedded, dark-brownish-red, medium-grained, ferruginous sandstones and dark-reddish-gray, mottled mudstones. Total thickness is about 80 feet (24.4 m).
(Salem synclinorium): Dark-reddish-gray interlayered mudstone, siltstone and fine-grained sandstone with a few 6- to 12-inch- (0.15- to 0.3- cm-) thick interbeds of fine-grained, ferruginous sandstones; 15 to 20 feet (4.6 to 6.1 m) thick near abandoned quarry 38. Butts' field notes indicate that he found eurypterids near this locality. This formation affords few outcrops and is typically recognized by the thin, reddish-brown, sandy soil developed on it.

Tuscarora Sandstone (Salem synclinorium): **Stu**, light-gray to white, coarse-grained, quartz-pebble conglomerate and conglomerate sandstone. Thickness is about 15 feet (4.6 m) all along Green Ridge. Locally, small parts of outcrops are covered by thin, light-gray, sandy soil.

Silurian-Ordovician

Tuscarora Sandstone and Oswego Formation (Read Mountain-Coyner Mountain area; Figures 2 and 3): **SO**, light-gray to white, coarse-grained conglomeratic, quartzose sandstones and quartz-pebble conglomerates in the upper 100 feet (30.5 m) and light-gray, fine- to medium-grained, quartzose sandstones in 2- to 10-foot (0.6- to 3.1-m) ledges separated by covered intervals in the lower 40 feet (12.2 m). The upper portion certainly belongs to the Tuscarora Sandstone; the lower portion includes rocks with characteristics of beds transitional to the Tuscarora and Oswego formations. Thickness is about 140 feet (42.7 m). The section is poorly exposed in the core of the Read Mountain anticline. At places a thin, light-gray, sandy soil is developed on intervals between the abundant bedrock ledges. Breccia (b) occurs locally at the contact with the underlying Martinsburg Formation. The breccia (R-8442) consists of angular to subrounded blocks of sandstone and quartzite loosely held together wth ferruginous cement.

Ordovician

Martinsburg Formation: **Omb**, uppermost beds dominantly medium-gray, fine-grained sandstones containing abundant specimens of *Lingula* (F-961). Below this interval, the dominant lithology is medium- to dark-gray, calcareous mudstone, which is interbedded with sandstone in the upper part of the unit, and with medium- to dark-gray, coarse-grained, bioclastic limestone (R-8414) in the lower part of the unit. Strophomenoid brachiopods (F-957) are in the upper portion. Butts' notes indicate the presence of specimens of *Dalmanella, Sowerbyella, Rafinesquina,* and *Ceratopsis* in these beds (REFERENCE LOCALITY 2). Thickness is estimated to be 1000 feet (305 m). A thin, light brown, clayey soil is commonly developed on the Martinsburg Formation.

Bays Formation (Salem synclinorium): **Oba**, light-gray, fine-grained, quartzose sandstones interbedded with thin beds of mottled maroon and green mudstones and siltstones; Thickness is about 200 feet (61 m).
(Green Ridge thrust sheet): The lithology and thickness of the formation in the Tinker Mountain area in the Green Ridge thrust sheet are similar to those in Salem synclinorium, but near Kingston the unit consists predominantly of interbedded maroon, fine- to medium-grained sandstones and both gray and maroon mud and siltstones with several 5- to 20-foot- (1.5- to 6.1- m-) thick intervals of light-gray, fine-grained quartzose sandstones. Thickness of this truncated section exceeds 600 feet (183 m). Previously many areas of what is herein included in the Bays Formation were mapped as part of the Martinsburg Formation (Amato, 1974; Hazlett, 1968). These areas contain gray shales similar to those in the Martinsburg, but abundant redbeds are interbedded with these gray shales throughout both the truncated section along the creek at Kingston and in an unweathered section exposed during road construction along Peter Creek in the adjacent Salem quadrangle (Amato, 1974). These redbeds are here considered part of the Bays Formation, and accordingly all beds within the Roanoke quadrangle near

Kingston are interpreted to belong to the Bays Formation. The unit is typically overlain by a light-brown to reddish-brown sandy soil.

Liberty Hall Formation (Salem synclinorium): **Olh**, predominantly interbedded dark-gray to black, calcareous, slaty mudstone and dark-gray, medium- to coarse-grained bioclastic limestone. True thickness was not determinable because the unit is disrupted by folds and faults.

(Green Ridge thrust sheet): Dark-gray to black, calcareous mudstone with few, scattered, thin (2- 12-inch; 5.1- to 30.4- cm) beds of dark-gray, fine-grained limestone. Penetrative cleavage is well developed in the black rock and commonly is cut sequentially by small "kink folds," calcite-filled joints (Figure 6) and numerous small thrust faults

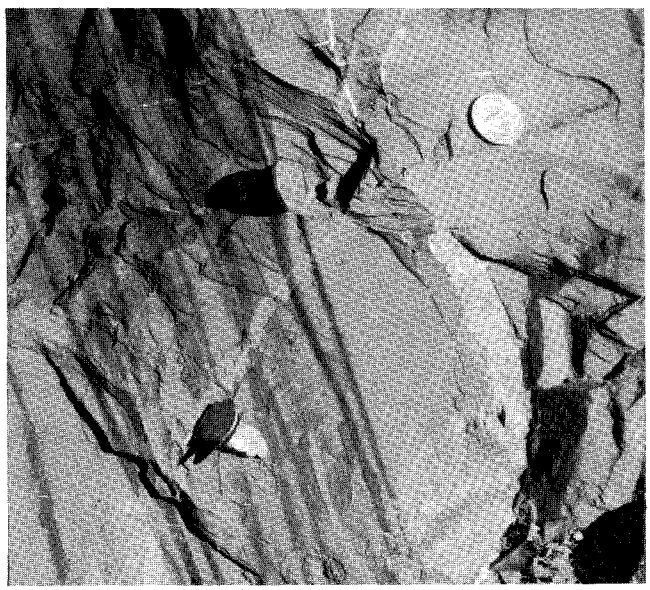


Figure 6. Typical mudstone of Liberty Hall Formation exposed in Deer Creek at REFERENCE LOCALITY 20 showing relationships of bedding (parallel to disc-plane of dime in lower left), cleavage (parallel to disc-plane of quarter in upper right), and kink bands (parallel to near vertical disc-plane of penny in upper center).

(Figure 7). Deformed graptolites (F-962) and specimens (F-963; F-964) of *Porterfieldia* (a genus formerly included in *Triarthrus)* were collected from the lower part of the unit between 20 and 100 feet (6.1 to 30.5 m) above the contact with the underlying Middle Ordovician limestone. Butts' notes indicate that he found specimens of *Dicellograptus* near REFERENCE LOCALITY 3.

(Read Mountain-Coyner Mountain area): An overturned section of the lower portion of the Liberty Hall is exposed within a tectonic slice on the southern flank of the structure at REFERENCE LOCALITY 4. This incomplete section is very similar to the section of the Liberty Hall Formation along the

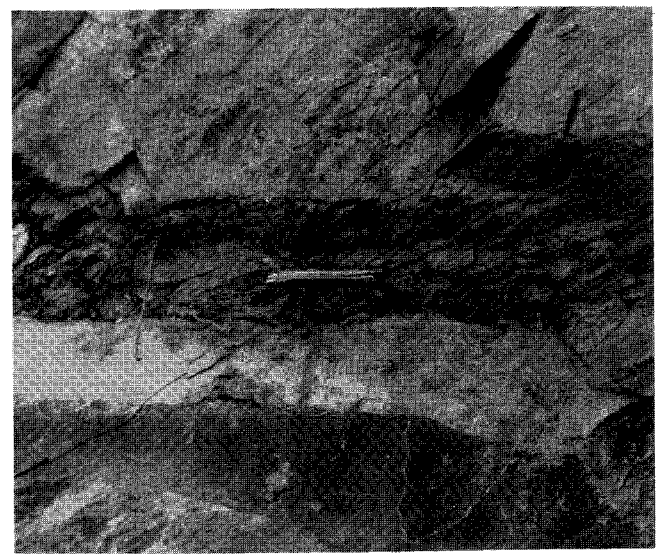


Figure 7. Small thrust fault in Liberty Hall mudstone at REFERENCE LOCALITY 20. Well-developed cleavage dips from right to left and is truncated by fault plane (parallel to length of knife) with 1- to 2-cm gouge zone at contact (knife blade point). Faint bedding, which dips toward left, is visible at lower left.

Pulaski thrust fault in the Christiansburg window (Bartholomew and Lowry, 1979). Because of this similarity, the slice in the Read Mountain-Coyner area also is considered to be derived from footwall rocks (Saltville thrust sheet) along the Pulaski thrust fault; the rocks of this slice thus represent a more westerly facies than sections described from the Salem synclinorium and the Green Ridge thrust sheet.

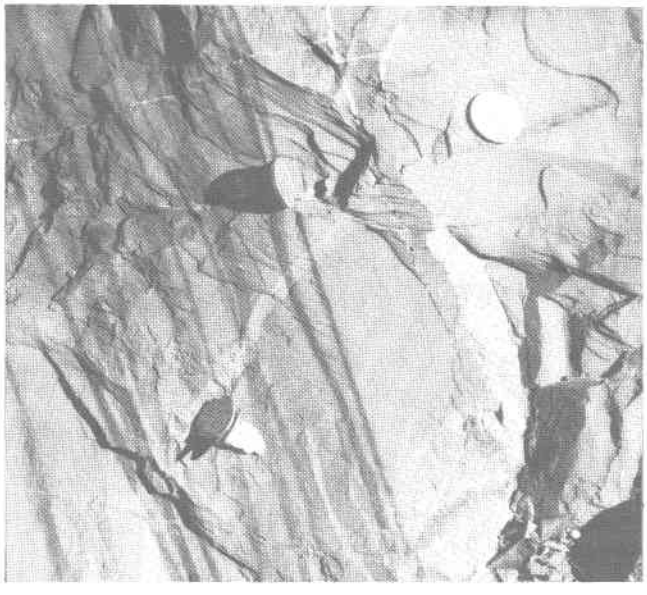
Onlap limestone sequence (Green Ridge thrust sheet): **ls**, dominantly light- to medium-gray, coarse-grained, massively bedded, sparry limestone with abundant fossil fragments, particularly bryozoan. This lithology of this laterally variable onlap unit is well exposed at abandoned quarry 24 as well as at REFERENCE LOCALITIES 5 and 6. Locally (REFERENCE LOCALITY 7), bryozoan reef complexes are preserved. Near Cloverdale the unit is characterized by a "New Market type" lithology, and is primarily dark-gray micritic limestone with scattered "eyes" of coarse-grained spar and locally contains abundant gastropods (REFERENCE LOCALITY 8). Elsewhere (REFERENCE LOCALITY 9) the unit consists of a "Lincolnshire-type" lithology, fossiliferous, dark-gray, micrite with both stylolitic partings and abundant black chert lenses and nodules. Thickness varies from about 50 to 100 feet (15.3-30.5 m).

(Read Mountain-Coyner Mountain area): Cyclic sequences of dark-gray, coarse-grained bioclastic limestone overlain by fine-grained micrite in pods and lenses surrounded by fine-grained dolomite, overlain by bryozoan reef complexes with micrite matrix and mudstone partings. The mudstone con-

Kingston are interpreted to belong to the Bays Formation. The unit is typically overlain by a light-brown to reddish-brown sandy soil.

Liberty Hall Formation (Salem synclinorium): **Olh**, predominantly interbedded dark-gray to black, calcareous, slaty mudstone and dark-gray, medium- to coarse-grained bioclastic limestone. True thickness was not determinable because the unit is disrupted by folds and faults.

(Green Ridge thrust sheet): Dark-gray to black, calcareous mudstone with few, scattered, thin (2- 12-inch; 5.1- to 30.4- cm) beds of dark-gray, fine-grained limestone. Penetrative cleavage is well developed in the black rock and commonly is cut sequentially by small "kink folds," calcite-filled joints (Figure 6) and numerous small thrust faults



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(Read Mountain-Coyner Mountain area): Cyclic sequences of dark-gray, coarse-grained bioclastic limestone overlain by fine-grained micrite in pods and lenses surrounded by fine-grained dolomite, overlain by bryozoan reef complexes with micrite matrix and mudstone partings. The mudstone con-

tent increases upward so that the contact with the overlying Liberty Hall Formation is gradational. The section within a tectonic slice (REFERENCE LOCALITY 4) is about 100 feet (30.5 m) thick; the rock in the highly deformed and overturned section is very similar to the limestone unit mapped by Bartholomew and Lowry (1979) within the Christiansburg window.

Beekmantown Formation: **Ob**, interbedded light- to medium-gray, massively bedded, fine-grained dolomite and light- to medium-gray, mi critic, massively bedded limestone. Locally the unit contains both lenses of light-gray, fine-grained, quartzose sandstone (s) with calcareous cement, and medium-gray, fine-grained burrowed limestone with dolomite fillings. Abundant 1- to 6-foot- (0.3- to 1.8- m-) thick interbeds of massive to layered, medium- to light-gray chert occur throughout the upper portion of the unit, which, where it is not concealed beneath unconsolidated deposits, is overlain by a characteristic light-brown, to light-reddish-brown soil and thick (10-20 feet; 3.1-6.1 m) saprolite containing abundant chert fragments. Butts' notes indicate that he found specimens of the Lower Ordovician gastropod *Lecanospira* near the middle of the unit at REFERENCE LOCALITIES 10 and 11. Specimens of *Finkelnburgia* (F-965) also occur near the middle of the unit, but slightly lower stratigraphically than those of *Lecanospira*. Butts' reported *Schizopea* (=*Roubidouxia*) at REFERENCE LOCALITY 12.

Cambrian

Conococheague Formation: **Ꞓcou**, upper member, cyclic sequences of dark-gray or mottled gray, algal limestone, cross-laminated calcarenite, and straticulate limestone interbedded with medium-gray, faintly laminated dolomite. The top of this unit was placed at the top of the upper zone of siliceous oolite and quartzose sandstone (s). The sandy beds and lenses contain calcareous cement and minor amounts of feldspar. The base of the unit was placed at the base of the lowest limestone in the lowest cycle of the sequence. Thickness is about 200 feet (61 m). **Ꞓcol**, lower member, dominantly light- to medium-gray, fine- to medium-grained, massive dolomite and well-bedded sandy dolomite with abundant thin sandstone beds and lenses. Near the middle of the unit is a discontinuous, 30- to 50- foot- (9.2- to 15.3-m-) thick zone of light-gray, fine-grained quartzose sandstone (s) containing minor amounts of feldspar and calcareous cement. Inarticulate brachiopods (F-958, F-966) occur about 4 to 10 feet (1.2 to 3.1 m) below this sandstone. Unit thickness is about 500 feet (152.5 m). Both of the major sandstones in the upper and lower units are mappable over large portions of the entire Salem synclinorium and the Green Ridge thrust sheet. In the western end of the synclinorium, upper and lower, distinctive sandstones mark the top and base, respectively, of the Copper Ridge Formation, a relationship that suggests synchroneity between the Conococheague and the Copper Ridge. In addition, the lowest sandstone of the Copper Ridge lies just a few feet above rocks containing a *Crepicephalus* zone fauna assemblage in the uppermost, limestone-bearing portion of the Elbrook Formation (Bartholomew and Lowry, 1979; Derby, 1965). Thus, the lowest dolomite unit in the lower part of the Conococheague appears to be laterally equivalent to both the uppermost portion of the Elbrook Formation as well as the basal portion of the Copper Ridge Formation. Much of the upper unit of the Conococheague is laterally equivalent to the upper portion of the Copper Ridge Formation. The soil overlying the Conococheague is characterized by a 0 to 10-foot (0 to 3.1- m), light-gray to brown, colluvial mantle containing locally derived siliceous oolite, sandstone, and chert detritus overlying a thicker, brown subsoil and saprolite.

Elbrook Formation: **Ꞓe**, limestone and dolomite, upper portion dominantly cyclic sequences of algal and straticulate limestones, calcarenites and carbonate conglomerates interbedded with both laminated and massive dolomite. The Elbrook grades downward into dominantly medium-gray, thinly laminated dolomite with minor amounts of dark-gray, thick-bedded algal limestone. Thickness was not determined. This formation is typically poorly exposed and is overlain by an orangish-brown soil and saprolite of variable thickness. **p**, polymictic carbonate breccia, light- to medium-gray, massive to crudely layered, unsorted carbonate breccia with angular to rounded fragments of dolomite, limestone and chert set in an unsorted matrix of similar material with a dolomitic cement. It is commonly cross-hatched with abundant calcite-filled fractures.

Rome Formation: **Ꞓr**, interbedded, mottled, maroon and greenish-gray, phyllitic mudstone, light-gray, fine-grained sand and siltstone with some lenses of conglomerate (R-8443; Figure 8) and numerous 10- to 50-foot (3.1- to 15.3-m) carbonate intervals (c) of dominantly dark-gray, fine-grained, thinly laminated dolomite and phyllitic mudstone. Locally, burrowed or algal limestone constitute a part of a carbonate unit. Thickness was not determined. Small inarticulate brachiopods (F-967) are locally abundant on bedding surfaces of the phyllitic mudstone. The Rome is overlain by a very thin, light-brown, silty soil which varies from 0-3 feet (0-0.9 m) in thickness. An orangish-brown soil, similar to that developed on the Elbrook Formation, is commonly

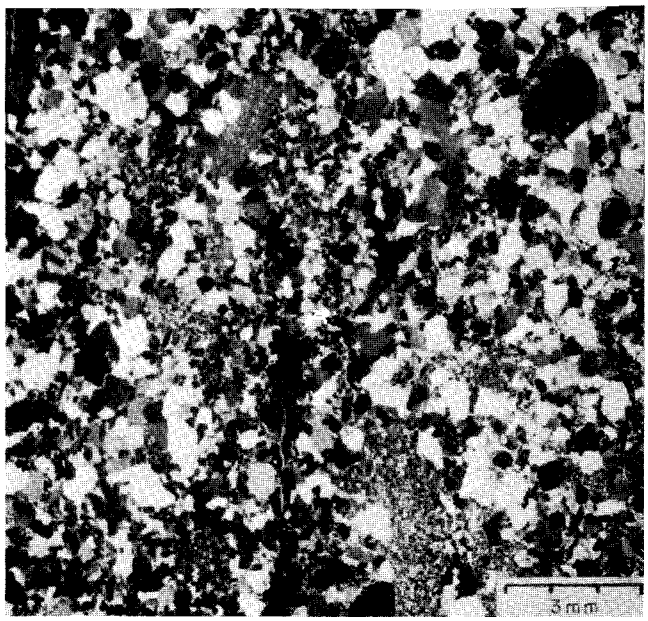


Figure 8. Photomicrograph of conglomerate (R-8443) in Rome Formation showing detrital quartz and small rock fragments in matrix of sericite and fine-grained quartz.

developed on Rome carbonate rocks. Butts' field notes indicate that he found specimens of *Olenellus* at REFERENCE LOCALITY 13 and local residents have found trilobites at REFERENCE LOCALITY 14. Butts (1941) illustrated a specimen of *Hyolithes wanneri* from REFERENCE LOCALITY 15.

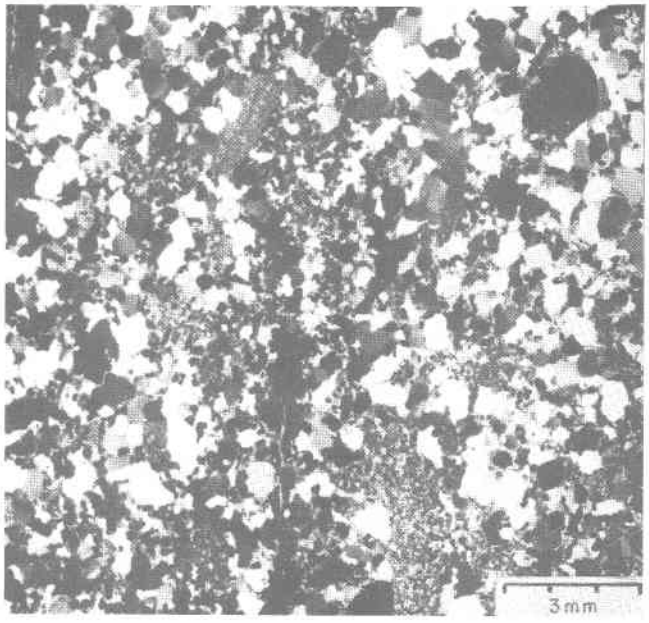
Shady Dolomite: **Ꞓs**, fractured medium-gray or light-gray to white, massive dolomite (R-8415) exposed at the base of Mill Mountain and within tectonic slivers adjacent to the Blue Ridge fault (Figure 3). Within this sliver the dolomite probably extends northward beneath the adjacent, relatively flat, colluvium-covered bench. The exposed interval is 20 feet (6.1 m) thick.

Antietam Formation: **Ꞓa**, light-gray, fine-grained metaquartzite (R-8416), medium- to coarse-grained quartz-pebble metaconglomerate (R-8417) and siliceous cataclasite (R-8418) in the northern tectonic sliver along the Blue Ridge fault. The exposed interval is 20 to 50 feet (6.1 to 15.3 m) thick. At Mill Mountain the Antietam is primarily interbedded light-gray, fine- to medium-grained quartzite, locally containing *Skolithos* (REFERENCE LOCALITY 16), and light-gray, fine- to coarse-grained quartzose sandstone, conglomeratic sandstone and siltstone. Outcrops of unit are interrupted by a very thin, light-brown, sandy soil developed on the unit. A wide belt of quartzite and siliceous cataclasite **(qsc)** also forms the southern tectonic sliver (Figure 3).

Weverton Formation: **Ꞓw**, dominantly dark-greenish-gray, well-foliated mudstone and siltstone-phyllite with abundant 1- to 20-foot (0.3- to 6.2- m) beds of medium-gray to greenish-gray, medium-grained, quartzose metasandstone near the base. Both metasandstone and greenish-gray, medium-grained metaquartzite become more abundant upward in the section and constitute the dominant lithology about 500-1000 feet (153-305 m) above the base. Quartz-pebble metaconglomerate and conglomeratic metasandstone occur locally. This easterly facies of the basal portion of the Chilhowee Group is exposed along the footwall side of the Rockfish Valley fault where clastic metasedimentary rocks lie nonconformably on Grenville-age crystalline rocks of the Pedlar massif. Because coarse-grained conglomerates characteristic of the top of the Weaverton Formation were not observed, the entire sequence is inferred to represent only the lower part of the Formation. Thickness was not determined. Generally, a thin, light-brown, sandy soil overlies the Weverton Formation.

PRECAMBRIAN
Proterozoic Z

Dikes (Pedlar massif): altered, mafic (**ad**) to felsic (**fd**) rocks. The more mafic dikes (R-8419) are generally dark-gray to black, and the felsic ones (R-8420) are greenish-gray to dark-gray. Some of the andesitic dikes (R-8422) are porphyritic; however, most relict textures are typically ophitic to subophitic. Original minerals were plagioclase and pyroxene with or without hornblende or biotite. The mineral assemblages of the altered rock are typically sericite, quartz, actinolite, biotite, sphene and magnetite. The dikes are along three dominant trends—about N45°E, N10°W and N60°W. They range in thickness up to about 30 feet (9.2 m). Two metagabbro (R-8421) bodies and 1 diorite body are associated with them. The apparent confinement of the dikes to the Pedlar massif suggests that they may be either Late Precambrian or Early Paleozoic dikes altered during Paleozoic metamorphism. **ag**, altered gabbro, dark-gray, coarse-grained metagabbro (R-8421) with an intersertal texture and minerals consisting primarily of plagioclase and pyroxene. **adi**, dark-gray, coarse-grained diorite with an intersertal to subophitic texture. The original minerals, which were plagioclase, biotite and hornblende (R-8445; Figure 9) were altered to sericite, epidote, quartz, chlorite and biotite. **n**, nelsonite, apatite- and ilmenite-bearing rock with some feldspar in highly deformed, poorly foliated (biotite-bearing) pod-shaped bodies cutting the porphyroblastic granulite gneiss. The rock (R-8423; Figure 10) occurs only in the western portion of the Pedlar massif.



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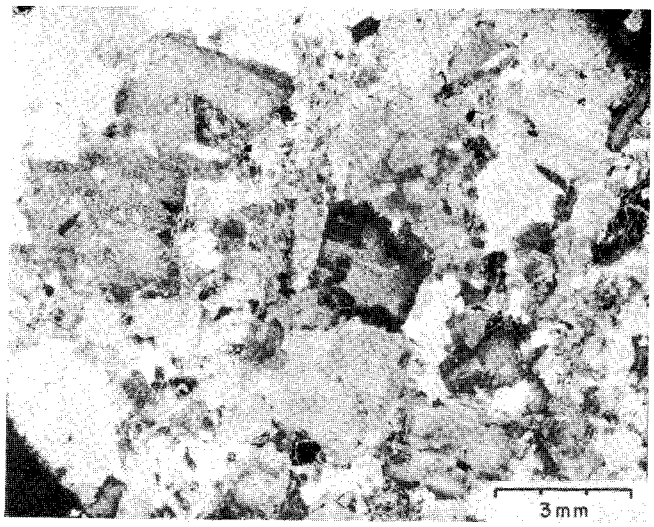


Figure 9. Photomicrograph of altered diorite dike (R-8445) composed primarily of plagioclase, hornblende, and biotite with actinolite, chlorite, epidote and sericite as the main alteration minerals.

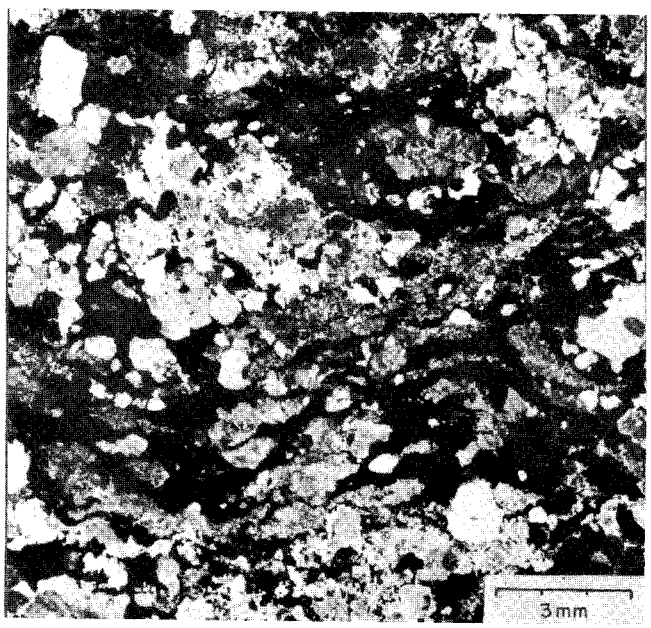


Figure 10. Photomicrograph of foliated nelsonite (R-8423) composed primarily of ilmenite and magnetite, apatite, and amphibole.

(Lovingston massif): **md**, medium-gray to green, fine-grained greenstone dikes (R-8430) containing relict plagioclase laths and pyroxenes in an altered matrix of sericite, biotite, actinolite, quartz, plagioclase, sphene and magnetite.

Granitic gneiss: **gg**, medium-gray or pinkish-gray, medium- to coarse-grained, poorly foliated to massive, granitic gneiss (R-8431) with relict hypidiomorphic-granular texture (Figure 11). Mineral assemblages are given in Table 1. **mg**, typically medium-gray, fine- to medium-grained, well-foliated mylonite gneiss (R-8432). This unit was developed during Paleozoic metamorphism of the granite gneiss. **gd**, dikes of granitic gneiss texturally and mineralogically similar to the orthogneiss described above. These dikes are generally 10 to 20 feet wide.

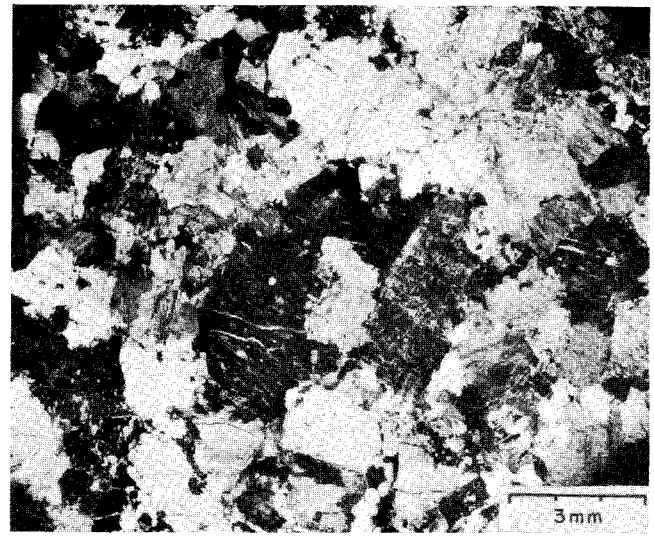


Figure 11. Photomicrograph of granitic gneiss (R-8431) showing relict hypidomorphic granular texture and composed mainly of perthitic feldspar and quartz.

Proterozoic Y

Leucocratic granulite gneiss: **lgg**, light-gray, quartzofeldspathic gneiss, typically coarse-grained with large (2-6 cm) porphyroblasts of white feldspar and small porphyroblasts of garnet (Figure 12). A well-developed biotite foliation commonly defines crude segregation layers, which are parallel to compositional layers in adjacent gneisses. Mineral assemblages are listed in Table 1. The texture is typically

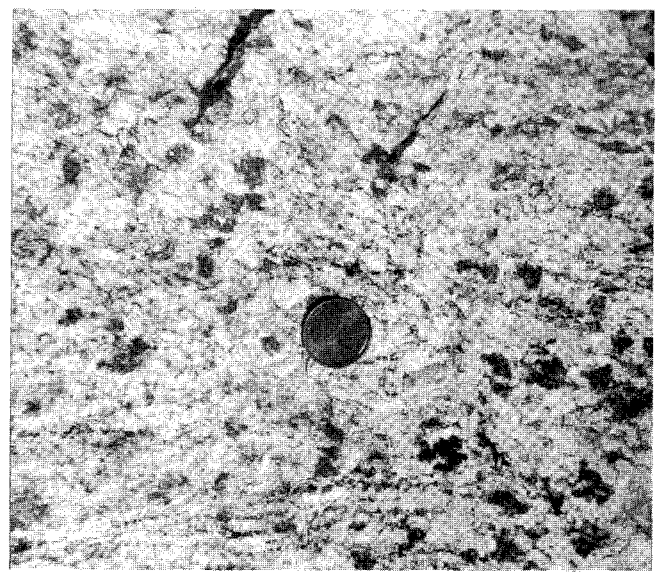
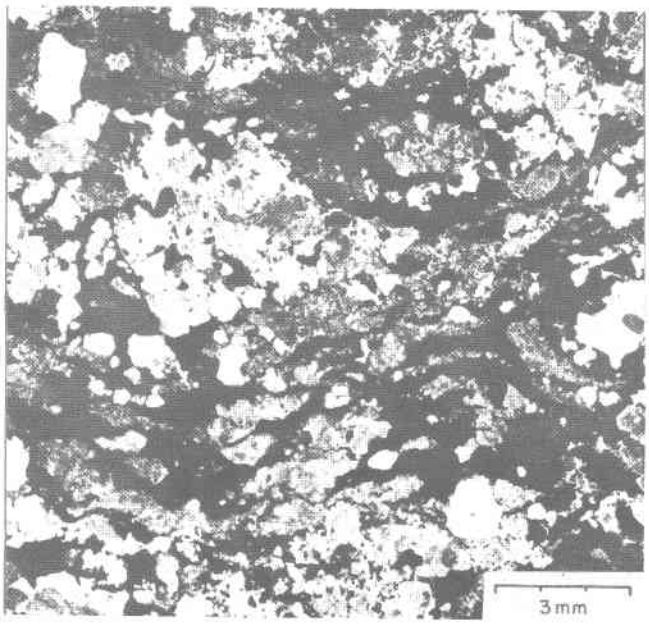


Figure 12. Typical exposure of leucocratic granulite gneiss at REFERENCE LOCALITY 21 showing poorly developed biotite foliation and porphyroblasts of garnets and feldspar.

Figure 9. Photomicrograph of altered diorite dike (R-8445) composed primarily of plagioclase, hornblende, and biotite with actinolite, chlorite, epidote and sericite as the main alteration minerals.



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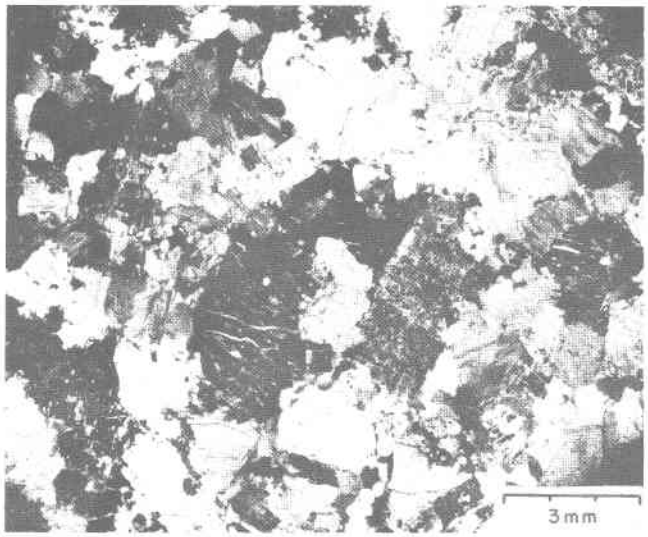

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Proterozoic Y

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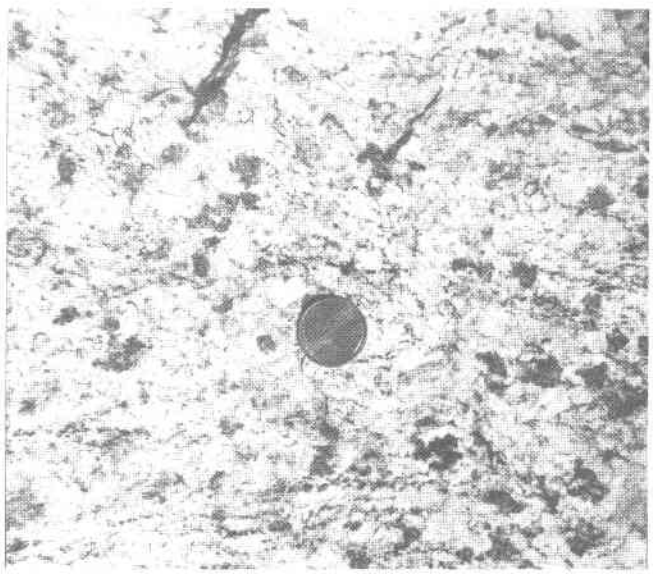

Figure 12. Typical exposure of leucocratic granulite gneiss at REFERENCE LOCALITY 21 showing poorly developed biotite foliation and porphyroblasts of garnets and feldspar.

granoblastic except locally in small bodies of granitic gneiss (**g**), with a hypidiomorphic-granular texture, which probably formed from partial anatexis of unit during Grenville oragenesis. Field relationships suggest that this unit cuts porphyroblastic granulite gneiss and probably massive granulite gneiss, both described below.

Massive granulite gneiss: **mgg**, uniformly dark-greenish-gray, medium-grained, quartzo-feldspathic orthogneiss (R-8424; Figure 13) with a well-

Figure 13. Photomicrograph of massive granulite gneiss (R-8424) composed of altered perthitic feldspar, quartz, hornblende and uralitized orthopyroxene.

developed, nonpenetrative, biotite foliation. The texture is dominantly granoblastic; the mineral assemblage is given in Table 1. The biotite foliation probably formed in Paleozoic time. The rock locally contains poorly developed segregation layers.

Porphyroblastic granulite gneiss: **pgg**, dominantly dark-grayish-green to dark-green, coarse-grained quartzo-feldspathic gneiss (R-8425, R-8444; Figure 14) characteristically containing 2- to 6- cm, greenish-white feldspar porphyroblasts and generally containing abundant 1- cm garnet porphyroblasts. The texture is dominantly xenomorphic granular (Figure 15) and segregation layering is poorly developed. The Grenville-age rock typically consists of plagioclase as well as potassium and perthitic feldspars, quartz, orthopyroxene, garnet and biotite. **pgm**, typically dark-greenish-gray, well-foliated, coarse-grained mylonite (augen) gneiss (R-8426) containing feldspar porphyroclasts. This myl-

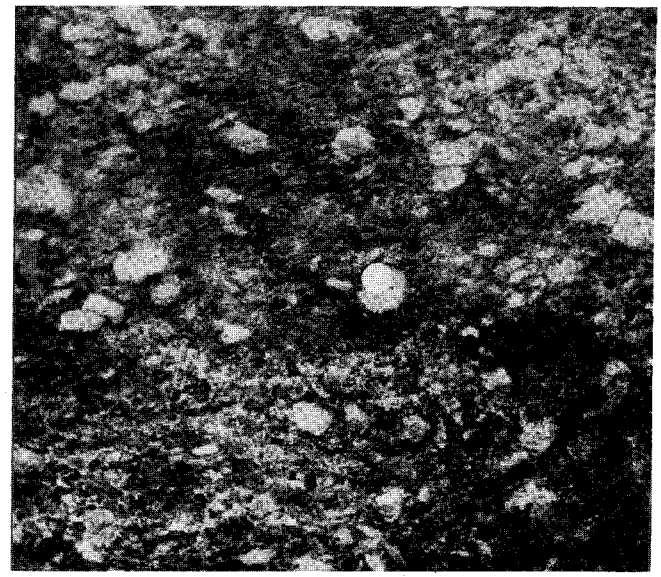

Figure 14. Typical exposure of green porphyroblastic granulite gneiss (R-8444) showing large feldspar porphyroblasts (quarter denotes size) crudely aligned with smaller garnets to form foliation.

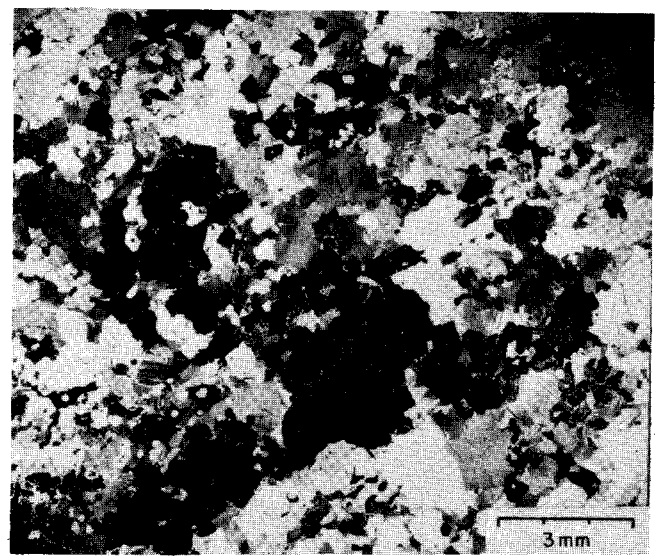

Figure 15. Photomicrograph of porphyroblastic granulite gneiss (R-8444) composed of perthitic feldspar, plagioclase, quartz, garnet and orthopyroxene.

onite was derived locally from the porphyroblastic granulite gneiss during Paleozoic deformation.

Horsepen Mountain suite: **hm**, typically medium- to dark-gray, coarse-grained, massive to faintly foliated, quartzo-feldspathic gneiss (R-8433) containing abundant xenoliths of layered gray gneiss (R-8434) as well as scattered mafic segregations (R-8435). This meta-igneous rock is characterized by abundant 1- to 4- cm feldspar phenocrysts, a relict hypidiomorphic-granular texture, numerous 2- to 10-foot (0.3- to 0.6-m) zones of protomylonite, and, commonly, a steeply dipping to vertical, nonpenetrative biotite foliation. **hmm**, dominantly

granoblastic except locally in small bodies of granitic gneiss (**g**), with a hypidiomorphic-granular texture, which probably formed from partial anatexis of unit during Grenville oragenesis. Field relationships suggest that this unit cuts porphyroblastic granulite gneiss and probably massive granulite gneiss, both described below.

Massive granulite gneiss: **mgg**, uniformly dark-greenish-gray, medium-grained, quartzo-feldspathic orthogneiss (R-8424; Figure 13) with a well-

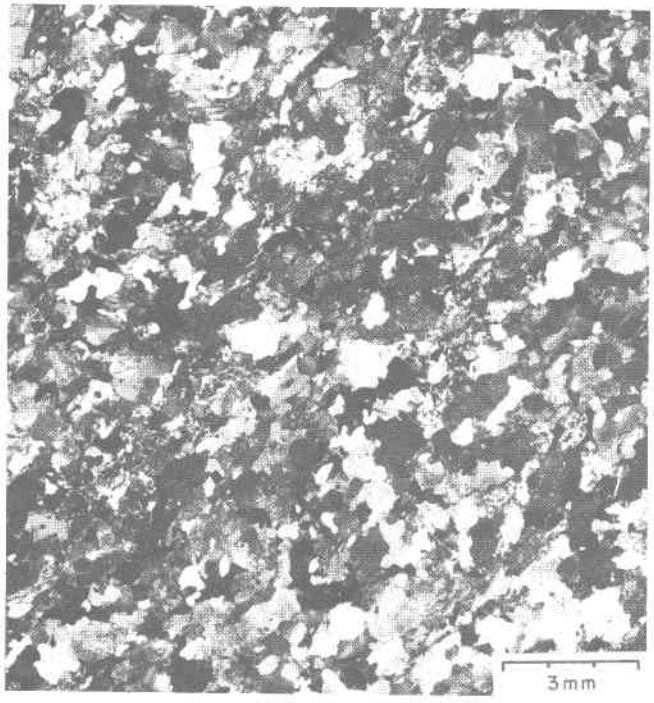

Figure 13. Photomicrograph of massive granulite gneiss (R-8424) composed of altered perthitic feldspar, quartz, hornblende and uralitized orthopyroxene.

developed, nonpenetrative, biotite foliation. The texture is dominantly granoblastic; the mineral assemblage is given in Table 1. The biotite foliation probably formed in Paleozoic time. The rock locally contains poorly developed segregation layers.

Porphyroblastic granulite gneiss: **pgg**, dominantly dark-grayish-green to dark-green, coarse-grained quartzo-feldspathic gneiss (R-8425, R-8444; Figure 14) characteristically containing 2- to 6- cm, greenish-white feldspar porphyroblasts and generally containing abundant 1- cm garnet porphyroblasts. The texture is dominantly xenomorphic granular (Figure 15) and segregation layering is poorly developed. The Grenville-age rock typically consists of plagioclase as well as potassium and perthitic feldspars, quartz, orthopyroxene, garnet and biotite. **pgm**, typically dark-greenish-gray, well-foliated, coarse-grained mylonite (augen) gneiss (R-8426) containing feldspar porphyroclasts. This myl-

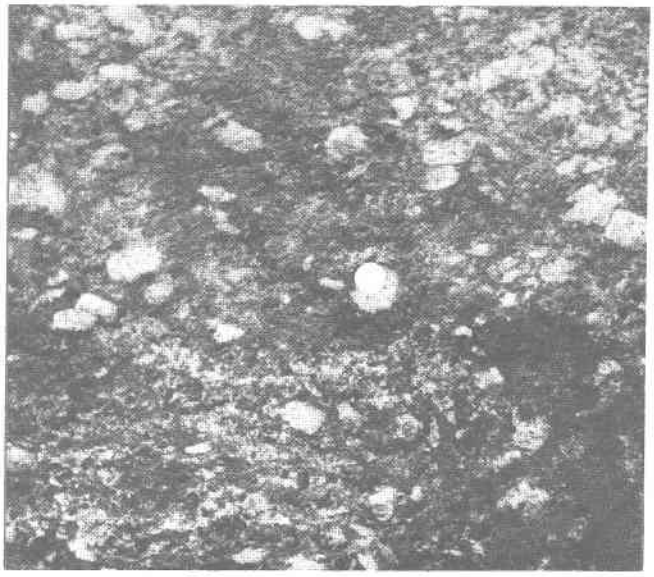

Figure 14. Typical exposure of green porphyroblastic granulite gneiss (R-8444) showing large feldspar porphyroblasts (quarter denotes size) crudely aligned with smaller garnets to form foliation.

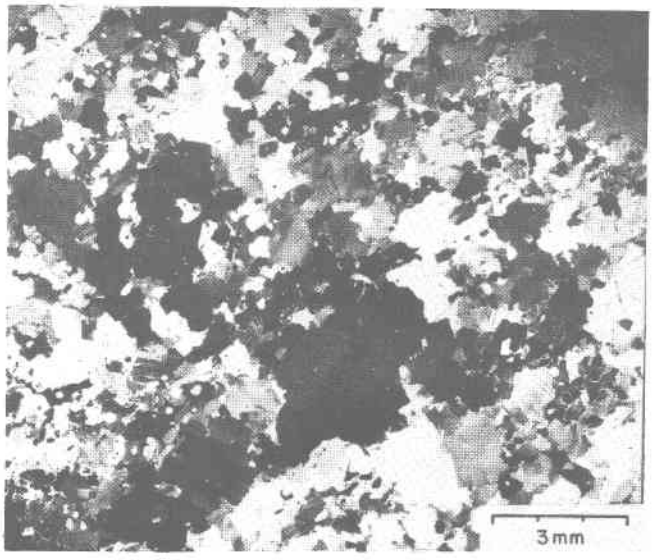

Figure 15. Photomicrograph of porphyroblastic granulite gneiss (R-8444) composed of perthitic feldspar, plagioclase, quartz, garnet and orthopyroxene.

onite was derived locally from the porphyroblastic granulite gneiss during Paleozoic deformation.

Horsepen Mountain suite: **hm**, typically medium- to dark-gray, coarse-grained, massive to faintly foliated, quartzo-feldspathic gneiss (R-8433) containing abundant xenoliths of layered gray gneiss (R-8434) as well as scattered mafic segregations (R-8435). This meta-igneous rock is characterized by abundant 1- to 4- cm feldspar phenocrysts, a relict hypidiomorphic-granular texture, numerous 2- to 10-foot (0.3- to 0.6-m) zones of protomylonite, and, commonly, a steeply dipping to vertical, nonpenetrative biotite foliation. **hmm**, dominantly

dark-gray or black, well-foliated, biotite-bearing, protomylonite and mylonite gneiss (R-8436) containing abundant 1- to 2-cm feldspar porphyroclasts (augen). **hmd**, medium-gray, fine- to medium-grained, massive gneiss (R-8437) as dikes. Rock contains scattered 1-cm feldspar phenocrysts and a relict hypidiomorphic-granular texture. Mineral assemblages of these late-stage dikes are listed in Table 1.

Mafic granulite gneiss: **m**, dark-greenish-gray to black, medium-grained rock with granoblastic texture (Figure 16). Both a large body and a small body

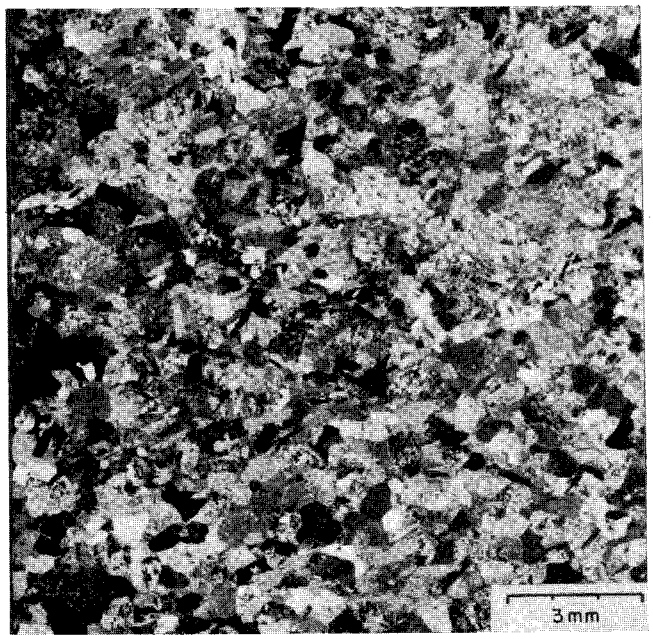

Figure 16. Photomicrograph of lense of mafic granulite from REFERENCE LOCALITY 22 composed of highly altered plagioclase, hornblende, biotite and pyroxene.

(R-8427) of this rock occur within the strongly layered granulite gneiss unit southeast of Greens Knob. Mineral assemblage of the unit is given in Table 1. In the Roanoke quadrangle are zones (0-10 feet; 0-3.1 m) of relatively mafic, fine- to medium-grained, medium-gray gneiss, with relict granoblastic texture (Figure 17) and an original mineral assemblage of plagioclase, hornblende, biotite and pyroxene. The rock is typically retrograded to sericite, biotite, actinolite and quartz.

(Strongly) layered granulite gneiss: **sgg**, dominantly dark-greenish-gray to dark-green, medium- to coarse-grained quartzo-feldspathic gneiss with well-developed segregation layers (Figure 18) and granoblastic texture. This rock (R-8428) is virtually the same as the "strongly layered granulite gneiss" mapped by Bartholomew (1977) in the Pedlar massif in central Virginia. The mineral assemblage is given in Table 1. Garnets in this unit are relatively

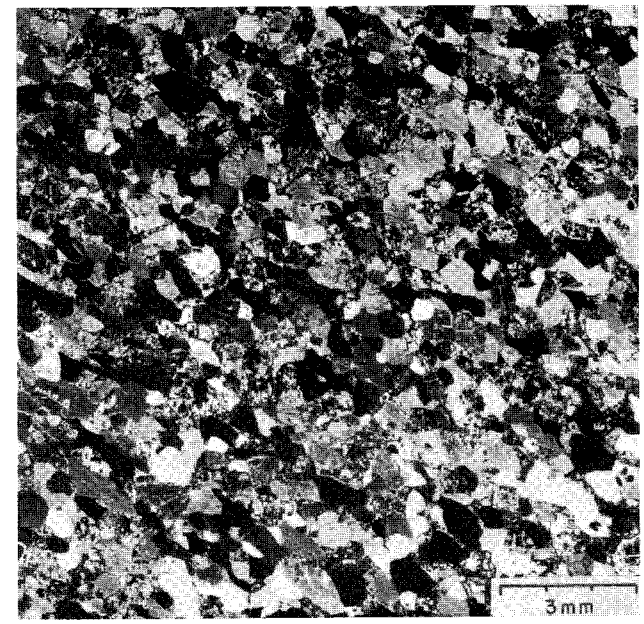

Figure 17. Photomicrograph of mafic granulite (R-8427) with granoblastic texture and composed of altered plagioclase (An50), uralitized orthopyroxene, clinopyroxene, and hornblende.

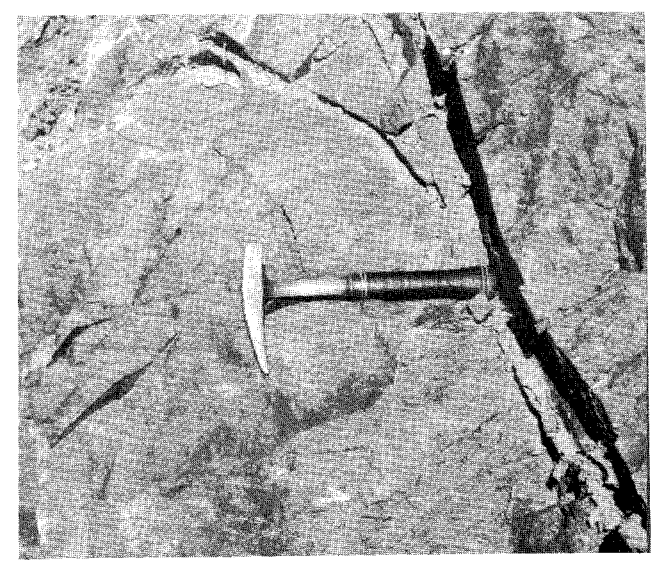

Figure 18. Typical exposure of strongly layered granulite gneiss (R-8428) showing well-developed, gently dipping segregation layering.

large and abundant in most areas where it is in contact with the porphyroblastic granulite gneiss. This suggests that either the porphyroblastic granulite gneiss intruded the strongly layered granulite gneiss and produced some contact effects, or that the porphyroblastic gneiss was derived from it when it was subjected to new pressure/temperature conditions. **sgm**, typically dark-grayish-green, well-foliated, fine- to medium-grained mylonite gneiss. The mylonite (R-8429) was developed locally during Paleozoic deformation of the parent material. **my**, mylonite and ultramylonite, dark-gray, poorly to

dark-gray or black, well-foliated, biotite-bearing, protomylonite and mylonite gneiss (R-8436) containing abundant 1- to 2-cm feldspar porphyroclasts (augen). **hmd**, medium-gray, fine- to medium-grained, massive gneiss (R-8437) as dikes. Rock contains scattered 1-cm feldspar phenocrysts and a relict hypidiomorphic-granular texture. Mineral assemblages of these late-stage dikes are listed in Table 1.

Mafic granulite gneiss: **m**, dark-greenish-gray to black, medium-grained rock with granoblastic texture (Figure 16). Both a large body and a small body

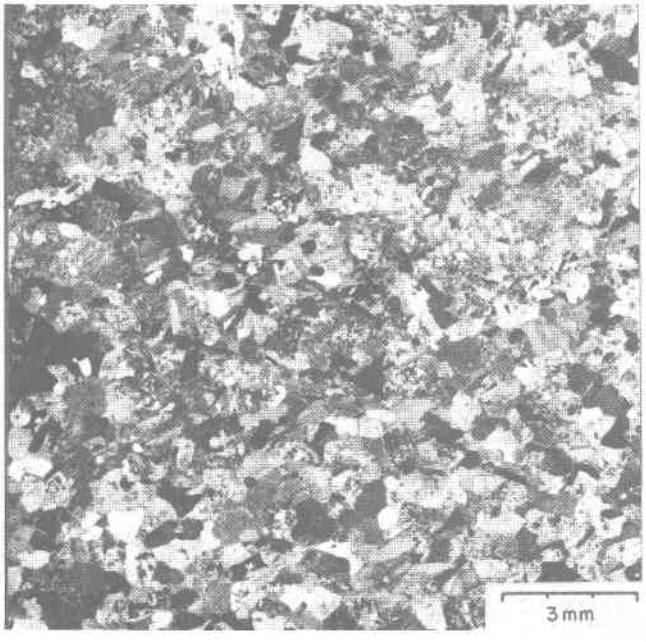

Figure 16. Photomicrograph of lense of mafic granulite from REFERENCE LOCALITY 22 composed of highly altered plagioclase, hornblende, biotite and pyroxene.

(R-8427) of this rock occur within the strongly layered granulite gneiss unit southeast of Greens Knob. Mineral assemblage of the unit is given in Table 1. In the Roanoke quadrangle are zones (0-10 feet; 0-3.1 m) of relatively mafic, fine- to medium-grained, medium-gray gneiss, with relict granoblastic texture (Figure 17) and an original mineral assemblage of plagioclase, hornblende, biotite and pyroxene. The rock is typically retrograded to sericite, biotite, actinolite and quartz.

(Strongly) layered granulite gneiss: **sgg**, dominantly dark-greenish-gray to dark-green, medium- to coarse-grained quartzo-feldspathic gneiss with well-developed segregation layers (Figure 18) and granoblastic texture. This rock (R-8428) is virtually the same as the "strongly layered granulite gneiss" mapped by Bartholomew (1977) in the Pedlar massif in central Virginia. The mineral assemblage is given in Table 1. Garnets in this unit are relatively

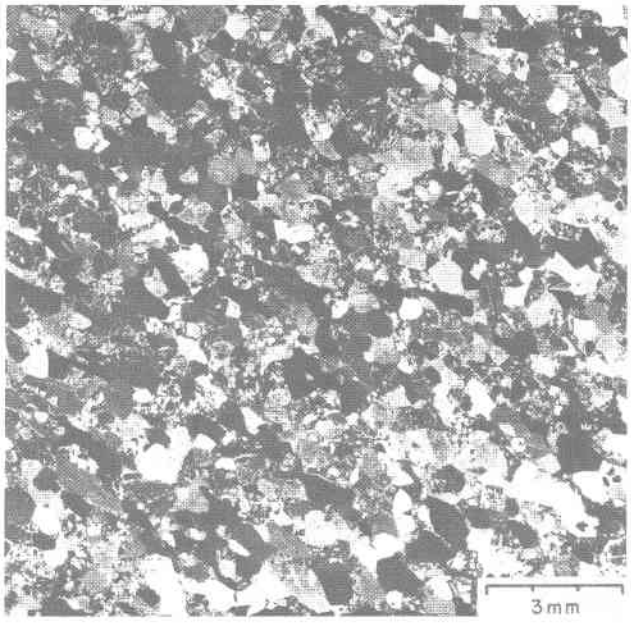

Figure 17. Photomicrograph of mafic granulite (R-8427) with granoblastic texture and composed of altered plagioclase (An50), uralitized orthopyroxene, clinopyroxene, and hornblende.

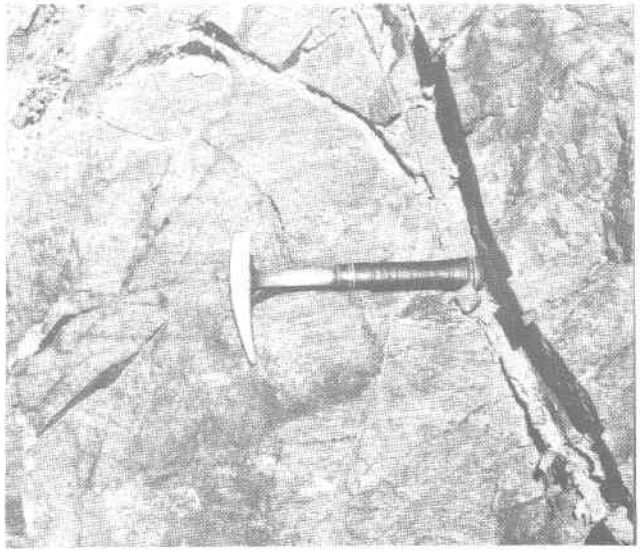

Figure 18. Typical exposure of strongly layered granulite gneiss (R-8428) showing well-developed, gently dipping segregation layering.

large and abundant in most areas where it is in contact with the porphyroblastic granulite gneiss. This suggests that either the porphyroblastic granulite gneiss intruded the strongly layered granulite gneiss and produced some contact effects, or that the porphyroblastic gneiss was derived from it when it was subjected to new pressure/temperature conditions. **sgm**, typically dark-grayish-green, well-foliated, fine- to medium-grained mylonite gneiss. The mylonite (R-8429) was developed locally during Paleozoic deformation of the parent material. **my**, mylonite and ultramylonite, dark-gray, poorly to

Table 1. Mineral assemblages in Grenville-age rocks of the Pedlar and Lovingston massifs.

		No. assemblages	Plagioclase	Perthitic Feldspar (+/- K-feldspar)	Quartz	Biotite	Garnet	Orthopyroxene	Clinopyroxene	Hornblende
PEDLAR MASSIF	Massive granulite gneiss	1	An_{36}	P	P	P		P		P
	Mafic granulite gneiss	1	An_{50}					P	P	P
	Porphyroblastic granulite gneiss	1	An_{32}	P	P	P	P	P		
	Strongly layered granulite gneiss	1	An_{33}	P	P	P	P	P		
		2	An_{33}	P	P			P		P
	Leucocratic granulite gneiss	1	An_{34}	P	P	P	P	P		
		2	An_{36}	P	P	P	P			
	Granitic gneiss pods	1	P	P	P					
LOVINGSTON MASSIF	Granitic gneiss	1	An_{32}	P	P					P
	Dikes of granitic gneiss	1	P	P	P					P
	Horsepen Mountain suite									
	Massive gneiss facies	1	P	P	P	P		P		
	Porphyritic dikes	1	P	P	P	P		P		
	Mafic segregations	1			P			P	P	P
	Layered gray gneiss	1	An_{33}	P	P	P		P		P
	Xenoliths within granitic gneiss	1		P	P	P	P			P
	Xenoliths within Horsepen Mountain suite	2	P	P	P	P				

P = present; blank = absent

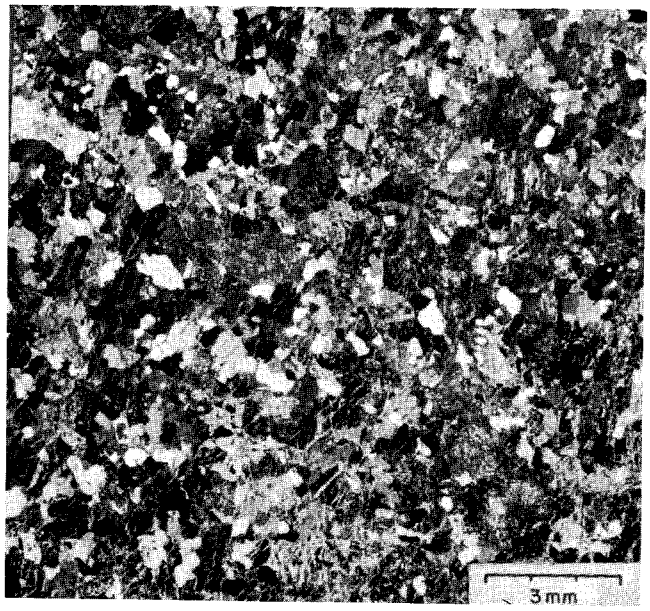

Figure 19. Photomicrograph of layered gneiss from REFERENCE LOCALITY 23 with granoblastic texture and showing alignment of altered plagioclase, perthitic feldspar and quartz as well as uralitized orthopyroxene, hornblende and biotite to form segregation layering.

well-foliated mylonite and light-gray, siliceous ultramylonite in local, 10- to 20-foot (3.1- to 6.2- m) zones.

Layered gneiss: **lg**, medium-gray, medium- to coarse-grained, quartzo-feldspathic gneiss (R-8438) with well-developed segregation layers and granoblastic texture (Figure 19). Mineral assemblages are given in Table 1. **lm**, typically medium-gray to black, fine- to medium-grained, well-foliated, interlayered 2-mica mylonite gneiss (R-8439) and mylonite schist.

Table 1. Mineral assemblages in Grenville-age rocks of the Pedlar and Lovingston massifs.

		No. assemblages	Plagioclase	Perthitic Feldspar (+/- K-feldspar)	Quartz	Biotite	Garnet	Orthopyroxene	Clinopyroxene	Hornblende
PEDLAR MASSIF	Massive granulite gneiss	1	An_{36}	P	P	P		P		P
	Mafic granulite gneiss	1	An_{50}					P	P	P
	Porphyroblastic granulite gneiss	1	An_{32}	P	P	P	P	P		
	Strongly layered granulite gneiss	1	An_{33}	P	P	P	P	P		
		2	An_{33}	P	P			P		P
	Leucocratic granulite gneiss	1	An_{34}	P	P	P	P	P		
		2	An_{36}	P	P	P	P			
	Granitic gneiss pods	1	P	P	P					
LOVINGSTON MASSIF	Granitic gneiss	1	An_{32}	P	P					P
	Dikes of granitic gneiss	1	P	P	P					P
	Horsepen Mountain suite									
	Massive gneiss facies	1	P	P	P	P		P		
	Porphyritic dikes	1	P	P	P	P		P		
	Mafic segregations	1			P			P	P	P
	Layered gray gneiss	1	An_{33}	P	P	P		P		P
	Xenoliths within granitic gneiss	1		P	P	P	P			P
	Xenoliths within Horsepen Mountain suite	2	P	P	P	P				

P = present; blank = absent

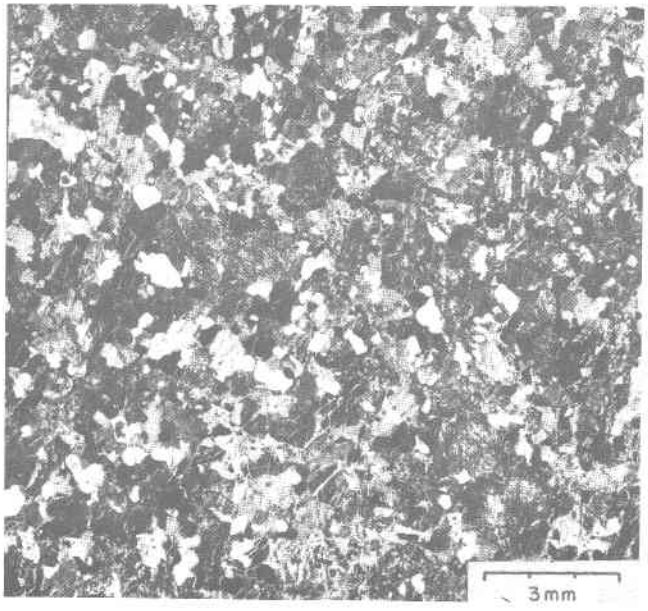

Figure 19. Photomicrograph of layered gneiss from REFERENCE LOCALITY 23 with granoblastic texture and showing alignment of altered plagioclase, perthitic feldspar and quartz as well as uralitized orthopyroxene, hornblende and biotite to form segregation layering.

well-foliated mylonite and light-gray, siliceous ultramylonite in local, 10- to 20-foot (3.1- to 6.2- m) zones.

Layered gneiss: **lg**, medium-gray, medium- to coarse-grained, quartzo-feldspathic gneiss (R-8438) with well-developed segregation layers and granoblastic texture (Figure 19). Mineral assemblages are given in Table 1. **lm**, typically medium-gray to black, fine- to medium-grained, well-foliated, interlayered 2-mica mylonite gneiss (R-8439) and mylonite schist.

SUMMARY OF TECTONIC HISTORY — VALLEY AND RIDGE

by
M. J. Bartholomew and W. H. Hazlett, Jr.

The Salem thrust sheet is characterized by polyfolded rocks of the Rome and Elbrook formations as well as relatively abundant carbonate breccia, which is common in the lower part of the Elbrook Formation. This thrust sheet is bounded on the northwest by the Salem fault which truncates the exhumed Pulaski fault in the Read Mountain-Coyner Mountain area. Folds first recognized by Bartholomew and Lowry (1979), which predate Late Paleozoic emplacement of the Pulaski thrust sheet also occurs throughout the Salem thrust sheet in these quadrangles. Somewhat younger (synthrusting), relatively tight folds with axial plane cleavage are also recognizable in the Rome Formation on the Salem thrust sheet. Structural relationships for the following discussions are shown in Figures 2, 3, 20, 21, and 22.

Rocks within the Read Mountain-Coyner Mountain area are in two structural settings: (1) in the tightly folded but well-defined Read Mountain anticline (Figure 20) in the Roanoke quadrangle and (2) in a series of tectonic slices (labeled C and F on Figure 2) which extend into the Coyner Mountain area of the Stewartsville quadrangle. As originally inferred by Hazlett (1968), the tectonic slices clearly were emplaced against the Read Mountain structure prior to final movement on the Pulaski fault, which truncates slices along the southern flank of Read Mountain. These slices were folded during movement on the Salem fault; this movement also was responsible for formation of the Read Mountain anticline. The slices were transported along the hanging wall of the Salem thrust (Figure 22) which is younger, but originated from a structurally lower position, than the Pulaski thrust. Both the Pulaski and Salem thrust sheets are folded. Northwest-trending high-angle faults cut across the Read Mountain anticline and developed during or after its formation. This deformational event predates the gentle east-west bending of the entire Read Mountain-Coyner Mountain area. The rocks of this area are similar to those in the Saltville thrust sheet about 10 miles (16 km) to the northwest, where the Salem synclinorium is thrust over the Saltville sheet along the Pulaski fault. Thus, the main fault along the southern flank of the Read Mountain-Coyner Mountain area is inferred to be an exhumed portion of the Pulaski fault system. The fault at the Bonsack window also is believed to be part of the Pulaski fault system.

The Green Ridge thrust sheet is thrust over the Salem synclinorium (cross section A-A′ on Plate 1). The Green Ridge fault merges with the Salem fault in the adjacent Salem quadrangle (Amato, 1974) and merges with or is truncated by the Glebe Mills fault (Bartholomew and others, 1980) in the Daleville quadrangle (Andrews, 1952: Hazlett, 1968; McGuire, 1976). The facies contrasts between rocks of the Green Ridge sheet and the Salem synclinorium are not great and movement on the Green Ridge thrust was probably a few miles. Rocks of the Glade Creek window are lithologically similar to those of the Green Ridge thrust sheet.

Folds, which formed after movement on the thrust faults, are represented both by northeast—trending, broad, open folds with nearly vertical axial surfaces and by the bending of rocks in the Read Mountain-Coyner Mountain area about a northwest-trending axial surface. These folds deformed the Pulaski/Salem thrust sheet into a series of gently plunging antiformal and synformal structures. The Bonsack and Glade Creek windows are eroded through the crests of such folds. Smaller scale F_3 folds and earlier folds are at REFERENCE LOCALITY 18.

SUMMARY OF TECTONIC HISTORY— BLUE RIDGE

by
M. J. Bartholomew

Bartholomew and Lewis (1977) proposed that a single, continuous zone of intense ductile deformation extends from northern Virginia southward along the core of the Blue Ridge anticlinorium at least as far as the vicinity of the Grandfather Mountain window in North Carolina. Recrystallized basement rocks of Grenville age are exposed continuously along this trend in two contrasting massifs on either side of the fault zone containing the ductilely deformed rocks. These two massifs, the Lovingston massif to the east and the Pedlar massif to the west, were first delineated in central Virginia (Bartholomew, 1977) where they are separated by the Rockfish Valley fault. The massifs are separated by the fault as far south as the vicinity of Radford, Virginia. There, both massifs end abruptly at the Fries fault. It herein is proposed that the names "Rockfish Valley fault" and "Fries fault" be restricted to segments of the fault zone northeast and southwest, respectively, of the oroclinal bend in the Appalachians at Roanoke, which lies near the 38th parallel. Thus, within the Stewartsville quadrangle, which lies just northeast of the bend, the Rockfish Valley fault separates the Lovingston and Pedlar massifs

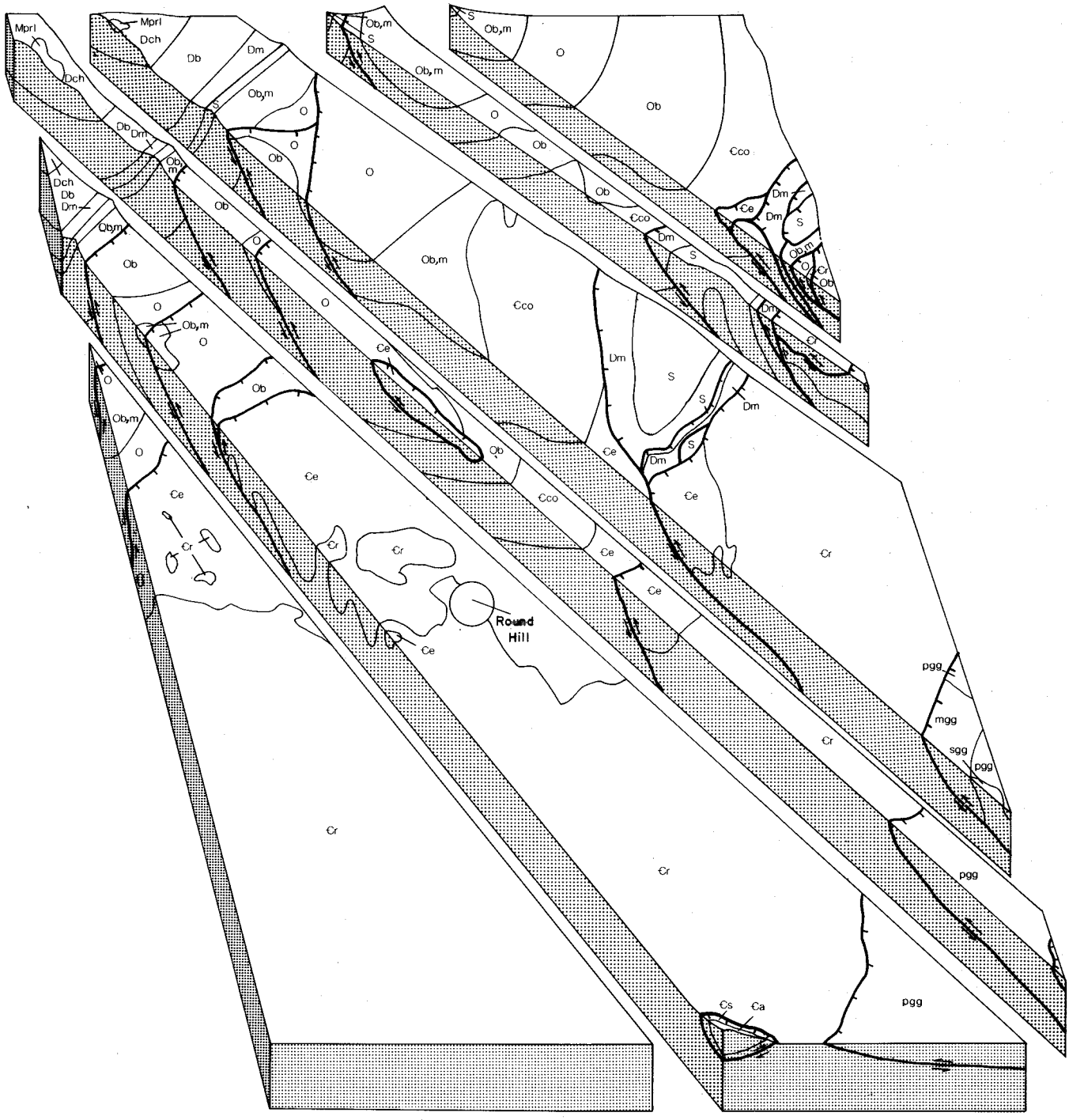

Figure 20. Block diagram of bedrock in the Roanoke quadrangle. Symbols are identical to those used under the title "Stratigraphic Column" except for the following cases. *S*, includes all Silurian units of the area or any one of them; *O*, includes the Middle Ordovician limestones and the Liberty Hall Formation; Obm, Bays and Martinsburg formations. Upper and lower units of the Conococheague are not differentiated on the diagram. Mylonites formed from porphyroblastic granulite gneiss and strongly layered gneiss are not differentiated from their parent rocks.

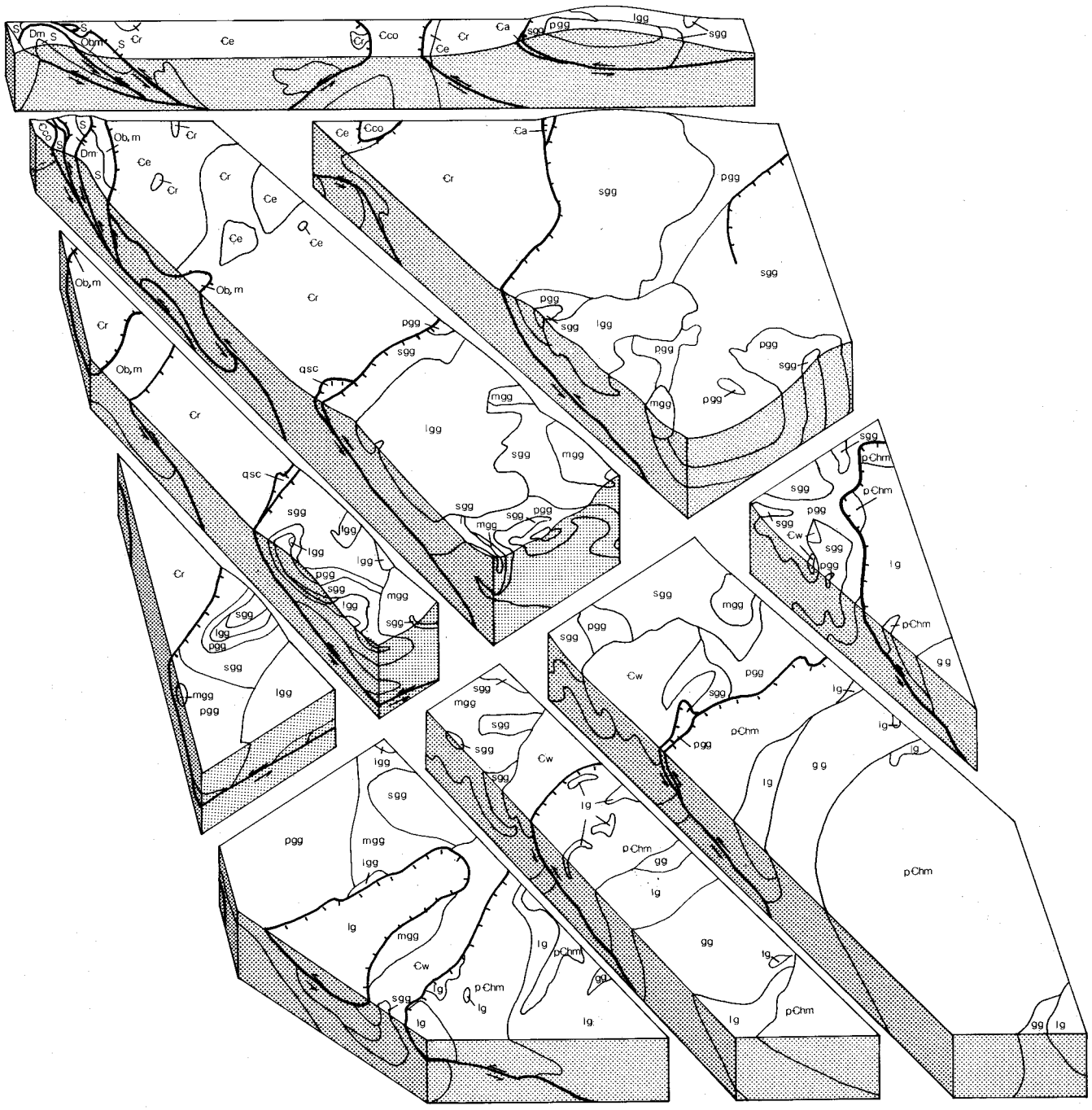

Figure 21. Block diagram of bedrock in the Stewartsville quadrangle. Symbols are identical to those used under the title "Stratigraphic Column" except for the following cases. *S*, includes all Silurian units of the area or any one of them; *O*, includes Middle Ordovician limestone and Liberty Hall Formation and is used for all or any one of these units; Obm, Bays and Martinsburg formations.Mylonitic rocks of various Precambrian units (including porphyritic granulite gneiss, strongly layered granulite gneiss, granitic gneiss, and rocks of the Horsepen Mountain suite) are not differentiated from their parent rocks.

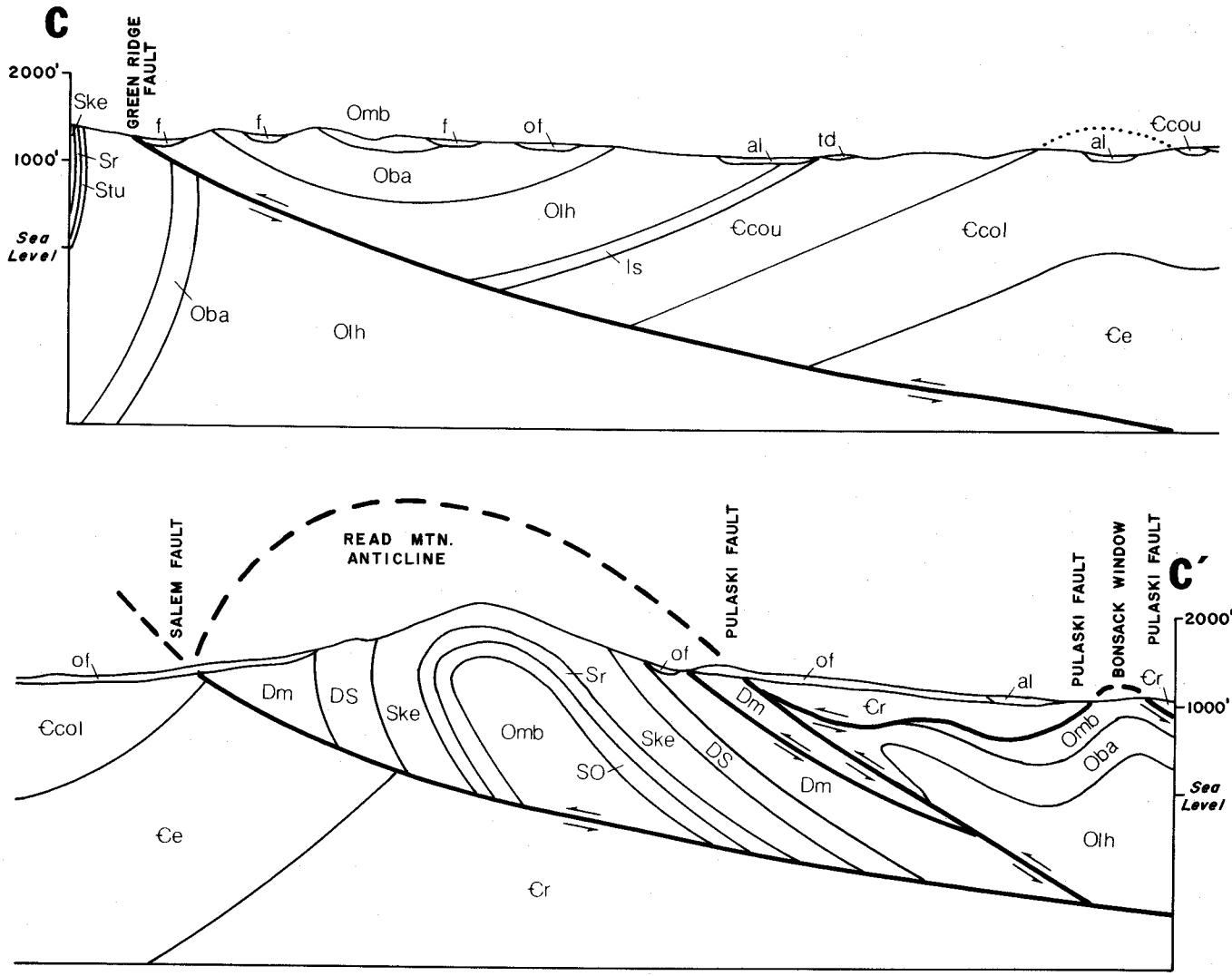

Figure 22. Cross section C-C′ from Plate 1.

(Figures 3 and 21 and cross section B-B′ on Plate 1) and defines this zone of ductile deformation, which formed in Middle Paleozoic time. The fault zone north of Roanoke, as in the Rockfish Valley farther north, is topographically expressed by a rather linear, 1- to 3-mile- (1.6- to 4.8-km-) wide valley lying between mountainous terrains containing less altered Grenville-age rocks. Basement rocks are poorly exposed from Radford, Virginia to near the Virginia-North Carolina border.

The oldest rock of the Lovingston massif within the Stewartsville quadrangle is layered gray gneiss, which forms roof pendants and xenoliths within the quartzo-feldspathic gneiss of the Horsepen Mountain suite and is the country rock of this area. The layered gray gneiss is similar to charnockitic gneisses described by Hillhouse (1960) and Herz (1969) from the Roseland area (to the northwest in Nelson County). The layered gray gneiss occurs in smaller masses and lacks the prominent segregation layers which characterize similar rocks in the Roseland area. The Horsepen Mountain suite is a large Grenville-age mass exposed in a series of folds for a distance of 10-15 miles (16-24 km) northeast and southwest of Roanoke. Both the layered gray gneiss and the quartzo-feldspathic gneiss are intruded by granitic gneiss which discordantly cuts the older rock contacts.

Rocks of the Lovingston massif contain mineral assemblages (Table 1) suggestive of the shallow granulite facies, whereas those of the Pedlar massif are indicative of the deeper granulite facies. Garnet in rocks of the Pedlar massif formed after orthopyroxene in most rock types. In the Pedlar massif, strongly layered granulite gneiss is the dominant country rock into which porphyroblastic granulite gneiss and massive granulite gneiss were emplaced. Leucocratic granulite gneiss of the Pedlar massif

represents the youngest Grenville-age pluton.

Within the Pedlar massif, the map pattern of the porphyroblastic granulite gneiss defines some probable Grenville-age folds which were refolded about younger, Paleozoic-age, isoclinal folds. Small folds are associated with crenulation cleavage that postdates the ductile deformation. These folds are within phyllitic units of the Weverton Formation as well as within mylonitic schist lenses along the Rockfish Valley fault.

In contradistinction to the Rockfish Valley ductile deformation zone, the Blue Ridge thrust fault zone is characterized by brittle deformation, from which it is inferred that movement on the Blue Ridge fault took place at a shallower depth than that associated with the Rockfish Valley fault, which occurred earlier.

ECONOMIC GEOLOGY

CLAY

Clay materials currently are produced from two large quarries within the Rome Formation at Webster (Stewartsville quadrangle). The larger quarry (1) has been operated by Webster Brick Company, Inc. (formerly Roanoke-Webster Brick Company, Inc.) since 1922. Both saprolite and bedrock derived from variegated phyllitic shales and carbonate rocks are used as raw materials for manufacture of a variety of types of bricks at the on-site brick plant. South of State Road 738, Weblite Corporation (formerly Virginia Lightweight Aggregate Corporation) has operated a quarry (2) since 1951. Here, material similar to that excavated at the larger quarry is used for manufacture of lightweight aggregate by the sintering process at the on-site plant. Similar bedrock is abundant on much of the Salem thrust sheet and provides a potential for either expansion of existing operations or development of new clay quarries.

PHOSPHATE

Watson (1907) described occurrences of nelsonite (apatite and ilmenite) dikes on the outskirts of Vinton and states that they were discovered in 1905 and extensively prospected before the end of 1907. Woodward (1932) noted the location of one of the main quarries (3), which is now filled with earth. Six abandoned quarries (3-8) and seven prospects (9-15) (Stewartsville quadrangle) are within areas where highly deformed, foliated nelsonite dikes are abundant. The largest quarry (4) trends about N40°E for roughly 1000 feet (305 m) along the slope of a hill. It has been excavated to a depth of about 70 feet (2.15 m) along a 50-foot- (15.3-m-) wide area; the width suggests that the mines essentially were excavations of the dikes themselves. Other openings (5, 6) on the hill to the southwest are much smaller and are terraced excavations. The remaining two openings (7, 8) are nearly filled with earth. Porphyroblastic granulite gneiss forms the host rock into which the dikes were intruded. The nelsonite bodies occur as highly deformed pod-like lenses (REFERENCE LOCALITY 17) which are commonly foliated. They vary in thickness from 1 to 30 feet (0.3 to 9.2 m). Little or no alteration of the country rock is discernable in most exposures.

SULFIDES

The Bonsack mine (16, Stewartsville quadrangle) was described by Watson (1907) as a single abandoned shaft less than 50 feet (15.3 m) deep. Watson (1907), Woodward (1932) and Currier (1935) all reported that pyrite, chalcopyrite and sphalerite were at the abandoned workings. Kemp (1903) stated that the mine yielded rich earthy oxidized ores, which passed at depth into a mixture of zinc-blende and pyrite. The shaft is collapsed now and filled with earth to a depth of 10 feet (3.1 m). A small gossan area is exposed at the surface. Several shallow depressions near the mine suggest that some additional prospecting was done; a small area apparently was quarried in dolomite just above the mine, perhaps for building stone used at the site.

IRON AND MANGANESE

Four prospects (prospect 17 has 3 associated, unnumbered ones) are on the northern end of Coyner Mountain (Stewartsville quadrangle) within the uppermost 50 feet (15.3 m) of the undivided Devonian-Silurian sandstones. At these prospects, as well as elsewhere along the contact of the sandstone with the Millboro shale, massive to semi-botryoidal, vuggy, poorly layered zones of hematite, limonite and manganese lie at high angles to bedding in the subjacent sandstones. These iron and manganese enriched areas generally exceed 6 feet (1.8 m) in thickness. The manganese commonly occurs either within the more massive ore or as thin discontinuous lenses forming the cores of botryoidal masses (R-8446). Five other iron prospects (Stewartsville quadrangle—No. 18, 3 prospects; No. 19, 2 prospects) are located on the southern portion of Coyner Mountain. These prospects are in discontinuous ferruginous sandstone beds or within the Rose Hill Formation (R-8440). Neither group of prospects appears to be located upon ore bodies of sufficient size to warrant additional investigation at this time. The Rome Formation was prospected for iron at prospect 44 and reportedly near where State Road 603 crosses

the Blue Ridge fault. Iron also was prospected within crystalline rocks of the Lovingston massif (prospects 45 and 46).

Numerous small prospects and abandoned pits are on Read Mountain (20, 21). The ores are in residual colluvial deposits of quartzite beccia cemented by hematite, limonite, and manganese. An additional prospect (22) is in similar colluvial material in the northeastern part of the quadrangle.

CRUSHED STONE

One small activity quarry (23) owned by ACCO Stone Company since 1968, and one small abandoned quarry (24) are in highly deformed and fractured carbonate rocks along the contact between the Liberty Hall Formation and underlying limestones near the westernmost branch of the Green Ridge thrust sheet (Roanoke quadrangle). Crushed stone is or was the product. In addition, 12 small abandoned quarries in carbonate rocks of the Beekmantown Group (25-29), Elbrook Formation (30, 31), and Rome Formation (32-36), also served as local sources of crushed stone and perhaps of building stone (Roanoke quadrangle).

One abandoned WPA quarry (37) is in the mylonite gneiss of the rocks of the Horsepen Mountain suite (Stewartsville quadrangle). This quarry was used as a source of crushed stone during construction of State Highway 24 and was closed about 1937. An analysis of rock from this quarry is listed in Table 2.

Table 2. Analyses of rock samples from WPA quarry (No. 37) (from Virginia Department of Highways, 1954).

Lab. No.	Year Sampled	Specific Gravity	Absorption	Los Angeles Loss Abrasion	Los Angeles Loss Grading	Soundness	Bituminous Adhesion Weight	Bituminous Adhesion Est.
A-23395	1949	2.79	0.69	26.0	A	0.67	—	—
A-28835	1951	2.81	0.35	23.1	A	OK	36	75

SANDSTONE

One abandoned quarry (38) is located in the Keefer Formation and probably was used as a local source of building stone (Roanoke quadrangle). This type of building stone, known locally as "Catawba stone," has been used widely in the Roanoke Valley as facing for houses; but here, it may have been used in construction of the nearby dam.

DOLOMITE

Five abandoned quarries (39-43) are in carbonates of the Rome and Elbrook formation (Stewartsville quadrangle). Rock from one quarry was likely used during the construction of U.S. Highway 460. The other quarries are small and rock from them probably was used locally for dimension stone, lime and crushed stone.

GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION

FLOODPLAIN AND FAN DEPOSIT AREAS

Areas adjacent to both low and steep-gradient streams typically are covered by a veneer of either alluvium or colluvium subject to periodic flooding. Such deposits on small or steep-gradient streams are generally too small to be shown on the geologic map. These unconsolidated deposits are excavated easily and some may be used locally as sources of sand and gravel. Because of flood hazard, these areas generally are restricted to agricultural or recreational uses. Landslides may be generated by excavation of such deposits.

SANDSTONE AND SHALE AREAS

The Mill Mountain thrust sheet, the Tinker Mountain and Kingston regions (labeled A and B on Figure 2) of the Green Ridge thrust sheet; most of the Salem synclinorium, and the Read Mountain anticline and tectonic slices (labeled C on Figure 2 and A and B on Figure 3) form these areas. Resistant, ledge-forming sandstones orthoquartzites, and/or chert of Mississippian through Silurian age cap the narrow, steep-sided, mountainous ridges. Excavation of these hard rocks will require blasting. Colluvial debris from these sandstones typically mantles the steep slopes underlain by shales and siltstones of the Millboro, Brallier and Chemung formations and Martinsburg shales, sandstones, and limestones. The steep mountainous slopes are commonly lined with V-shaped ravines which, if denudated or excavated, may be subject to landslides during periods of heavy rainfall. The land is suitable for either forestry or limited residential development on the ridge crests or major spurs. For residences placed at higher elevations, the depth to groundwater may be substantial. Suitable condi-

tions for operation of a small number of septic systems may exist locally. Groundwater generally is at depths of 100 to 600 feet (30.5 to 183 m); yields are low to medium.

The basal part of the Weverton Formation (Ꞓw) nonconformably overlies crystalline rocks of the Pedlar massif near the Rockfish Valley fault (Figures 2 and 3). It is characterized by interbedded, well-foliated phyllitic rocks and poorly foliated to massive, resistant, ledge-forming sandstones and metaquartzites. The land surface on the Weverton is typically hilly and is cut by narrow, steep-sided stream valleys which are subject to periodic flash flooding during period of heavy rainfall. Soil cover is typically thin and the phyllitic rocks are moderately easy to excavate; however, the hard, ledge-forming rocks may require blasting. Areas underlain by the Weverton Formation are suitable for forestry and agricultural or limited residential development. Groundwater supplies and yields probably are adequate for most domestic uses. Locally, soil conditions probably are suitable for operation of septic systems for a smaller number of residences.

SHALE AND CARBONATE ROCK AREAS

The Rome belt of the Salem thrust sheet, the Bonsack window (Figures 2 and 3) and those portions of the Salem synclinorium and Green Ridge thrust sheet which are underlain by Liberty Hall shale (Figure 2, labeled D), as well as small tectonic slices (Figure 2, labeled F; Figure 3, labeled C and D) form these areas. The Rome belt of the Salem thrust sheet is underlain primarily by shale with some interbedded carbonates up to about 50 feet (15.3 m) thick. In places the carbonate rock outcrops are narrow and linear and have been eroded to form cavernous and karst terrain. Except for scattered areas where unconsolidated fan and terrace deposits mantle them, the shales adjacent to carbonate units generally are overlain by a thin soil veneer, which is easily excavated. Land is suitable for agriculture or residential development; however, sewage treatment facilities are essential for large-scale development in order to prevent contamination of surface and groundwater supplies. These areas are not suitable for operation of septic tanks. Groundwater is generally at depths between 100 and 400 feet (30.5 to 122 m). Yields are moderate to low; but high yields occur locally. The Bonsack window in the Salem thrust sheet (Figure 2) contains interbedded shale and limestone of the Martinsburg Formation (Omb) along with minor amounts of sandstone of the Bays Formation. The tectonic slice (D in Figure 2) beneath the Blue Ridge thrust contains dolomite (Ꞓs) and metaquartzite (Ꞓa). All of these areas are characterized by a gently rolling to moderately dissected land surface, much of which is covered by a 5- to 50-foot (1.5- to 15.3-m) veneer of unconsolidated fan and terrace deposits. Where the veneer is absent, soil and saprolite developed over the shales rarely exceeds 10 feet (3.1 m) in depth, but over the carbonates, it may be up to 20 or 30 feet (6.1 or 9.2 m) thick between pillars of bedrock. The thicker sandstone and quartzite beds commonly hold up small ridges. Karst terrain and cavernous areas commonly develop in the carbonate rocks. Inasmuch as surficial deposits do not reflect rock type at depth, bore-hole tests may be necessary to determine suitability of an area for either deep excavations or erection of large structures. Land is suitable for agriculture or residential development; however, sewage treatment facilities will need to be constructed for large-scale development, such as is currently taking place, to prevent contamination of surface and groundwater supplies; these areas are not suitable for operation of septic tanks. Groundwater is generally at depths between 100 and 400 feet (30.5 and 122 m); yields are low to moderate in the shales and moderate to high in the carbonates, but low-yield wells occur locally.

CARBONATE ROCK AREAS

The Elbrook belt in the Salem thrust sheet and portions (labeled E and G on Figure 2) of the Green Ridge thrust sheet and the Glade Creek window are areas primarily underlain by carbonate rocks with minor amounts of chert, sandstone, and/or shale. The Elbrook belt of the Salem thrust sheet (Figures 2 and 3) is composed of chaotic, complexly folded, faulted, and fractured bedrock consisting of minor shales and carbonate rocks (c) of the Rome Formation (Ꞓr), and polymictic carbonate breccia (P) and interbedded limestone and dolomite of the Elbrook Formation (Ꞓe). Within the Glade Creek window in the Green Ridge thrust sheet (Figure 2) are interbedded dolomite, sandy dolomite and sandstones (s) of the Conococheague Formation (Ꞓc).

These areas of carbonate rock are characterized by a gently rolling to moderately dissected land surface which is commonly mantled by a 5- to 50-foot (1.5- to 15.3- m) veneer of unconsolidated fan and terrace deposits. Extensive karst terrains and cavernous zones are over large tracts of this carbonate terrain. Saprolite may reach 20-40 feet (6.1-12.2 m) in depth between bedrock pillars. Land is suitable for agricultural or residential/industrial development; however, because areas underlain by carbonate rocks are subject to solution weathering, borehole tests may be required to determine suitability of construction sites prior to deep excavations or

erection of large structures. Sewage treatment facilities are essential to prevent contamination of groundwater; the area is not suitable for operation of septic tanks. Groundwater is generally at depths between 100 and 600 feet (30.5 and 183 m). Yields are moderate to high, but low yield wells occur locally.

CRYSTALLINE ROCK AREAS

Rocks of the Pedlar massif (Figures 2 and 3) are generally massive or layered gneisses except in the vicinity of the Rockfish Valley fault where they may be well foliated. The land surface of the massif is generally mountainous except locally. A thin (0-10 feet; 0-3.1 m) veneer of sandy soil and saprolite is common over the boulder-strewn terrain characterized by many large outcrops. Narrow, boulder-strewn stream valleys are subject to periodic flash flooding during heavy rainfall. Denudation or excavation of precipitous slopes, such as those near the Blue Ridge fault, could lead to landslides (the landslide along the Blue Ridge Parkway is an example) or debris avalanches during periods of heavy rainfall. The land is suitable for forestry, recreational use or limited residential development. Locally, soil conditions may be satisfactory for operation of septic systems for small numbers of dwellings. Groundwater is generally at depths between 50 and 400 feet (15.25 and 122 m); yields are likely to be low to moderate. At present, two surface reservoirs supply the water needs of the City of Roanoke. Development in these areas should be prevented to avoid either contamination of existing water supplies or drawdown of groundwater levels which would adversely affect the reservoir levels. High yield wells at depths of 300 to 600 feet (91.5-183 m) may be related to fractures near the Blue Ridge thrust fault zone. Large water demands will need be met by either damming surface water or by tapping an outside source. Sewage treatment facilities are probably necessary because of the highly variable depth to bedrock and the very low permeability of it. Some of the massive gneisses may prove suitable for dimension stone.

Rocks of the Lovingston massif (Figure 3) are generally well-foliated gneisses and schists but also include some layered and massive gneisses. The land surface contrasts sharply with that of the Pedlar massif in being more Piedmont-like. It is typified by gently rolling to hilly terrain cut by numerous, narrow to moderately wide stream valleys. Bedrock commonly exposed in the streams bears a thin veneer of alluvium. Bedrock also crops out abundantly above the steep-sided valley floors; however, on the upland areas, outcrops are restricted to somewhat rare isolated pillars of unweathered bedrock which are between large areas underlain by a residual reddish-orange saprolite up to about 50 feet (15.3 m) thick. The land is suitable for forestry and limited agricultural or residential development, for when denudated or excavated, the soil and saprolite is subject to rapid erosion commonly leading to numerous and deeply incised gullies. Groundwater supplies for domestic and agricultural use are satisfactory and low to moderate yields of groundwater are at depths typically between 150 and 400 feet (4.8-122 m). Large water needs could only be supplied by either damming of surface water or from an outside source. Sewage treatment facilities, and not septic tanks, are probably necessary because of the highly variable depth to bedrock and the very low permeability of it. Some of the more massive gneisses may be suitable for dimension stone.

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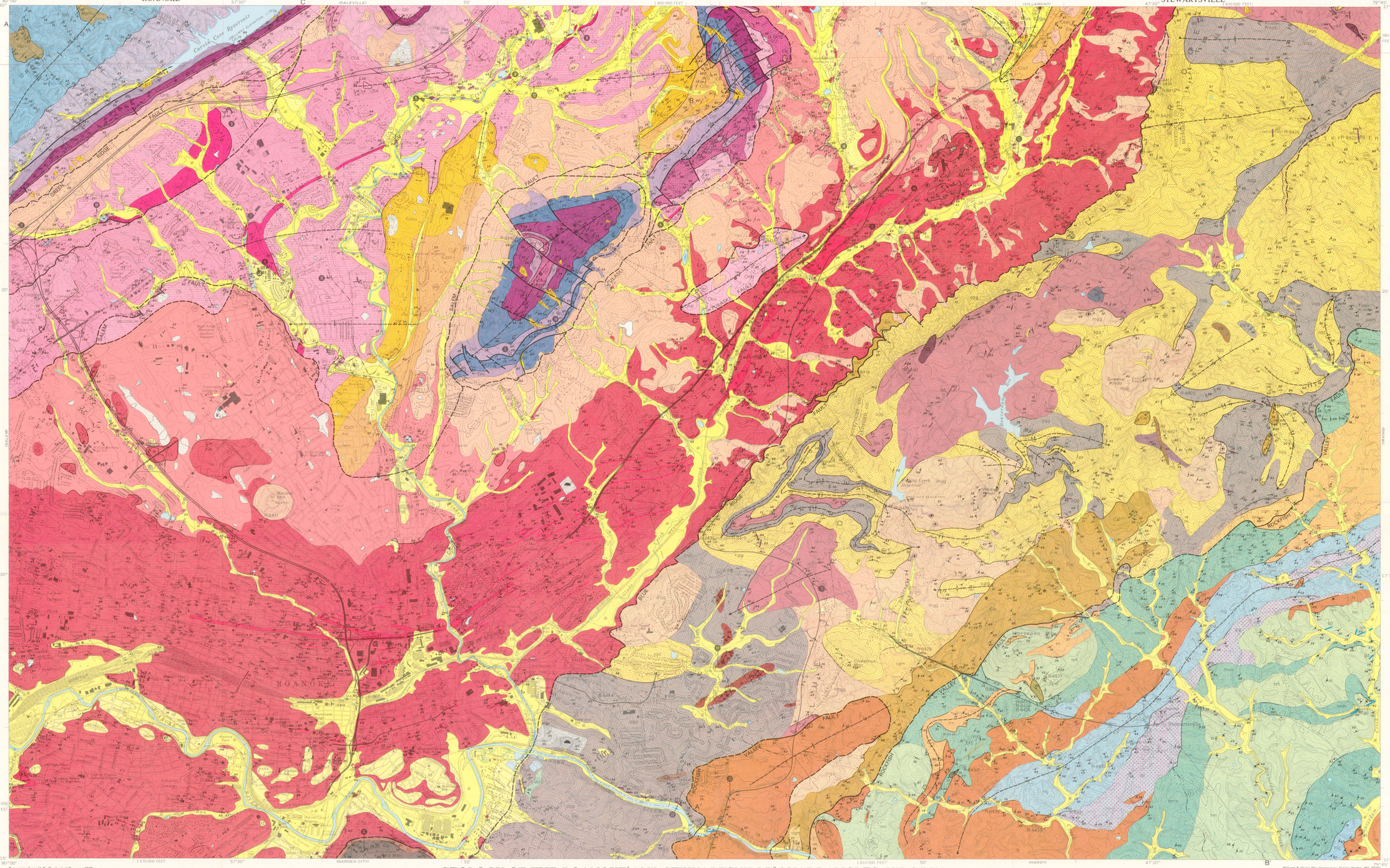
PUBLICATION 34
(GM 109C and D)
ROANOKE-STEWARTSVILLE QUADRANGLES

ROANOKE[1] — STEWARTSVILLE[2]



Base map from U.S. Geological Survey, 1963
Roanoke and 1963 Stewartsville Quadrangles,
7½ Minute Series

Williams & Heintz Map Corporation, Capitol Heights, Md. 20743

GEOLOGY OF THE ROANOKE[1] AND STEWARTSVILLE[2] QUADRANGLES, VIRGINIA

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

1981

[1]Geologic map of the Roanoke quadrangle by Mervin J. Bartholomew and William H. Hazlett; [2]geologic map of the Stewartsville quadrangle by Mervin J. Bartholomew

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

PLATE 1

EXPLANATION

CENOZOIC

QUATERNARY

al, alluvium; f, younger fan deposit

td, terrace deposit; of, older fan deposit

tu, Tufa

ta, Talus

PALEOZOIC

MISSISSIPPIAN

Mpri, Price Formation lower member

DEVONIAN

Dch, Chemung Formation

Db, Brallier Formation

Dm, Millboro Formation

Dh, Huntersville chert

DEVONIAN-SILURIAN

DS, Lower Devonian and Upper Silurian rocks

SILURIAN

Ske, Keefer Formation

Sr, Rose Hill Formation

Stu, Tuscarora Sandstone

SILURIAN-ORDOVICIAN

SO, Tuscarora Sandstone and Oswego Formation

ORDOVICIAN

Omb, Martinsburg Formation

Oba, Bays Formation

Oh, Liberty Hall Formation

ls, Limestone sequence

Ob, Beekmantown Formation; s, quartzose sandstone

CAMBRIAN

Ccou, Ccol, Conococheague Formation; Ccou, upper member; Ccol, lower member; s, quartzose sandstone

Ce, p, Elbrook Formation; p, polymictic carbonate breccia

Cr, Cc, Rome Formation; c, carbonate interval

Ck, Shady dolomite

Ka, qtc, Antietam Formation; qtc, cataclasite

Kw, Weverton Formation

PRECAMBRIAN

PROTEROZOIC Z

ad, do, u, mf, md, Diabase Dikes; ad, diorite; do, altered gabbro; u, ultramafite; mf, felsic rock; mf, mafic rock; md, greenstone

gg, mg, Gneiss; gg, granitic gneiss; mg, mylonite gneiss; gd, dike of gg

PROTEROZOIC Y

lgg, Gneiss; lgg, leucocratic granulite gneiss; g, granitic gneiss

mgg, Massive granulite gneiss

pgg, pgm, Gneiss; pgg, porphyroblastic granulite gneiss; pgm, mylonite gneiss

hm, hmm, hmd, Horsepen Mountain suite; hm, massive quartzo-feldspathic gneiss; hmm, protomylonite and mylonite gneiss; hmd, dike of massive gneiss

m, Mafic granulite gneiss

sgg, sgm, Gneiss; sgg, layered granulite gneiss; sgm, mylonite gneiss; sgm, mylonite and ultramylonite

lg, sm, Gneiss; lg, layered quartzo-feldspathic gneiss; sm, mylonite gneiss

KEY

CONTACTS

Exposed

Inferred

FOLDS (trace; direction of plunge)

Anticline or antiform

Syncline or synform

Antiform or overturned anticline

Synform or overturned syncline

Isoclinal anticline or antiform

Isoclinal syncline or synform

Minor fold

Minor fold (trace only)

FOLDS (attitudes of minor fold axial planes)

Strike and dip of axial plane

Strike of vertical axial plane

Horizontal axial plane

FAULTS

Exposed or approximate (solid); covered or inferred (dashed); T, upper sheet; tick mark, direction of dip

Shear zone

ATTITUDE OF ROCKS

Horizontal | Inclined | Vertical | Overturned | Overturned more than 180°

Bed

Bed for which tops are known from sedimentary structures

Compositional layering

Schistosity

Cleavage (cremulation)

SAMPLE LOCATIONS

R-8442, R, repository number of rock sample

F-953, F, repository number of fossil sample

Reference locality described in text

MINES, QUARRIES AND PROSPECTS

Active quarry

1 Webster Brick Co., Inc. (brick)
2 Wehlite Corp. (lightweight aggregate)
23 ACCO Stone Co. (crushed stone)

Abandoned mine or quarry

Prospect

LAND MODIFICATION FACTORS

Modified land: sanitary landfill

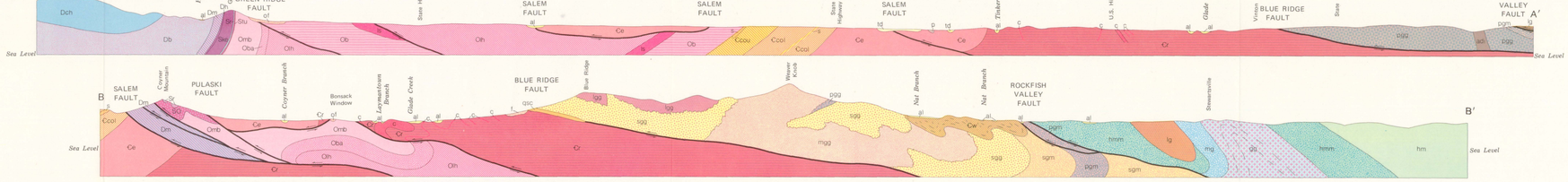
Modified land: extensive cut or fill (man-made)

Karst land: areas of known or potential sinkhole development, subsidence and cave opening

Sinkhole

Landslide

Breccia



See accompanying text for cross-section C–C'