Natural Bridge, Virginia: Origin Speculations

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Abstract

Natural Bridge, Virginia is a striking geologic structure, and this paper presents a model for its development within a young earth framework. A brief review of uniformitarian conjectures for the origin of the bridge is given. The latter employ erosion by fluvial processes over long periods whereas the creationist model requires erosion by a large volume of water in a short time span.

Introduction

The Natural Bridge of Virginia is an impressive arch (Figure 1) located in Rockbridge County, Virginia (Figure 2). It is easily accessible being two miles from Interstate 81 or 14 miles southwest of Lexington, Virginia along U. S. Highway 11, which crosses the top of the natural structure. The arch has a thickness of 37 ft. on one side and 45 ft. on the other with a length of around 90 ft. The top of the arch is about 200 ft. above Cedar Creek which flows underneath the bridge (Spencer, 1964, p. 3; 1968, p. 3; 1985, p. 4; Thornburg, 1965, p. 123). Visitors can attend an awe-inspiring evening program viewing the bridge illuminated by various lighting effects with a background of music while the Genesis Creation account is recited.

Figure 1. Natural Bridge, Virginia. People walking under the arch can be used as a scale to judge the immensity of the arch. Note that the strata are horizontal.

History

The initials G. W. have been carved on the wall of the bridge at about 23 ft. above water level. These initials are believed to have been placed there by George Washington in 1750 when he was a surveyor. Two stone markers engraved with Washington's initials and the surveyor's cross have been found nearby. On July 5, 1774, 157 acres of land on which the bridge is located was

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transferred by King George III of England to Thomas Jefferson for 20 shillings. Jefferson referred to the feature as "the most sublime of Nature's work" (Wright, 1936, p. 54). The bridge is still privately owned with a hotel, dining room, visitor center, gift shop, and wax museum and factory on site with Natural Bridge Caverns close-by.

Geologic Setting of the Natural Bridge Region

Natural Bridge is located in the central part of the Great Valley of Virginia which is floored by sedimentary rocks predominately limestones, dolomites and shales (Spencer, 1985, p. 37). This region includes sections of the Blue Ridge and Valley and Ridge physiographic provinces (Spencer, 1964, p. 1). The bridge consists of dolomites and limestones of the Ordovician Beekmantown and Chepultepec Formations (Spencer, 1968, p. 3). See Table I for a brief description of the lithology of these formations.

The Great Valley of Virginia is considered "...one of the major karst regions of the United States" (Thornburg, 1965, p. 120). Several caverns are found in the Shenandoah Valley of Virginia and Natural Bridge Caverns are adjacent to Natural Bridge. Other karst features found in the region are sinkholes, natural tunnels, and sinking creeks (underground streams).

Also as noted by Erikson (2001, p. 199):

> In limestone terrain natural bridges are created in tunnels excavated by groundwater solutions, resulting in a collapse of the tunnel roof. Natural Bridge in Virginia... is the most famous example of this type of bridge in the United States.

Speculations on How Natural Bridge Formed

Thomas Jefferson wrote on the development of the bridge in 1785 stating that "It is on the ascent of a hill which seems to have been cloven through its length by some great convulsion" (as quoted in Wright, 1936, p. 54). Later Frances W. Gilmer accompanied by Jefferson viewed the arch and suggested that since the structure consisted of calcium-containing rocks which readily dissolve in water that the bridge is all that remains of the roof of a former cave (Gilmer, 1818). He conjectured that the waters of Cedar Creek were diverted through fractures and joints in the limestone and dolomites eventually forming an underground passageway which was gradually enlarged until the roof of the natural tunnel collapsed leaving the present Natural Bridge. As expressed by Cleland (1910, p. 327) when discussing the Natural Bridge of Virginia:

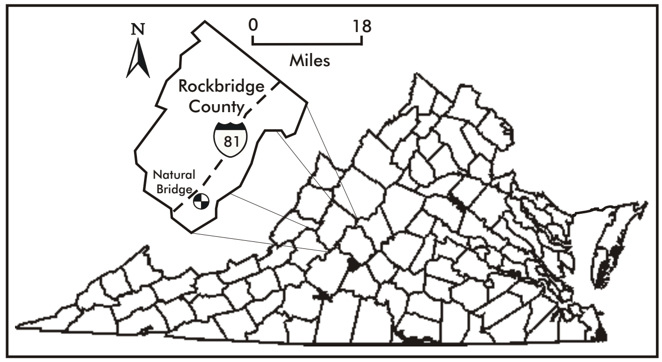

Figure 2. The location of Natural Bridge in Rockbridge County, Virginia.

> In bridges of this character the cavity which later produced the bridge was formed by water percolating through a joint or fissure athwart [across] the stream [brackets added].

All subsequent uniformitarian discussions of the origin of the structure are variations of the Gilmer hypothesis and these ideas will be presented briefly in chronological order.

First, however it is not difficult to convince yourself that the Gilmer theory is reasonable. As you proceed up Cedar Creek from Natural Bridge, you walk along the bottom of a gorge which can be imagined as once having been a tunnel formed by rushing subterranean water, the roof of which collapsed and was carried away or dissolved by the flowing water. Later the walls of the gorge were modified by weathering (Figure 3). As you stroll beside Cedar Creek you hear rushing water in one of the ledges. This sound caused workmen to blast a hole in the ledge around 1812 (Spencer, 1985, p. 4) revealing a stream, called Lost River (Figure 4), flowing through fissures inside the rock. Observing a narrow gorge and an underground stream above the bridge makes it easy to believe the Gilmer concept!

The strata at the bridge are almost horizontal (Figure 1) whereas the layers of limestone in and along Cedar Creek are inclined toward the bridge both upstream and downstream (Figure 5). Thus the bridge is situated at the trough of a downward fold in the strata (i.e., a syncline). Ashburner (1885) suggested that the bridge is a remnant of

Table I. Geologic Formations that Comprise Natural Bridge (after Spencer, 1968, pp. 8, 22, 25)

Formation	Lithology
Beekmantown	Light to medium gray dolomite containing floating sand grains, interbedded with gray to dark blue limestones with chert beds
Chapultepec	Thin bedded to massive gray limestone containing layers of magnesian limestone and massive light gray dolomite containing floating sand grains

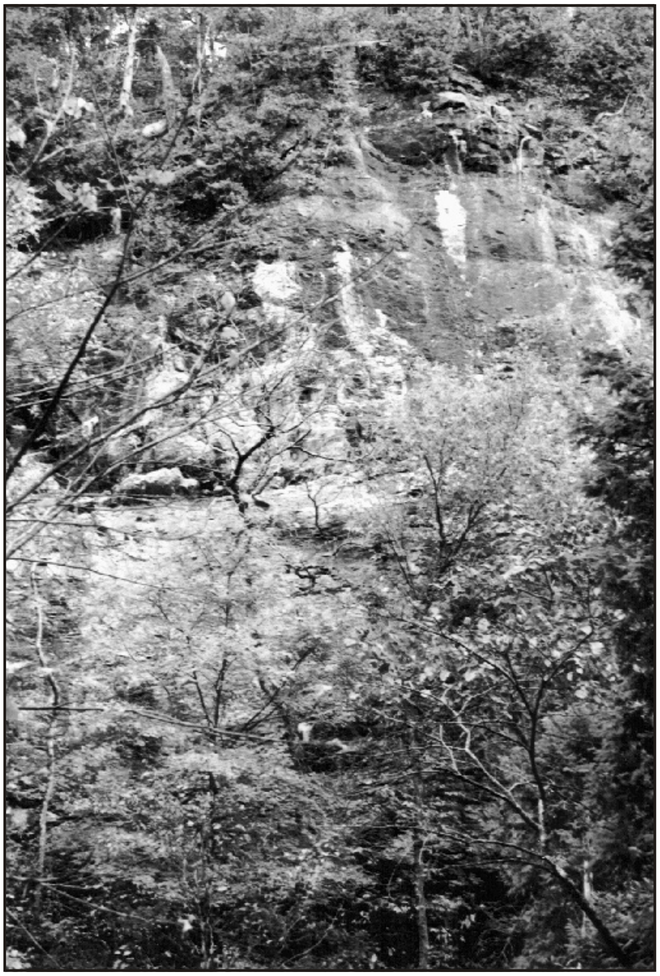

Figure 3. Steep-sided wall of gorge upstream of Natural Bridge, Virginia.

the top of a cave because of its location near the center of a gently dipping syncline, water would not penetrate and dissolve this portion of the strata as rapidly as it would the concave layers above and below the bridge.

Walcott (1893) offered a revised model that was more detailed and somewhat different from the Gilmer concept. Walcott proposed that Cedar Creek deepened the gorge (rejuvenation) from the the James River (Figure 6) to a point below the present level of the top of the bridge where a waterfall existed. Around the same time Cedar Creek developed a subterranean passage in the limestone strata upstream. This tunnel gradually enlarged until all of the water of the creek flowed through it leaving the bridge.

Malott and Shrock (1930) proposed another approach to bridge development. The water in Cedar Creek once flowed into Cascade Creek (Figure 6). Cedar Creek took a sharp turn about 0.25 mile above the present bridge along a meander spur to connect with Cascade Creek. At this sharp bend the water of Cedar Creek began to cut an underground passage into the spur. Cedar Creek formed the subterranean passage while a gorge was developing

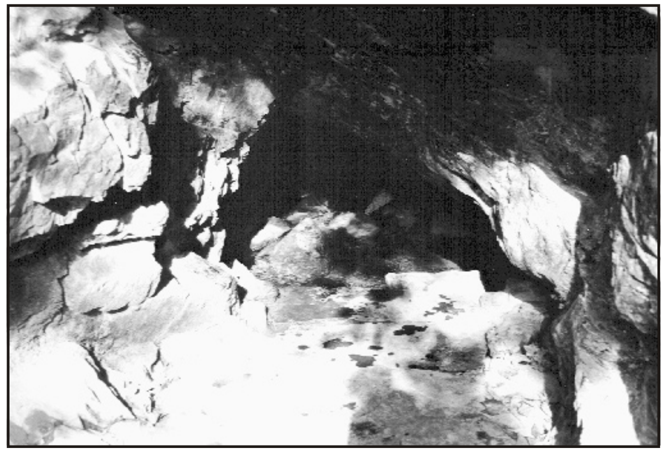

Figure 4. Lost River was revealed when a section of rock ledge was blasted away so that the stream could be observed. Lost River eventually empties into Cedar Creek. It is not known where the source of the stream originates.

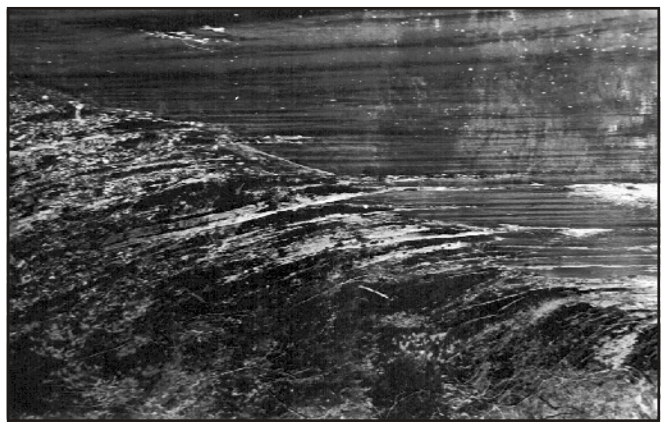

Figure 5. Gently dipping limestone layers in Cedar Creek upstream from Natural Bridge, Virginia.

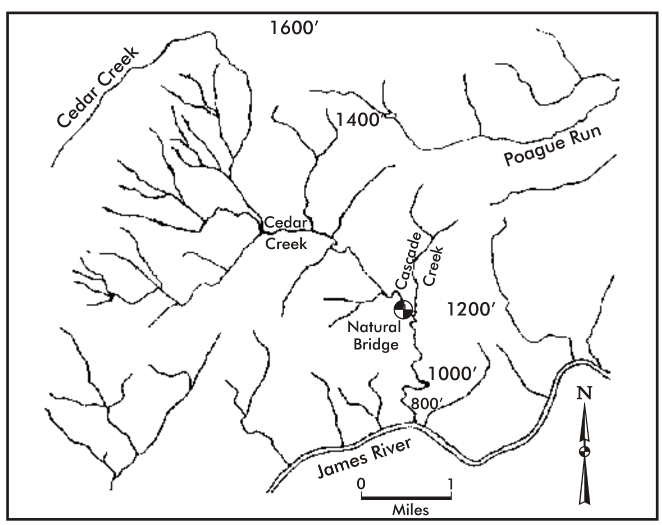

Figure 6. Regional drainage pattern around Natural Bridge, Virginia (after Spencer, 1968, p. 5). The various elevations are noted in feet at certain locations. Natural Bridge is at 1046 feet.

on the lower side of the spur by similar processes. The tunnel roof collapsed along the underground route except where the roof contained massive limestone and dolomite leaving the bridge. This "cutting off" of stream meanders forming natural bridges had been discussed earlier by Cleland (1910, pp. 314–321) by a process he called perforation of the neck of an incised meander. The Malott-Shrock model however involves the development of a longer passageway than would be required to cut off a meander neck. Also there is a height difference between the upper and lower portions of the meander that Cedar Creek breached.

Woodward (1936) and Wright (1936) presented separate, but similar stream piracy models leading to eventual bridge formation. Wright's ideas have been called the sink-piracy model, whereas the Woodward concept involves the "ancestral" waters of Cedar Creek, Cascade Creek and Poague Run (Figure 6). This stream diversion scheme increases the volume of water available to form an underground tunnel.

Most of the previous uniformitarian proposals employ the massively bedded strata at the bridge to explain why the roof of a subterranean passage remains at that point. Moneymaker (1948) observed from his studies in the Tennessee Valley that extensively jointed limestones were more cavernous than less jointed limestones a few miles away. Likewise all of the uniformitarian proposals for the development of Natural Bridge, Virginia feature erosion and dissolution of dolomites and limestones by fluvial processes acting over long periods of time.

Introductory Flood-Young Earth Model for Bridge Development

It is assumed that the deposition of the regional limestones and dolomites occurred during the Flood. It is assumed also that these calcium-containing sedimentary deposits would have set initially similar to the setting of portland cement (Williams and Herdklotz, 1977, pp. 197–198). Since the newly deposited strata were underwater, the sediments would be water-laden and would need time under subaerial conditions to dewater which would cause them to further harden.

As the Flood began to retreat from the region, solution and erosion of the recently deposited limestones and dolomites could have formed a phreatic tube (underwater solution cavity) [Williams and Herdklotz, 1977, pp. 193, 197–198; 1978, p. 88] along the synclinal fold as water easily penetrated the sloping layers of limestone. Eventually the decreasing Flood water level would be close to the top of the ridge. The phreatic tube would become a preferential flow path for the retreating water with the upper opening of the tube acting like a sink hole. If this circumstance developed, the exiting water would cease to erode or dissolve the upper ridge surface leaving an arch intact. The gorge would form rapidly "upstream" and "downstream" as the water flow through it would cause the roof to collapse with the debris being swept away by the rapid water flow. Water would funnel through and under the arch of the bridge where the massive limestone at that location would resist extensive widening.

The major erosional process at this phase would be downcutting as gorge development would follow the ever decreasing water level toward the "ancestral" James River, likely a major Flood retreat channel (See Froede, 1994, p. 192 [Figure 7] for a miniature natural bridge formed in Georgia by similar processes as I have described.) The exposed sediments would begin to dewater and likely cliff sapping (Austin, 1994; Froede, 1996) would occur along the gorge widening it in places with the debris being washed away or dissolved in the rapidly-flowing water. The regional drainage pattern observed at the present time eventually would be established with the underfit Cedar Creek flowing beneath the bridge. This view of the development of Natural Bridge, Virginia depends upon considerable available water (Flood conditions) allowing the structure to be formed in a short period of time. The entire erosional process could have begun in the late phases of the Flood and continued possibly into the post Flood period.

Appendix: Geomorphic Models

My suggested model for bridge and canyon (gorge) development is one of many possibilities that could be suggested. The model appeals to the karst features in the region. The possibility of canyon formation in limestones in Trans-Pecos, Texas has been discussed previously (the lower portion of Santa Elena Canyon, Big Bend National Park [Williams and Howe, 1996]) and Contrabando Canyon (Williams, 1997) by processes of cave development and roof collapse. All models such as these are subject to revision or entirely different conjectures could be offered for canyon and bridge formation.

Recently Michael Oard (2001a; b) proposed an all-encompassing geomorphic model for the formation of canyons, water gaps, pediments, etc. in relation to the Flood. He did not include natural bridges or karst features in his model. General models often ignore local geomorphic features in various regions. Hopefully Oard will integrate other geomorphic structures into his model in the future. It would be worth the effort and I would enjoy reading the extension of his postulations into other regions.

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