

**ROCK CHARACTERISTICS**

**Quaternary:**  
 Alluvium: Flood-plain deposits of stratified light-gray to light-brown, unconsolidated sand, silt and clay with beds and channels of pebbles and cobbles. Thickness: 0-30 feet (0-9.3 m).  
 Tuff: Stratified deposits of light to medium-gray, poorly consolidated, angular to subangular pebbles and cobbles of dolomite, limestone and chert in an unsorted matrix of silt and clay with calcareous cement. Thickness: 0-20 feet (0-6.1 m).  
 Tuff deposits: Unconsolidated, unsorted boulder beds composed of 1-6 foot (0.3-1.8 m) thick angular boulders of quartzite, siliceous sandstone and quartzite conglomerate. This unit has been derived from nearby strata of Manassas, Shenandoah and Devonian age.  
 Terrace deposits: Unconsolidated, poorly stratified deposits of dark-brown to dark reddish-brown, 2-8 inch (5.1-20.3 cm) thick, well rounded cobbles (0.7-27.0) of sand quartz, metamorphic and feldspathic sandstone in a clayey to silty matrix. Fine-grained quartz cobbles are usually discolored in the interior, but have only a thin oxidized veneer. Metamorphic cobbles are discolored in the interior and have a 2 mm or less oxidized rind. Feldspathic sandstone cobbles are typically discolored and oxidized throughout. The upper few feet of the soil horizons are commonly light brown, grading abruptly downward to darker colors. Thickness: 2-20 feet (0.6-6.1 m).  
 Macerated formation: Mmcs (upper member), thick-bedded medium-gray sandstone and mudstone and light to medium-gray, sandy quartzite (2-770) (1-1 m) conglomerate and coarse-grained conglomerate sandstone. Thickness: 200-300 feet (61-91 m). The member is characterized locally by a thin (1-2 feet, 0.3-0.6 m) light-brown sandstone, which is a shallow-water fauna (Reference Locality 1) of Silurian, Neoproterozoic, Neoproterozoic and graptolite. Mmcs (lower member), cyclic deposits of sandstone, siltstone and claystone with green mudstone and green mudstone. The member is characterized by a thin (1-2 feet, 0.3-0.6 m) light-brown sandstone, which is a shallow-water fauna (Reference Locality 1) of Silurian, Neoproterozoic, Neoproterozoic and graptolite. The member is characterized by a thin (1-2 feet, 0.3-0.6 m) light-brown sandstone, which is a shallow-water fauna (Reference Locality 1) of Silurian, Neoproterozoic, Neoproterozoic and graptolite.  
 Price Formation: Mpru (upper member), a modified macerated and green mudstone underlain by interbedded dark-gray to black mudstone and coal which in turn is underlain by a nonmarine cyclic sequence of quartzite and sandstone. The thickness of the modified mudstone increases upward, and the contact with the overlying Macerated Formation is well exposed at Reference Localities 2 and 3. The coal measures are best developed near the base of the Price Formation and are commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation. Mpru (lower member), a modified macerated and green mudstone underlain by interbedded dark-gray to black mudstone and coal which in turn is underlain by a nonmarine cyclic sequence of quartzite and sandstone. The thickness of the modified mudstone increases upward, and the contact with the overlying Macerated Formation is well exposed at Reference Localities 2 and 3. The coal measures are best developed near the base of the Price Formation and are commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
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 Knob Group (upper part): Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Knob Group (lower part): Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
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 Millboro Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Newfound Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Unidentified Lower Devonian and Upper Silurian rocks: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Devonian rocks: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Silurian rocks: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Keeler Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Row Hill Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Tuscarora Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
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 Martinsburg Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.

**Geologic and Economic Factors Affecting Land Modification**

**Floodplain**—are the level areas adjacent to streams which are covered by alluvium. Because they are subject to periodic flooding they are generally restricted to agricultural or recreational development. The alluvium is easily removed and may be used as a source of sand and gravel. These excavations, however, are subject to landslides and collapse. Hard calcareous tuff deposits may underlie alluvium along some streams.

**Area of chert rocks**—Mississippian rocks crop out in the Price Mountain window and in the Salville block, north of the leading edge of the Palaski thrust (Figure 1). These rocks consist primarily of interbedded sandstone, siltstone and shale with local occurrences of coal. The land surface is generally rolling to hilly on the eastern end of Price Mountain. In contrast, the deeply dissected, steeply inclined flanks of Price and Brush Mountain are abundant, gently sloping to flat spurs underlain by moderately dipping, resistant sandstone ledges. The top of Brush Mountain is relatively flat although narrow, whereas the top of Price Mountain is a broad, comparatively flat surface underlain by nearly horizontal strata. Soil is typically thin, except where the land surface is gently rolling or flat. The land is forested and suited for farming in only a few places. Residential development should be restricted to spurs and ridges because the narrow, V-shaped valleys may be subject to flash floods during major storms, and because landslides and collapse may occur where steep-sided slopes have been excavated or denuded. Ground water supplies from strata beneath the coal measures may be chemically and bacteriologically unacceptable because the dip of bedrock facilitates infiltration of acid mine waters and because waste effluent from drain fields and septic tanks along the upper slopes is likely to be a source of contamination. Depth to ground water is unknown at higher elevations, but is generally encountered at depths between 50 and 300 feet (15 and 91 m) at lower elevations. Numerous mine dumps and open or caved shafts and adits are along zones where the coal measures occur at the surface known as surface, subsurface, mined-out areas are shown on the geologic map.

**Areas of dolomite and carbonate rocks**—the Barringer Mountain window and areas labeled A (Figure 1) are regions underlain by dolomite and limestone. The dolomite and limestone are thin, shaly, interbedded with some sandstone in the Barringer, Millboro, Martinsburg and Boyss formations, or limestone in the Liberty Hill and Martinsburg formations. Local masses and narrow beds of resistant siliceous quartzite, calcarenite, chert and sandstone crop out on numerous hills and are likely to be encountered in some drill holes, excavations of their beds may require blasting. The land surface in the window is characterized by numerous narrow, steep-sided, flat-topped ridges separated by narrow, low gradient stream valleys that are subject to flooding. Steep slopes may be subject to landslides when excavated or denuded. These hills are suitable for pasture and forestry uses. Residential development should be confined to the more stable flat-topped ridges and spurs. Shallow soil and rapid runoff may require sewage-treatment facilities and an outside water supply.

**Areas of carbonate rocks**—the Salem synclinorium, Christiansburg window, Crab Creek allochthon and area labeled B (Figure 1) are regions underlain by beds of (1) uniformly dipping dolomite and a few thin sandstone ledges of the Elbrook and Copper Ridge formations, (2) dolomite with considerable interbedded limestone in the upper part of the Knob Group, and (3) limestone of the New Market and Lincolnshire formations, and an undivided limestone unit (4). The gently rolling land surface is covered by 5 to 20 feet (1.5 to 6.1 m) of light-brown residual soil which in places contains an abundant amount of gravel- and cobble-size chert and sandstone fragments derived from the underlying bedrock. The early excavated collateral veneer and saprolite ranges from 10 to 50 feet (3 to 15 m) above the bedrock. The saprolite is likely to contain bedrock pinacles and, locally, chert and sandstone ledges and are likely to be encountered in some strata ranges from nearly flat in the northeast corner of the quadrangle to steeply dipping or vertical in the southeast corner. This is suitable for agricultural and residential development, but sewage-treatment facilities are essential for large-scale developments to prevent contamination of ground- and surface-water supplies. Ground water is usually obtained from depths between 100 and 1000 feet (30 and 305 m), and potential for wells of moderate to large yields is present in some areas. Zones of cavernous rock and karst terrain are common, in which the ground water reservoir is very susceptible to contamination from unsaturated surface sources.

**Areas of deformed rocks**—the Blacksburg and Belmont systems and areas labeled C (Figure 1) are regions underlain by chert, complexly folded, faulted and fractured bedrock of calcareous, polygenic breccia, shale of the Rome Formation, and dolomite with interbedded limestone and minor sandstone of the Elbrook and Copper Ridge formations. The gently rolling to moderately dissected land surface is covered by 5 to 20 feet (1.5 to 6.1 m) of light-brown residual soil that in places contains abundant quartzite and cobble-size fragments of chert, sandstone, quartzite and vein quartz derived either from the underlying bedrock and/or from ancient strata deposits. The collateral veneer and saprolite ranges from 10 to 100 feet (3 to 31 m) above the bedrock, but may be as thick as 50 feet (15.3 m) between pinacles of dolomite and limestone. Inasmuch as surficial deposits do not always reflect the type and depth of underlying bedrock, boreholes may be necessary prior to both deep excavations and the erection of large structures. The collateral veneer and saprolite are easily excavated and the land is suitable for horticultural and residential development. Sewage-treatment facilities will be essential for large-scale development to prevent contamination of ground- and surface-water supplies. Ground water is generally encountered at depths between 100 and 300 feet (30.5 and 91.5 m) below ground surface.

**Structures include several generations of folds (reference to light-to-orientation to strongly overturned folds (REFERENCE LOCALITIES 15, 6, 8, 15, 17) more or less generally related to a middle to late Paleozoic phase of Valley Ridge deformation. In this area this event culminated with emplacement of the Palaski thrust and the closely related Salem-Yellow Springs thrust sheets in post-early Mississippian time. The intensely disrupted nature of many of these F2 folds (REFERENCE LOCALITY 8, and the presence of F2 structures in incision zones derived from the decapitated Christiansburg anticline, suggest that thrusting slightly post-dates F2 folding. Hence, the small-scale F2 structures probably developed at about the same time as the Christiansburg anticline, but prior to emplacement of the Palaski thrust. By analogy F2 folds, which are along the leading edge of the Salem fault as well as within tectonic belts associated with the Valley Ridge thrust, can be inferred to pre-date the Christiansburg anticline. The latter rocks, however, are tectonically older than large-scale folds of similar trend in the Salem synclinorium. F1 structures have not been identified within the Salem synclinorium, where F2 folds are gently plunging, north-trending, open to tight folds (mainly local) with steeply southeast-dipping axial surfaces. Northeast of Blacksburg this dominant type appears to be refolded about east-west trending axial surfaces.**

**The Crab Creek allochthon contains strata derived from the southern flank of the decapitated Christiansburg anticline, and probably was emplaced during early movement along the Palaski thrust. In contrast, thrusting along the Palaski fault appears to have terminated with movement along a branch of the fault (cross section A-A') which decapitated the Barringer Mountain structure and probably the Christiansburg anticline (see below the Palaski fault). Superimposed on the Palaski fault along the northern flanks of the Christiansburg and Barringer Mountain windows was probably concurrent with this final movement. Total movement on the Palaski fault system in this quadrangle exceeds 10 miles (16 km).**

**F2 structures are broad, open, east-west trending antiforms and synforms that have broadly warped the Palaski thrust sheet during formation of the antiformal Price Mountain window and adjacent Blacksburg and Belmont systems. These late-Paleozoic, post-thrusting folds are associated with numerous,**

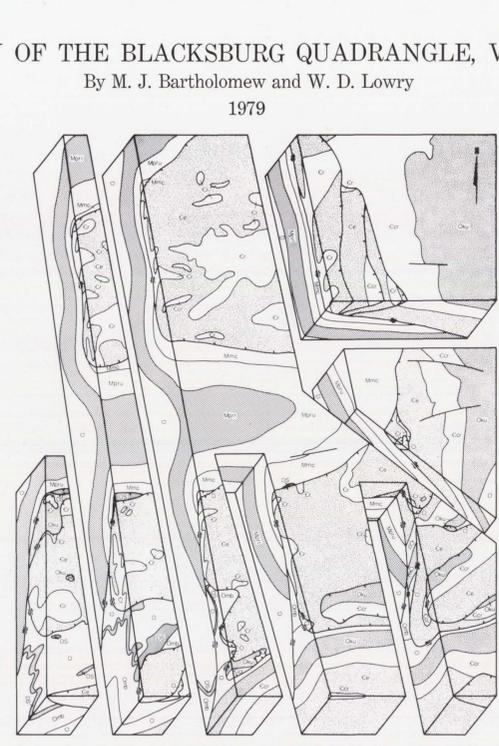


Figure 2. Block diagram showing deformation of bedrock in the Blacksburg quadrangle.

**SUMMARY OF DEFORMATIONAL HISTORY**

The complexly folded Palaski thrust sheet (cross section A-A') overlies autochthonous Mississippian rocks of the Salville block exposed both in the Brush Mountain area and within the Price Mountain window (Figures 1 and 2). South of the window, Cambrian through Devonian rocks of the Salem synclinorium are exposed in the Christiansburg and Barringer Mountain windows. Numerous tectonic slices occur within these windows (REFERENCE LOCALITIES 8, 10, 20, 22, 27) and along the leading edge of the Yellow Sulphur fault (REFERENCE LOCALITIES 21, 22, 23), which is probably a near fault related to the Salem synclinorium. The nature of the F2 structures is uncertain, but multiple episodes of breccia formation are suggested by the observations. First, the distinctive gray-green breccia contains abundant, randomly oriented chips of gray-green phyllosilicate mudstone derived from transitional beds of the lowermost Elbrook Formation, indicating that this type of breccia is post-orogenic; second, layering within the most typical polygenic carbonate breccias is commonly folded about F2 and F3 axial surfaces, but not about F1; third, polygenic carbonate breccias occur in the cores of both F1 and F2 folds in lieu of F3 axial surfaces; fourth, more massive types of polygenic carbonate breccias commonly truncate both F1 and F2 structures; fifth, massive breccia is very common along or near the Palaski and Salem faults (REFERENCE LOCALITIES 8, 24), and sixth, masses of relatively cohesive breccia up to about 10 feet (3.0 m) in diameter are incorporated in younger breccias. Hence, breccia development appears to have been an integral part of the lengthy Paleozoic deformational history of the Palaski-Salem thrust complex.

**MINERAL RESOURCES SUMMARY**

The Merriam seam, which is the thickest and most laterally continuous seam in the main coal measure in this area, is at the base of the upper member of the Price Formation. Numerous thinner seams occur both stratigraphically above and below the Merriam seam. In addition, a few thin, discontinuous seams are in the uppermost Price and overlying Macerated formations, and these appear to grade laterally into shale over short distances. The number and thickness of coal seams increase to the southwest along Brush Mountain and to the south or southeast in Price Mountain. The Merriam seam consists of about 6 feet (1.8 m) of interbedded coal and shale, of which about 75 percent is dry with a high ash content (Campbell and others, 1925; Stevens, 1959). Stevens estimated that the seam contains about 9561 tons of coal per acre he also noted the occurrence of methane in the coal, particularly adjacent to faults and to a lesser extent when mining below the water table. Approximate mid-out-crops of the Merriam seam in the larger mines are shown on the geologic map; however, most of the smaller mines are believed to have been mined at least down to the water table, and mined-out areas may be more extensive than shown. The Merriam Mine (U2), which was the largest, closed in about 1934 because of a drainage problem (Stevens, 1959) related to the intersection of a stream with the Merriam seam. Instead, the surface data suggest that the coal measures may extend southward beneath the Palaski thrust sheet for a considerable distance (cross section A-A'). Core drilling and/or seismic profile would be necessary to determine the location, thickness, and quality of coal measures beneath the Palaski thrust sheet both north and south of Price Mountain. Stevens (1959) reported that an average of about 50 tons of coal per day was produced from the Northside mine (N3) in 1958-1959, and that smaller operators generally mined an average of less than

10 tons per day. Most of the mined coal was for local domestic use. Known major coal mining operations in the Blacksburg quadrangle include (1) Sprague Price mine (Oxy or Colby mine); (2) Blacksburg Mining & Manufacturing Company mine (Pulaski); (3) Lantana mine (Oxy mine); (4) Lantana mine (Price mine); (5) Kinross mine; (6) Northside Coal Company mine; (7) Old Jack slope; (8) Lykens Coal Company mine; (9) Kops Antelope Coal Company mine; (10) Beckman mine; (11) Lantana Hill mine; (12) Merriam Mine; (13) Merriam Mine; (14) Merriam Mine; (15) Hart Coal Corporation mine; (16) Brantford mine; and (17) an unnamed strip mine. The approximate location and subsurface features of the Merriam seam are shown by Campbell and others, 1925; and (18) Merriam seam at the southern limit of the Merriam Mine. Locations of these and the above 15 coal-mining operations are shown by the corresponding numbers on the geologic map.

Oil & Gas—The Chevron Oil Company (The California Company) drilled the Kops Antelope Coal Company #1 Well (W-62) in 1949 to a total depth of 9340 feet (2848.7 m), where it intersected the Merriam Formation in a 40-foot (12.2 m) gas cross section A-A'. The well was selectively cased, logged and then plugged and abandoned. Data on open file at the Virginia Division of Mineral Resources indicate that about 7000 cubic feet of gas was produced from the well. The well was cased to a depth of about 5220-5580 feet (1592.1-1701.9 m) and 3555-7410 feet (1083.3-2261.1 m). At the latter horizon fractured rocks of the Martinsburg Formation yielded about 50 SCF; however, core analysis indicated 0 permeability and less than 2 percent porosity in the reservoir.

Inasmuch as abundant methane is found in the Mississippian sandstone, the potential exists for recovery of this gas by wells drilled through the Palaski thrust sheet. Likewise, Mississippian sandstones may prove to be a suitable reservoir for gas beneath the Palaski thrust sheet.

Crossed Stone—A quarry (16) in the Elbrook Formation was opened in about 1967 during construction of the U. S. Highway 460 by Pass around Blacksburg. This quarry has been operated by the Adams Construction Company since 1971, and currently produces about 265,000 tons per year. Three other dolomite quarries (17, 18, 19) were opened in the Elbrook Formation and Knox Group for numerous purposes.

Dimension Stone—Numerous small dimension-stone quarries (20-27) are located in the northern part of the quadrangle in the Elbrook Formation and Knox Group. These quarries and limestone from them were used primarily for building on the campus of Virginia Polytechnic Institute and State University. Although none of the quarries is currently in use, several have been, and probably will continue to be operated intermittently whenever the Virginia needs stone. Sandstone was quarried from the Price Formation (28-29), presumably for dimension stone.

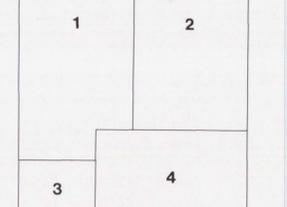
Limestone—Only one attempt was made to operate a lime kiln in this area (30). The quarry is located in steeply dipping, interbedded limestone and dolomite of the Knox Group, and was abandoned because it could not be worked extensively.

Iron—Iron was prospect and mined from residual soils, and from the bedrock, of the Ridgeley Sandstone in the Barringer Mountain area (31-34).

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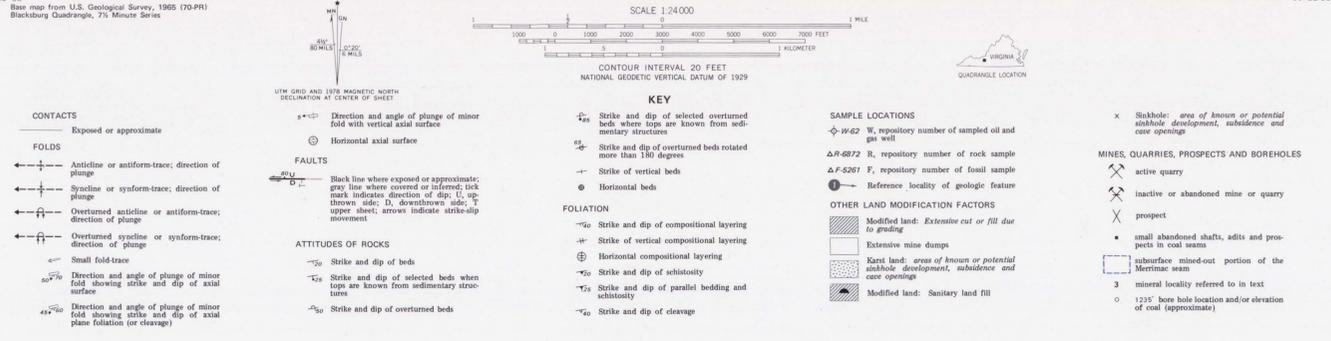
Credit for geologic mapping.



1 - M. J. Bartholomew  
 2 - M. J. Bartholomew and W. D. Lowry; in part modified after G. S. Ritter, 1970  
 3 - M. J. Bartholomew and W. D. Lowry; in part modified after J. D. Hergemodt, 1958  
 4 - F. R. Glass, 1970; slightly modified by M. J. Bartholomew and W. D. Lowry  
 Fossil identification by: G. A. Cooper, W. D. Lowry, C. G. Tillman, Ellis Tscholch

**REFERENCE NOTE**

Portions of this publication may be quoted if credit is given to the Virginia Division of Mineral Resources. The following is the recommended reference form: Bartholomew, M. J., and Lowry, W. D., 1979. Geology of the Blacksburg quadrangle, Virginia. Virginia Division of Mineral Resources Bulletin 14 (GM 81B), text and 1:24,000 scale map.



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 Chemung Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Brainerd Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Millboro Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Newfound Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Unidentified Lower Devonian and Upper Silurian rocks: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Devonian rocks: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Silurian rocks: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Keeler Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Row Hill Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Tuscarora Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Juniata Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.  
 Martinsburg Formation: Dm, light to medium-gray, massive, thick bedded, fine to medium-grained sandstone and siltstone. It is commonly laminated and interbedded with thinly laminated black mudstone. See Campbell and Stevens, 1959, and Stevens, 1959, for detailed information on the Price Formation.

**Geologic and Economic Factors Affecting Land Modification**

**Floodplain**—are the level areas adjacent to streams which are covered by alluvium. Because they are subject to periodic flooding they are generally restricted to agricultural or recreational development. The alluvium is easily removed and may be used as a source of sand and gravel. These excavations, however, are subject to landslides and collapse. Hard calcareous tuff deposits may underlie alluvium along some streams.

**Area of chert rocks**—Mississippian rocks crop out in the Price Mountain window and in the Salville block, north of the leading edge of the Palaski thrust (Figure 1). These rocks consist primarily of interbedded sandstone, siltstone and shale with local occurrences of coal. The land surface is generally rolling to hilly on the eastern end of Price Mountain. In contrast, the deeply dissected, steeply inclined flanks of Price and Brush Mountain are abundant, gently sloping to flat spurs underlain by moderately dipping, resistant sandstone ledges. The top of Brush Mountain is relatively flat although narrow, whereas the top of Price Mountain is a broad, comparatively flat surface underlain by nearly horizontal strata. Soil is typically thin, except where the land surface is gently rolling or flat. The land is forested and suited for farming in only a few places. Residential development should be restricted to spurs and ridges because the narrow, V-shaped valleys may be subject to flash floods during major storms, and because landslides and collapse may occur where steep-sided slopes have been excavated or denuded. Ground water supplies from strata beneath the coal measures may be chemically and bacteriologically unacceptable because the dip of bedrock facilitates infiltration of acid mine waters and because waste effluent from drain fields and septic tanks along the upper slopes is likely to be a source of contamination. Depth to ground water is unknown at higher elevations, but is generally encountered at depths between 50 and 300 feet (15 and 91 m) at lower elevations. Numerous mine dumps and open or caved shafts and adits are along zones where the coal measures occur at the surface known as surface, subsurface, mined-out areas are shown on the geologic map.

**Areas of dolomite and carbonate rocks**—the Barringer Mountain window and areas labeled A (Figure 1) are regions underlain by dolomite and limestone. The dolomite and limestone are thin, shaly, interbedded with some sandstone in the Barringer, Millboro, Martinsburg and Boyss formations, or limestone in the Liberty Hill and Martinsburg formations. Local masses and narrow beds of resistant siliceous quartzite, calcarenite, chert and sandstone crop out on numerous hills and are likely to be encountered in some drill holes, excavations of their beds may require blasting. The land surface in the window is characterized by numerous narrow, steep-sided, flat-topped ridges separated by narrow, low gradient stream valleys that are subject to flooding. Steep slopes may be subject to landslides when excavated or denuded. These hills are suitable for pasture and forestry uses. Residential development should be confined to the more stable flat-topped ridges and spurs. Shallow soil and rapid runoff may require sewage-treatment facilities and an outside water supply.

**Areas of carbonate rocks**—the Salem synclinorium, Christiansburg window, Crab Creek allochthon and area labeled B (Figure 1) are regions underlain by beds of (1) uniformly dipping dolomite and a few thin sandstone ledges of the Elbrook and Copper Ridge formations, (2) dolomite with considerable interbedded limestone in the upper part of the Knob Group, and (3) limestone of the New Market and Lincolnshire formations, and an undivided limestone unit (4). The gently rolling land surface is covered by 5 to 20 feet (1.5 to 6.1 m) of light-brown residual soil which in places contains an abundant amount of gravel- and cobble-size chert and sandstone fragments derived from the underlying bedrock. The early excavated collateral veneer and saprolite ranges from 10 to 50 feet (3 to 15 m) above the bedrock. The saprolite is likely to contain bedrock pinacles and, locally, chert and sandstone ledges and are likely to be encountered in some strata ranges from nearly flat in the northeast corner of the quadrangle to steeply dipping or vertical in the southeast corner. This is suitable for agricultural and residential development, but sewage-treatment facilities are essential for large-scale developments to prevent contamination of ground- and surface-water supplies. Ground water is usually obtained from depths between 100 and 1000 feet (30 and 305 m), and potential for wells of moderate to large yields is present in some areas. Zones of cavernous rock and karst terrain are common, in which the ground water reservoir is very susceptible to contamination from unsaturated surface sources.

**Areas of deformed rocks**—the Blacksburg and Belmont systems and areas labeled C (Figure 1) are regions underlain by chert, complexly folded, faulted and fractured bedrock of calcareous, polygenic breccia, shale of the Rome Formation, and dolomite with interbedded limestone and minor sandstone of the Elbrook and Copper Ridge formations. The gently rolling to moderately dissected land surface is covered by 5 to 20 feet (1.5 to 6.1 m) of light-brown residual soil that in places contains abundant quartzite and cobble-size fragments of chert, sandstone, quartzite and vein quartz derived either from the underlying bedrock and/or from ancient strata deposits. The collateral veneer and saprolite ranges from 10 to 100 feet (3 to 31 m) above the bedrock, but may be as thick as 50 feet (15.3 m) between pinacles of dolomite and limestone. Inasmuch as surficial deposits do not always reflect the type and depth of underlying bedrock, boreholes may be necessary prior to both deep excavations and the erection of large structures. The collateral veneer and saprolite are easily excavated and the land is suitable for horticultural and residential development. Sewage-treatment facilities will be essential for large-scale development to prevent contamination of ground- and surface-water supplies. Ground water is generally encountered at depths between 100 and 300 feet (30.5 and 91.5 m) below ground surface.

**Structures include several generations of folds (reference to light-to-orientation to strongly overturned folds (REFERENCE LOCALITIES 15, 6, 8, 15, 17) more or less generally related to a middle to late Paleozoic phase of Valley Ridge deformation. In this area this event culminated with emplacement of the Palaski thrust and the closely related Salem-Yellow Springs thrust sheets in post-early Mississippian time. The intensely disrupted nature of many of these F2 folds (REFERENCE LOCALITY 8, and the presence of F2 structures in incision zones derived from the decapitated Christiansburg anticline, suggest that thrusting slightly post-dates F2 folding. Hence, the small-scale F2 structures probably developed at about the same time as the Christiansburg anticline, but prior to emplacement of the Palaski thrust. By analogy F2 folds, which are along the leading edge of the Salem fault as well as within tectonic belts associated with the Valley Ridge thrust, can be inferred to pre-date the Christiansburg anticline. The latter rocks, however, are tectonically older than large-scale folds of similar trend in the Salem synclinorium. F1 structures have not been identified within the Salem synclinorium, where F2 folds are gently plunging, north-trending, open to tight folds (mainly local) with steeply southeast-dipping axial surfaces. Northeast of Blacksburg this dominant type appears to be refolded about east-west trending axial surfaces.**

**The Crab Creek allochthon contains strata derived from the southern flank of the decapitated Christiansburg anticline, and probably was emplaced during early movement along the Palaski thrust. In contrast, thrusting along the Palaski fault appears to have terminated with movement along a branch of the fault (cross section A-A') which decapitated the Barringer Mountain structure and probably the Christiansburg anticline (see below the Palaski fault).**