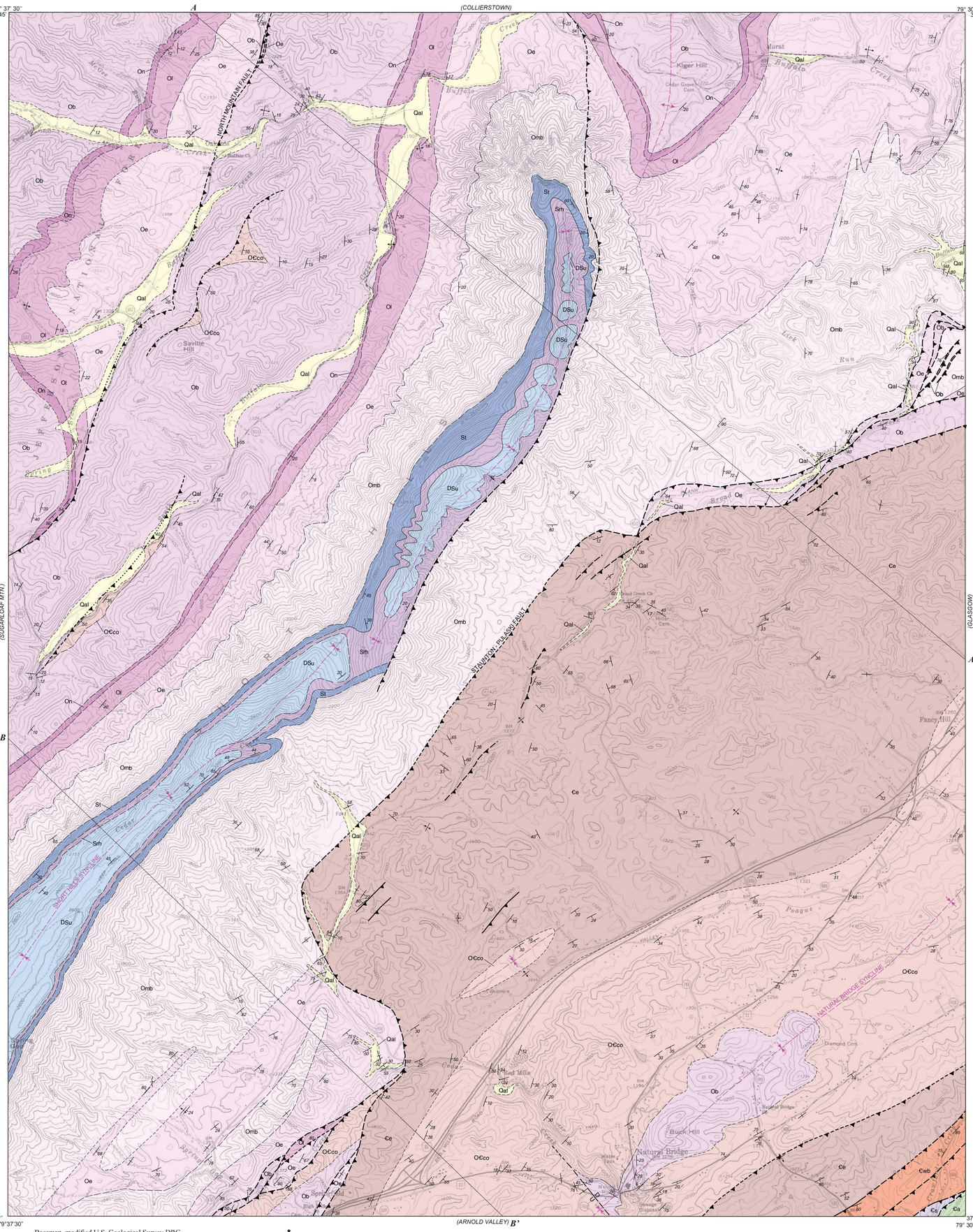
GEOLOGIC MAP OF THE NATURAL BRIDGE QUADRANGLE, VIRGINIA

EDGAR W. SPENCER

2010



Basemap, modified U.S. Geological Survey DRG
1961 Natural Bridge Quadrangle, Virginia

Polyconic projection: UTM zone 17, NAD 1927

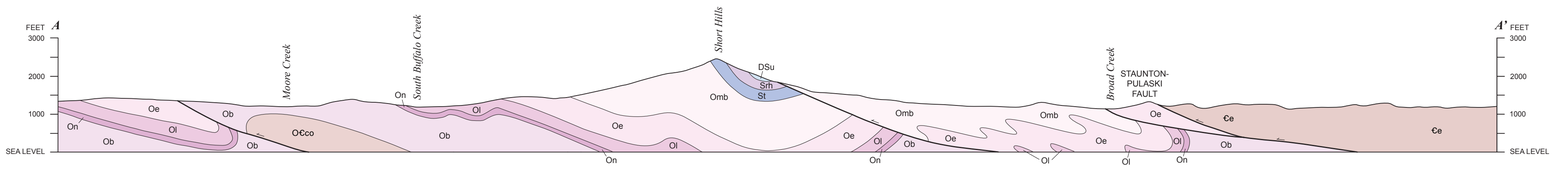
Digital cartography by Peter J. Hof and Elizabeth V.M. Campbell

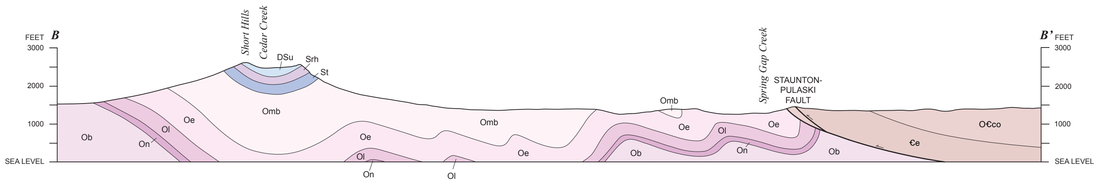
MN GN 8.7° 155 MILS 0°53' 16 MILS
UTM GRID AND 2010 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped from 1966 to 1968
Additional field work from 2008 to 2010





Interpretive cross-section
1. No vertical exaggeration
2. Subsurface structures interpreted from surface measurements

DESCRIPTION OF MAP UNITS

Qal — **Alluvium -** Unconsolidated flood-plain deposits of well-stratified light-brown to light-gray clay, silt, sand, and gravel.

DSu — **Devonian and Silurian Rocks Undivided -** Sandstone and orthoquartzite: Includes the Keefer Sandstone, a white to light-gray, thick-bedded, massive sandstone that forms prominent ridges on Short Hills. Sandstone equivalents of other units in the Upper Silurian and Lower Devonian are present on Short Hills, but no limestones were observed. Thickness ranges from 100 to 200 feet.

Srh — **Rose Hill Formation -** Sandstone: Maroon, medium-grained, hematitic, well-indurated sandstone interbedded with red, green, and gray shale and siltstone. Thickness ranges from 200 to 250 feet.

St — **Tuscarora Formation -** Sandstone and orthoquartzite: White to light-gray, thick-bedded, medium- to coarse-grained sandstone and orthoquartzite with quartz-pebble conglomerate in the lower part of the unit. Thickness ranges from 100 to 200 feet.

Omb — **Martinsburg Formation -** Shale, sandstone, and limestone: Impure, medium-grained sandstone, siltstone, and shale occur in the upper part. Gray to greenish-gray shale occurs in the middle part. Gray fossiliferous limestone interbedded with shale and sections of limestone and shale similar to the Liberty Hall facies of the Edinburg Formation are present in the lower and middle part. Thickness ranges from 1000 to 1500 feet.

Oe — **Edinburg Formation -** Limestone and shale: Interbedded thin layers of black, aphanic limestone and black shale comprise the Liberty Hall facies. Black, aphanic limestones also occur as more massive beds in the formation. See the notes for additional information about the relationship between the Edinburg and Martinsburg Formations in this area. Thickness ranges from 500 to 1200 feet.

Ol — **Lincolnshire Formation -** Limestone: Light-gray, coarse-grained, massive fossiliferous limestone comprises the Murat facies, the most distinctive part of the Lincolnshire. A few sections of the formation resemble the Liberty Hall facies of the Edinburg Formation. Dark-gray, thin-bedded, medium- to coarse-grained limestone-bearing black chert, known as the Whistle Creek Limestone (Cooper and Cooper, 1946), occurs at the base of the Lincolnshire. Thickness ranges from 100 to 250 feet.

On — **New Market Formation -** Limestone: Light dove-gray, aphanic, thick-bedded to massive limestone. Thickness ranges up to 100 feet.

Ob — **Beekmantown Formation -** Dolostone and limestone: Light to medium-gray, medium to very thick-bedded, fine-grained dolostone with distinctive "butcher-block" jointing on weathered surfaces. Black bedded chert and beds of pink to white chert occur within the unit. Limestone similar to the New Market occurs near the top of the unit. Thickness is approximately 1000 feet.

OꞒco — **Stonehenge and Conococheague Formations, undivided -** Limestone and dolostone: Medium-gray, thin to very thick bedded, fine-grained limestone with silty laminae. Medium-gray, medium-grained, calcareously cemented sandstone, and medium-gray, fine- to medium-grained dolostone are also present. The Stonehenge consists of dark-blue-gray to black, fine-grained, massive to thin-bedded limestone with black chert stringers. The Stonehenge is not present throughout the quadrangle. Total thickness is estimated to be about 2000 feet.

Ꞓe — **Elbrook Formation -** Shale, dolostone, and limestone: Light-gray, pink, and greenish shale with lesser amounts of white aphanic limestone, and a few massive layers of dolostone that are often shattered. Algal colonies are present in some of the limestone beds. Thickness is approximately 1000 feet.

Ꞓwb — **Waynesboro Formation -** Shale and limestone: Maroon, greenish, and gray shale interbedded with medium-gray, fine-grained, bioturbated limestone. Some black chert nodules and calcareous dolostone are present. Thickness is estimated to be about 1000 feet.

Ꞓs — **Shady Formation -** Dolostone and limestone: Dark-gray and dark-bluish-gray, fine-grained, thick-bedded with lesser amounts of dark blue-gray, fine-grained limestone and some layers of tan dolostone. Thicknesses of 1000 to 1500 feet have been described in this region.

Ꞓa — **Antietam Formation -** Sandstone and orthoquartzite: White to buff colored, thick-bedded, fine- to medium-grained, cross-laminated with minor quartz-pebble conglomerate. *Skolithos* trace fossils are abundant in some of the thicker beds. The unit forms prominent ridges along the flank of the Blue Ridge. Thickness in this region is between 500 and 600 feet.

NOTES ABOUT THE REVISION OF THE NATURAL BRIDGE QUADRANGLE

The Natural Bridge quadrangle was originally mapped by the author in the 1960's (Spencer, 1968). The updated map contains many improvements that are based upon additional field work. The following notes are intended to clarify some of the field relationships that emerged during the revision.

Alluvium & Colluvium
Colluvium covers both flanks of the Short Hills syncline, making it difficult to establish the contact between the Tuscarora and Martinsburg Formations.

Thick soil covers most of the area mapped as Elbrook on the hanging wall of the Staunton-Pulaski Fault. In a few places, soil containing calcareous cemented sandstone of the Conocheague Formation is present, but exposures are insufficient to accurately map the contact between the Elbrook and Conocheague.

The Natural Bridge
Ideas advanced to explain the origin of Natural Bridge are briefly reviewed in Spencer (1964). More recent studies of the karst features of this area are covered in Stafford and Fratesi (2009).

Staunton-Pulaski Fault
The fault labeled Staunton-Pulaski Fault is also called the Staunton Fault, and Pulaski-Staunton Fault in other publications. It is part of the major thrust fault system that extends from near Staunton, Virginia, into Tennessee. Although actual displacements can not be determined in the field, it is often interpreted as a major plane of displacement in the Southern Appalachians. Locally the Middle Cambrian Elbrook Formation is faulted onto the Middle and Upper Ordovician Edinburg and Martinsburg Formations. Complex structures are shown in the northeast corner of this map. These are southwestern continuations of features indicated on the Glasgow Quadrangle (Spencer, 2000) and previously interpreted as a ramp fragment on the Staunton-Pulaski Fault (Spencer, 1991)

North Mountain Fault
A fault that appears to be the southern continuation of the North Mountain Fault as mapped by Bick (1960) and Wilkes and others (2007) enters the northwestern corner of the Natural Bridge quadrangle. This fault can be traced southwest along the North Fork of Buffalo Creek. Along much of this trace, the Conococheague or Beekmantown Formations are faulted onto the Edinburg Formation, but at the southern end of this trace the fault passes into the Beekmantown Formation and stratigraphic throw becomes indeterminant. This appears to be the southern end of this branch of the North Mountain Fault. Because much greater stratigraphic throw and displacement is present on this fault farther north, it seems likely that the fault in the Natural Bridge quadrangle is a branch of the main fault that lies farther west.

Edinburg/Martinsburg Stratigraphy
Separation of the Edinburg and Martinsburg Formations is especially difficult in the outcrop belt located immediately northwest of the trace of the Staunton-Pulaski Fault. This difficulty extends into the Arnold Valley, Buchanan, Glasgow, and Lexington quadrangles along the trace of the Staunton-Pulaski Fault. Good exposures of this part of the section occur along U.S. Route 11 and along Buffalo Creek in the Glasgow quadrangle and along U.S. Route 60 east of Lexington. In these sections, ten- to twenty-foot-thick intervals of rocks that are lithologically similar to the Liberty Hall facies of the Edinburg Formation as defined by Campbell (1905) and discussed by Cooper and Cooper (1946, p. 55) lie within shales mapped as Martinsburg Formation by Butts (1940), Edmundson (1958), Spencer (2000), and Wilkes (2007).

MAP SYMBOLS

For all contact and fold symbols: lines are solid where the location is exact, long-dashed where the location is approximate; short-dashed where the location is inferred; dotted where the location is concealed. Queries added where identity or existence may be questionable. For geologic observation symbols, observation sites are centered on the strike bar or at the intersection point of multiple symbols.

Contacts

Fault Contacts

Reverse - sawteeth on upthrown block

Normal - U = upthrown block, D = downthrown block

Folds - showing direction of plunge where appropriate

Anticline

Syncline

Geologic Observations

Strike and dip of inclined beds

Strike of vertical beds

Strike and dip of overturned beds

Strike and dip of inclined cleavage

Strike of vertical cleavage

Strike of vertical contorted bedding

Strike of vertical axial surface of minor anticline

Strike of vertical axial surface of minor syncline

Strike and dip of inclined axial surface of minor asymmetric anticline

Strike of vertical axial surface of minor asymmetric anticline, long arrow indicating dip direction of axial surface

Inclined generic lineation or linear structure

Breccia

Complexly folded bedding

PHOTOGRAPHS

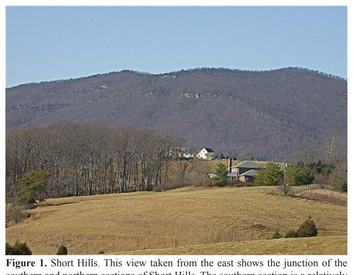


Figure 1. Short Hills. This view taken from the east shows the junction of the southern and northern sections of Short Hills. The southern section is a relatively simple synclinal structure developed in Silurian and Devonian sandstones. The eastern limb of the northern section of the syncline is absent as a result of thrust faulting. The prominent layer in the foreground is the Tuscarora Formation.

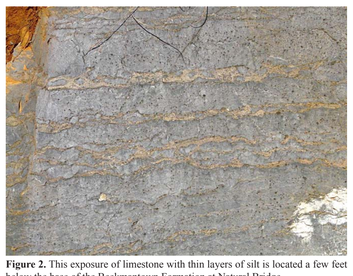


Figure 2. This exposure of limestone with thin layers of silt is located a few feet below the base of the Beekmantown Formation at Natural Bridge.

Figure 3. Complex folds developed in the Liberty Hall facies of the Edinburg Formation. These structures are commonly formed in the thin bedded limestones and shales that occur in the footwall of the Staunton-Pulaski fault.

Many of these sections of black limestone interbedded with shale are so deformed that it is impossible to determine whether they are fault slices or part of a normal stratigraphic section. Because a few of these sections are slightly deformed and look like normal parts of the section, the author concludes that the Liberty Hall facies is interfingered with parts of the Martinsburg Formation. They are mapped as a single unit, Martinsburg. Much thicker sections of fine-grained, black limestone are also present in this region and they are mapped as the Edinburg Formation.

Stonehenge/Conococheague Stratigraphy
The Stonehenge Formation is exposed along the axis of the Natural Bridge syncline. Because a rich soil develops on this unit, exposures are sparse in areas with low topographic relief. While a few exposures of dark blue-gray limestone with black chert are present in this quadrangle, exposures directly below the Beekmantown dolomite on the eastern flank of the Natural Bridge syncline, where State Route 130 crosses the syncline, are limestones with silty layers, a lithology characteristic of parts of the Conococheague Formation. The absence of the Stonehenge is interpreted as an indication that the Stonehenge is discontinuous in this area. For this reason, the Stonehenge has not been mapped separately.

Short Hills Syncline
The Great Valley is only 3.5 miles wide in the Natural Bridge quadrangle and continues to narrow toward the southwest to Buchanan, where it is slightly over a mile wide. The Short Hills syncline forms the first ridge west of the Great Valley in this area. The Short Hills are held up by the Silurian and Lower Devonian section of rocks.

The Short Hills are composed of two synclinal structures that are joined about one half mile north of the place where Cedar Creek flows down the southeastern side of the ridge and continues southeast passing under the Natural Bridge. Both of the synclines are doubly plunging, but they differ in structure. The northwestern limb of the northern syncline dips southeast at a steep angle, and most of the southeastern limb of the structure is missing northeast of Cedar Creek. Although no exposures of the fault breccia have been found, outcrops of Martinsburg shale occur close to large quantities of Rose Hill float and outcrops of the Keefer quartzite. The exposures along logging roads have prompted changes in the mapping shown on the 2007 Rockbridge County map as well as the original map of the Natural Bridge quadrangle. Evidence collected along these roads confirms that the southeastern limb has been faulted out. This fault is thought to be the same fault that is exposed near the northern border of the quadrangle and in the Collierstown quadrangle. Aerial photographs provide the best guide to the outcrop belts on these steep slopes. The lower parts of the slopes are covered by colluvium and landslide debris that originate in the Rose Hill Formation. These surficial deposits cover most of the contacts between the Martinsburg and the Silurian section.

The southern syncline continues into the Buchanan quadrangle where it changes from the single synclinal structure seen in the Natural Bridge quadrangle to several, open, northeast trending synclines and anticlines. This southern syncline is a simple "canoe-shaped syncline" along much of its length, but it appears to be pinched near where Cedar Creek emerges from the axis of the syncline.

Transverse Fault at Southern End of Natural Bridge Syncline
A northwest-trending, high-angle transverse fault cuts across the Natural Bridge syncline a short distance southwest of the Natural Bridge. Evidence for this fault is seen along U.S. Route 11 immediately south of the Natural Bridge. Fault breccias are also found in Cedar Creek southeast of a dam on the creek. The southwest side of this fault is upthrown. Another probable fault zone is present in Natural Bridge Cavern where one of the largest rooms is a straight, high, and narrow passage that has a trend almost parallel with Cedar Creek.

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