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THE GEOLOGY OF NATURAL TUNNEL STATE PARK

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INTRODUCTION

Natural Tunnel is one of the great natural wonders of Virginia and indeed of the world. The spectacular rock ampitheatres, which rise steeply above the waters flowing through the tunnel, were formed by the forces of nature eroding and dissolving the rock over many thousands of years. The tunnel is nestled, half hidden, in the scenic beauty of Southwestern Virginia, and its mode of origin has stirred the imaginations of naturalists and geologists since it was first described.

Natural Tunnel was named by Lt. Col. Stephen H. Long, when it was visited by him in the summer of 1831 (Long, 1832). The tunnel, located near Duffield, Scott County, Virginia, is preserved today as one of the Commonwealth's state parks. This report provides a general overview of the geologic setting of the park area and specific descriptions of the major geologic features of the park. Visitors should obtain permission from local landowners should they wish to study geologic features outside of the park.

TOPOGRAPHY

Natural Tunnel State Park lies within the Appalachian Highlands in southwestern Virginia. This part of the Appalachian Highlands consists of four major physiographic provinces; from east to west, the Piedmont Plateaus, the Blue Ridge, Valley and Ridge, and Appalachian Plateau (Figure1). The park is in the Valley and Ridge Physiographic Province, a region characterized by long, parallel ridges separated by narrow, deep valleys. The topography of the Valley and Ridge reflects the relative differences with which the inclined layers of rock of the region are eroded. The more resistant rock layers stand in relief as ridges or mountains, whereas the weaker layers are carved into valleys by the forces of nature (Figure 2).

To the northwest of the Valley and Ridge lies the Appalachian Plateaus Physiographic Province. The Plateaus contain the vast Appalachian coalfields that extend from Pennsylvania to Alabama. Coal is king in this part of the Appalachians and, indeed, is the principal mineral resource of the region.

To the southeast of the Valley and Ridge, billion-year old crystalline rocks, mostly granitic in nature, underlie the peaks

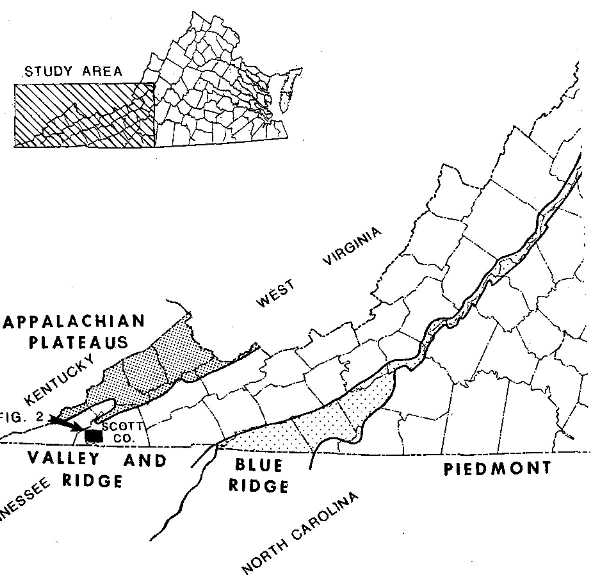


Figure 1. Physiographic regions of Southwestern Virginia.

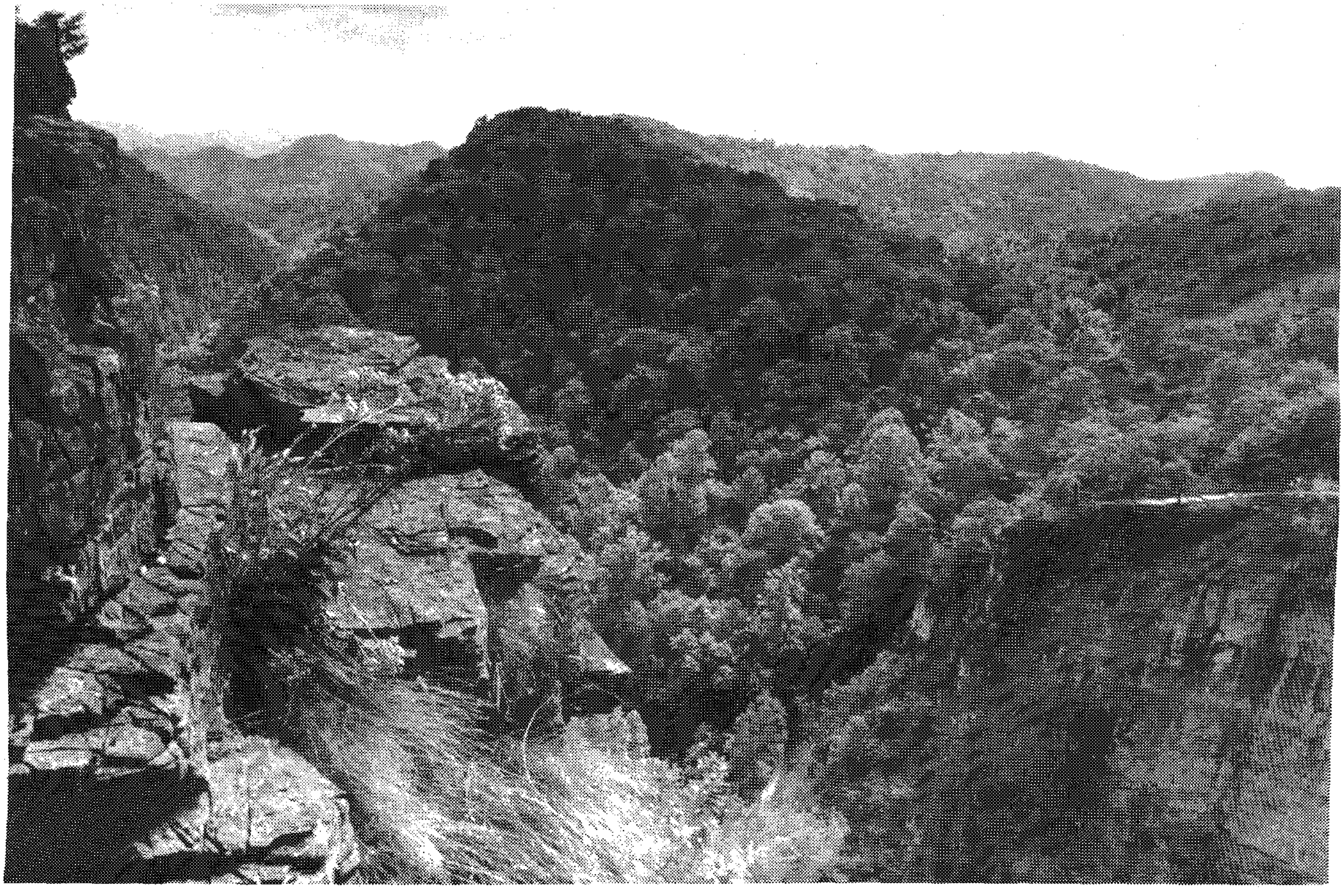


Figure 2. View of ridge and valley topography, looking south of tunnel. Stock Creek Valley is in upper left; south portal ampitheatre is in lower right.

of the Blue Ridge. In Virginia, the mountains of the Blue Ridge generally attain elevations that are about a thousand feet higher than the mountains in adjacent physiographic regions.

DRAINAGE PATTERNS

A multitude of tributaries in the headwaters of the Tennessee and New Rivers have been carving a rugged mountainous terrane into this part of the Appalachian Mountain chain since its creation before Mesozoic dinosaurs walked the earth. In general, the drainage pattern of the Appalachian Valley and Ridge is trellis-like and is called trellis drainage by geologists (Figure 3). This pattern reflects the topography of the region, which in turn is controlled by the underlying sequence of resistant and non-resistant strata. In trellis drainage, the master streams flow across the regional trend of the mountain ranges, whereas their principal tributaries generally follow the linear valleys formed by selective erosion of relatively weak strata.

GEOLOGIC TIME

The strata of the Appalachian Valley and Ridge are Paleozoic in age. The Paleozoic Era lasted from about 570 to about 225 million years ago (MA). The beginning of the Paleozoic Era is marked by the occurrence of abundant invertebrate life that possessed parts capable of preservation in the ancient shallow seas that then flooded much of the earth's continents. The remains or impressions of these animals commonly are preserved within the rocks as fossils. The Paleozoic Era is divided into seven geologic periods, based chiefly upon the life forms, or fossils, contained within stratified rocks (Table). The characteristic suites of fossils that occur in the rocks deposited during each of the Periods enable paleontologists and geologists to correlate strata, geologic events, and hence the history of the earth, worldwide. In eastern North America, Paleozoic rocks contain a multitude of marine invertebrate fossils, and some fossils of the fishes, amphibians, and relatively small reptiles that lived in the shal[illegible]tinental seas or on adjacent lands. The simple pla[illegible]loped in the early history of the earth evolved thr[illegible]aleozoic Era. At first, plants lived only wit[illegible]t seas. Primitive plant life gained a rootho[illegible]g the Silurian Period, about 435 million [illegible]volved slowly and progressively into the di[illegible] plant forms so characteristic of the grea[illegible]orests, swamps, and marshes of the Pe[illegible]rmian Periods, 320-245 MA.

TABLE. Major stratigraphic units in the Natural Tunnel area and geologic time scale (Pennsylvanian and Permian Periods of the Paleozoic Era and the Mesozoic Era are not represented by strata in the Natural Tunnel area).

EON	ERA	PERIOD/ EPOCH	FORMATION	SYMBOLS ON MAP AND CROSS SECTION	AGE MILLIONS OF YEARS AGO (MA)
PHANEROZOIC	CENOZOIC	HOLOCENE / PLEISTOCENE	*Unnamed Alluvial And Colluvial Deposits On Floodplains, In Terraces, And In Fan Deposits	t f	1.6
	PALEOZOIC	MISSISSIPPIAN	Pennington Group	Mu	320
			Newman Limestone		
			Maccrady Formation		
			Grainger Formation		360
		DEVONIAN	Chattanooga Shale	Du	
			Wildcat Valley Sandstone		408
		SILURIAN	Clinch Sandstone, Rose Hill, And Hancock Formations	Su	438
		ORDOVICIAN	Numerous Limestone And Shale Formations	Ols	
			*Knox Group And Maynardville Limestone	€Od	505
		CAMBRIAN	Nolichucky, Rogersville Shales	€sh	
			Maryville, Rutledge Limestones	€ls	
			Rome And Pumpkin Valley Formations	€ss	
			Shady Dolomite		
			Chilhowee Group		570
PROTEROZOIC			Ocoee Series		1,000
			Grenville "Basement" ?		
ARCHEOZOIC					

* Formation exposed at Natural Tunnel.

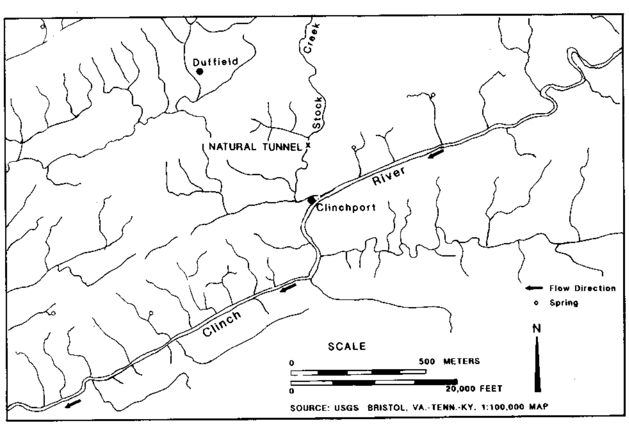


Figure 3. Trellis drainage in the Natural Tunnel area.

THE ROCKS

The rocks of the Natural Tunnel State Park area are classified as sedimentary; i.e., they were formed from the particles and precipitates that had accumulated within a great basin of deposition that at one time extended along the length of the Appalachian Mountains. The sedimentary rocks of Natural Tunnel State Park and surrounding area may be divided into two broad types, those comprised chiefly of carbonate minerals (carbonate rocks) and those comprised mostly of clay and quartz (siliciclastic rocks). In general, the carbonate rocks were formed by the chemical and organic precipitation of lime and from particles derived from the abrasion of these materials within a local basin of deposition. These particles do not come from distant sources. A major carbonate rock type, dolostone, consists principally of many small crystals of the mineral dolomite ($CaMg(CO_3)_2$). The rock, limestone, is comprised mostly of the mineral calcite ($CaCO_3$). Limestone and dolostone commonly contain impurities, either chemicals bound up in the crystal structure of the carbonate minerals, or non-carbonate materials, such as clay, silt, and sand, that are intermixed with the calcite or dolomite minerals within the carbonate rock.

The siliciclastic rocks of Natural Tunnel area were formed chiefly from a variety of clay minerals and quartz, commonly with minor amounts of mica and feldspar that were derived from the erosion and fragmentation of older rocks and sediments. Once formed, the particles were transported either by wind or running water to their places of accumulation in and near the ancient seas that flooded the continent during the Paleozoic Era. A few strata contain rock fragments derived from the older formations that were exposed and eroded at the earth's surface. Other strata contain an abundance of carbonaceous or bituminous material derived from the incorporation of the organic remains of the plants and animals that existed when the sediments were being deposited.

Transportation by water or wind commonly separates, or sorts, sedimentary particles into sizes that reflect their ease of transportation. Heterogeneous mixtures of sediment, thus, are separated by wind, running water, and gravity into clay, silt, sand, pebble, cobble, and boulder sizes. As they are buried more and more deeply within the earth by the accumulation of subsequent deposits, the sediments are compressed and dewatered, heated, and turned into stone (lithified). Pores between sedimentary grains commonly are filled with calcite or silica that has precipitated from fluids contained within or migrating through the sedimentary layers. Under certain geologic conditions these pores may contain oil or natural gas, and the sedimentary strata may be suitable as source beds or reservoirs for these hydrocarbons. In general, the siliciclastic rocks thus formed are called shale or mudstone, siltstone, sandstone, and conglomerate, depending upon the sizes of the particles they contain.

THE STRATA

About 10,000 feet of Paleozoic strata comprise the geologic section in the Natural Tunnel area. These strata have been divided into approximately 50 formations, or mappable units, by the geologists who have worked in this area (Harris and Miller, 1958; Brent, 1963). Only the major geologic units are listed in the Table.

The strata of one of these geological units, called the Knox Group, underlie all of the area of the Park. In this area the Knox Group, which was named from exposures at and near Knoxville, Tennessee, is about 2000 feet thick. These strata consist chiefly of dolostone, generally colored in shades of gray but with some beds mottled grayish-red.

Impure gray-colored amorphous silica, called chert or flint, occurs in irregular bands or nodules in some rock layers. This type of chert probably formed as a precipitate upon the ancient sea floor and subsequently was incorporated within or replaced the carbonate strata. In contrast, irregular yellowish-gray lumps or masses of chert have accumulated in the residual clayey soils forming above the Knox during the current cycle of weathering and erosion. Because they are more difficult to erode than relatively pure clay soils, chert-bearing soils commonly underlie rounded hills of low to moderate relief.

Some formations within the Knox Group contain fine-grained gray limestone beds, and these beds are used as "markers" by geologists for the subdivision of the Knox into mappable units. In places within the Knox, "markers" of sandy dolostone or sandstone occur interlayered with the carbonate strata. These siliceous layers are relatively resistant to erosion and, consequently, tend to underlie some of the higher topography in the park area.

In general, the dolostone beds in the Knox are thick bedded and fine to coarse grained. The crystalline, or sugary, texture of much of the Knox appears to have developed shortly after the carbonate sediments were deposited and as the result of chemical reactions of lime muds, silts, sands, and conglomerates with impure circulating waters. Fossils of algae are relatively common in the Knox and appear in the rocks as evenly layered laminae, wavy or hemispherical laminations (stromatolites), or as irregular, clotted masses (thrombolites). Fossils of invertebrates are not common and are preserved mainly in chert or in relatively unaltered limestone beds. Gastropods (snails) inhabited the Knox seas in abundance, where they very likely grazed upon the "algae of the day," and they are one of the more common invertebrate forms preserved within the strata of the Knox Group.

ORIGIN OF NATURAL TUNNEL

Woodward (1936) postulated that Natural Tunnel is the uncollapsed remains of a large cave system that once extended northward to the vicinity of Horton Summit—an hypothesis not supported by the geologic evidence available to us today. Instead, Natural Tunnel was formed by the preferential solution of carbonate rock along a greatly fractured fault zone as the landscape was lowered by erosion during the past million years or more.

Natural Tunnel (Figure 4) and the creek that flows through it, Stock Creek, are aligned along a zone of structural weakness that occurs between the gently folded Rye Cove syncline (downfold) on the east and the more tightly folded Purchase

Figure 4. South portal ampitheatre of Natural Tunnel. Glenita fault is exposed [illegible] railroad track in lower right of portal.

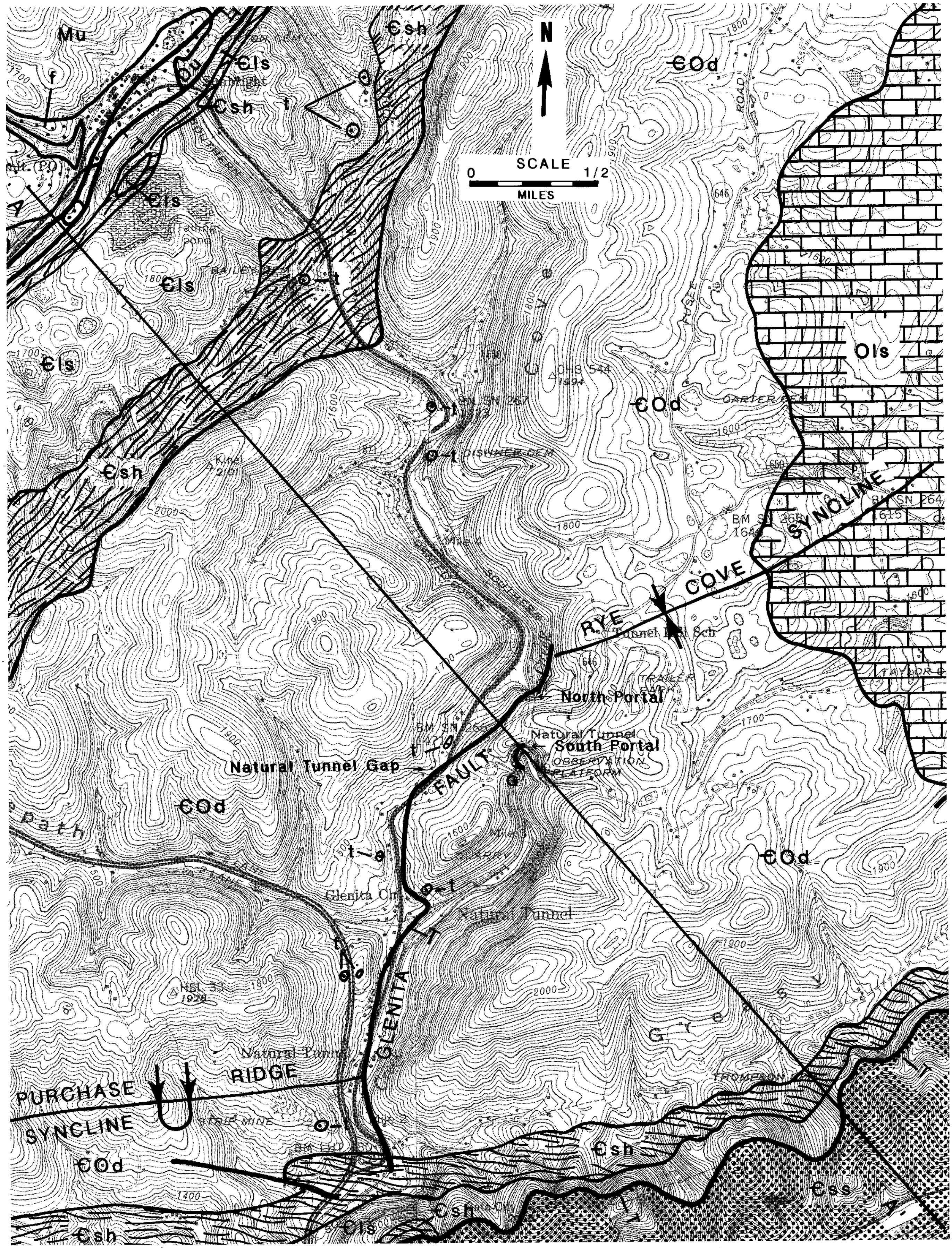


Figure 5a. Generalized geologic map of the Natural Tunnel area. Geology adapted from detailed geologic maps by Brent (1963) and Harris and Miller (1958).

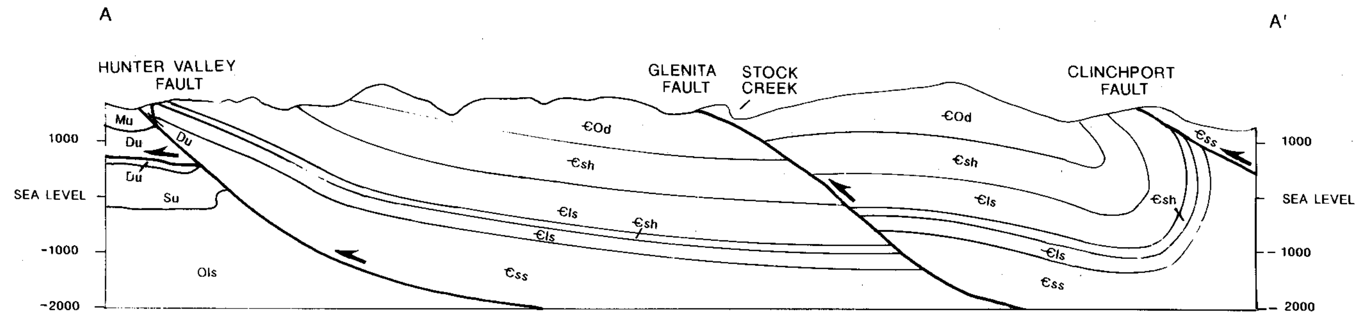
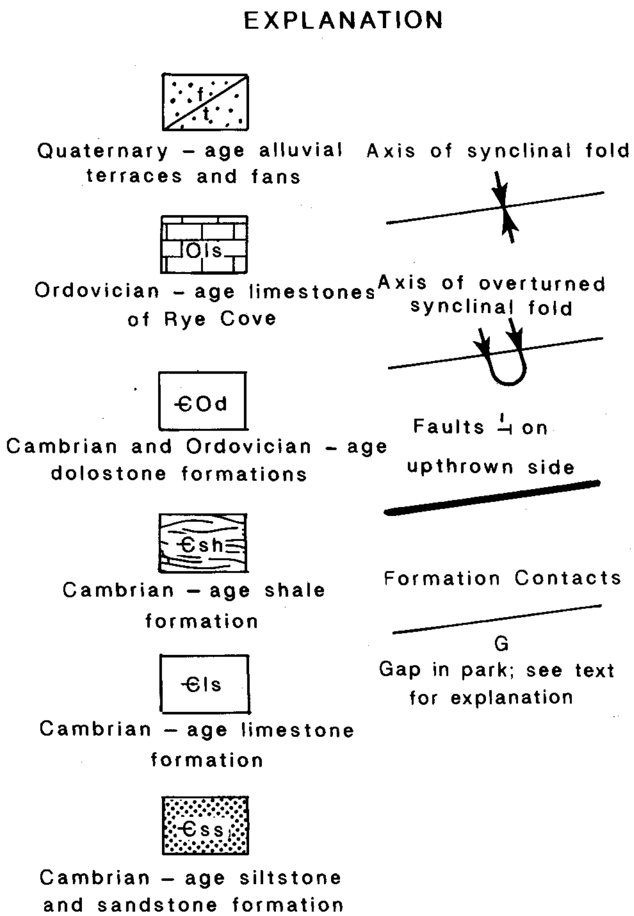


Figure 5b. Cross section A-A', Figure 5a. Scale in feet; no vertical exaggeration.



Ridge syncline to the southwest (Figure 5a). This zone, called the Glenita fault, was mapped by geologists from the town of Natural Tunnel (Glenita) through Natural Tunnel gap along State Route 871, and beneath Natural Tunnel. Folded and faulted carbonate rock may be seen in both the south and north portals of the tunnel where the fault passes beneath it. Because of the many fault-induced fractures, circulating ground waters are better able to dissolve the deformed rocks along this fault zone than they are to dissolve the adjacent undeformed carbonate rocks, which are less accessible to groundwater.

The erosional history of the Natural Tunnel area is long and complex. Both the valley of Stock Creek and Natural Tunnel have been formed by erosion (wearing away) and solution (dissolving) of the ancient Paleozoic bedrock that underlies the area. At present, there is little geological information in this area that can be used to provide numerical dates for specific events in the recent geologic past. The generalized sequence of events which gave rise to present-day landforms, however, can be deduced from the available geologic data.

In essence, Natural Tunnel was formed by the subterranean capture of a surface stream, the precursor to Stock Creek, which at one time flowed over the area of Natural Tunnel Park (Figure 6a). This stream bed is known to have had a minimum elevation of 1471 feet above sea level, the current elevation of Natural Tunnel gap, through which it once flowed (Figure 5a). A couple of miles to the south of the tunnel, isolated patches of high level terraces consisting of red soils and quartz grit and pebbles attest to the existence of an ancient stream at elevations of a little less than 1500 feet.

The diversion of Stock Creek's upper reaches into the subterranean cavern that eventually would become Natural Tunnel apparently took place many tens of thousands or perhaps even many hundreds of thousands of years ago, along solution-enlarged fractures associated with the Glenita fault. It is likely that, over a period of time, a large sink (doline) developed in the area of the north portal, with its rim approximately 300 feet above the present valley floor. Water entered the sink, descended underground approximately to the present level of Stock Creek or below, and then flowed southward to where it emerged near but above the south portal, rising from the depths as a large spring. As the capacity of the sink increased by progressive enlargement of the underground passageways, surface waters were diverted more and more through the subterranean channel (Figure 6b). With continued downcutting, Stock Creek rapidly became incised into a steep-sided valley below the tunnel. Above the tunnel, a slightly broader valley was formed as headward-retreating cascades and rapids were carved into carbonate rocks and shales by the rapidly flowing waters of Stock Creek that were laced with abrasive grains of quartz sand and gravel.

An early period of downcutting of Stock Creek might have taken place between periods of continental glaciation during the Pleistocene Epoch, when the climate was relatively mild so that colluvial materials on hill sides and mountain tops were relatively stable, and when streams very likely flowed upon bedrock as they do today. Subsequently, perhaps under late Pleistocene periglacial (cold climate) conditions, Stock Creek Valley was filled with extensive alluvial deposits

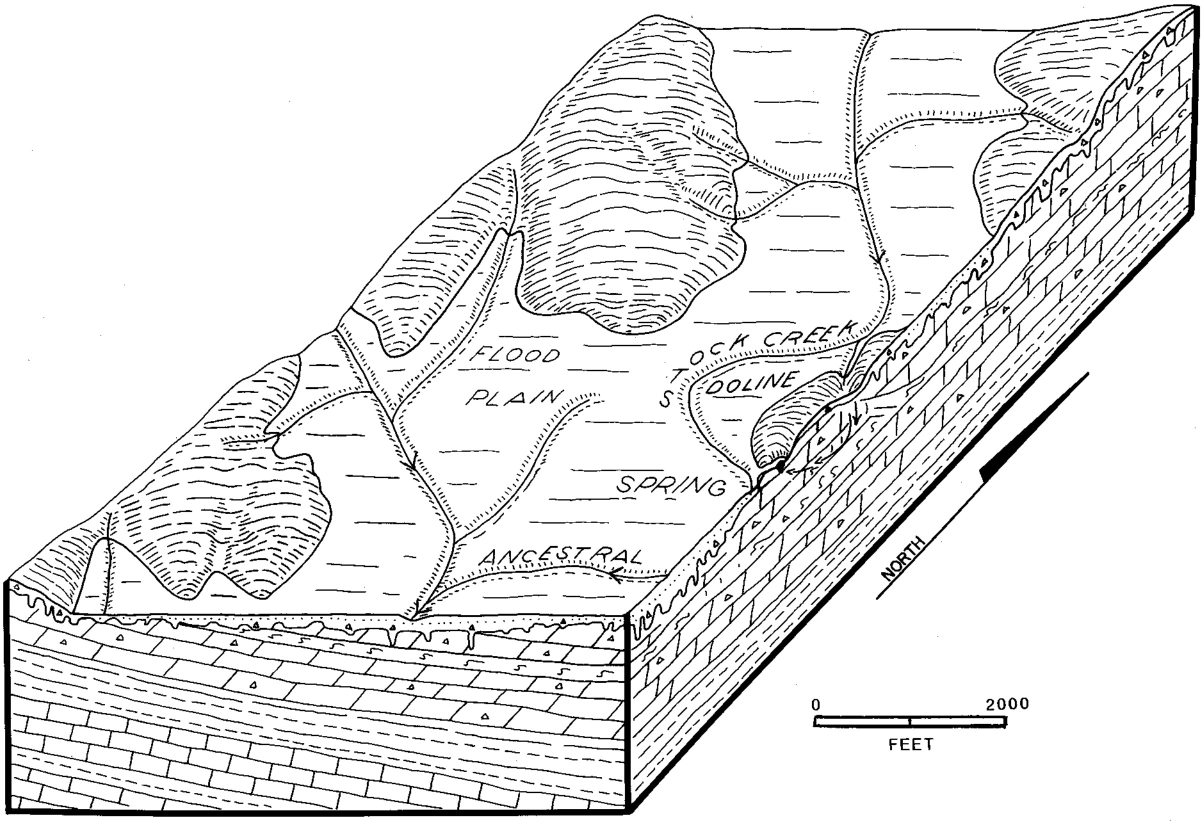


Figure 6. Block diagrams illustrating the development of Natural Tunnel. In cross sections dots represent alluvium, triangles represent cherty residuum, dolostone by , shale by —, limestone by , deformed rock of the Glenita fault zone by . Note very irregular top-of-rock interface with overlying surficial material. a. High level flood plain of ancestral Stock Creek. In side cross section, solution - enlarged fractures associated with the Glenita fault zone divert part of the drainage underground, southward to where it emerges as a large surface spring; time is earliest Pleistocene or older. Arrows show direction of water flow.

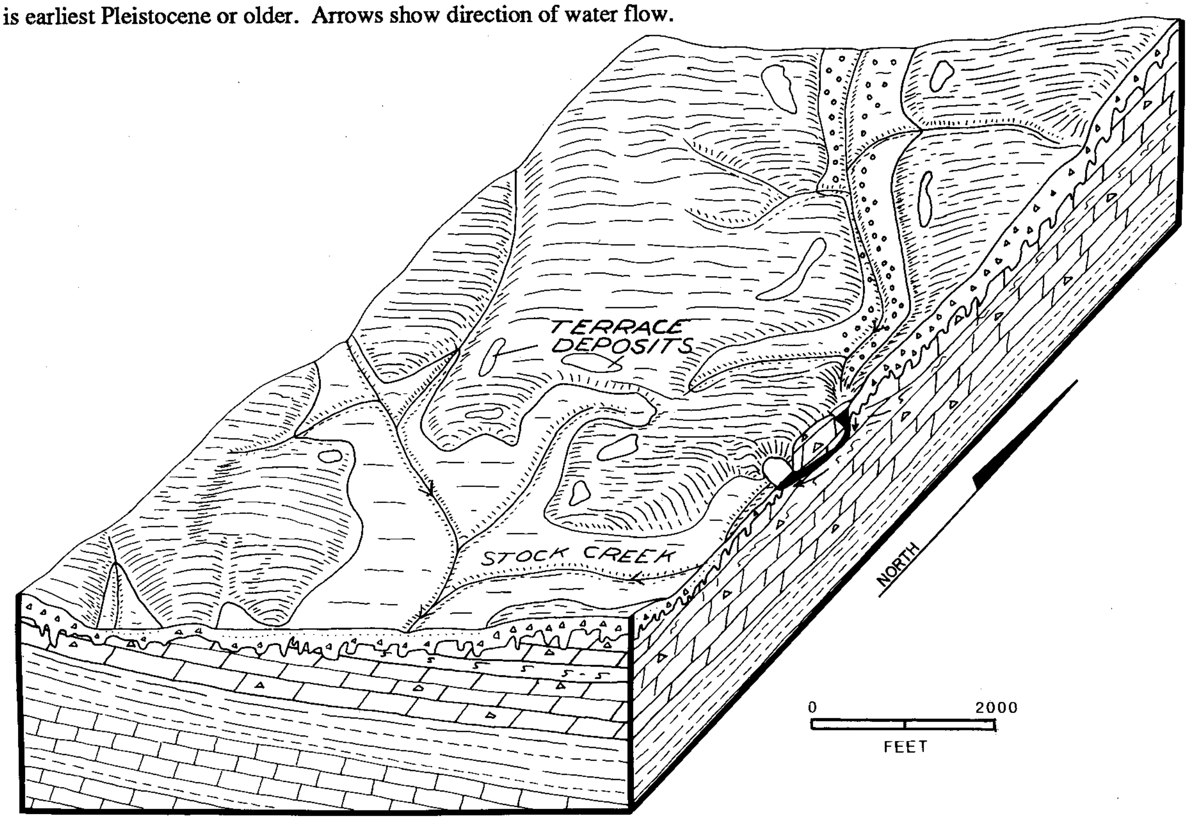


Figure 6 b. At a later time, drainage is at a lower level because of the progressive erosion of the topography. Flood plains are more restricted; underground drainage through the tunnel is well established now; cobbles and boulders are deposited on the flood plain of upper Stock Creek under periglacial climatic regimes; if the underground passage way becomes clogged with sediment and debris, a lake may form, with the roof rocks of Natural Tunnel acting as a barrier to the southward flow of water; except for remnants, the higher level terraces are being eroded. South portal ampitheatre develops as a steep-sided spring.

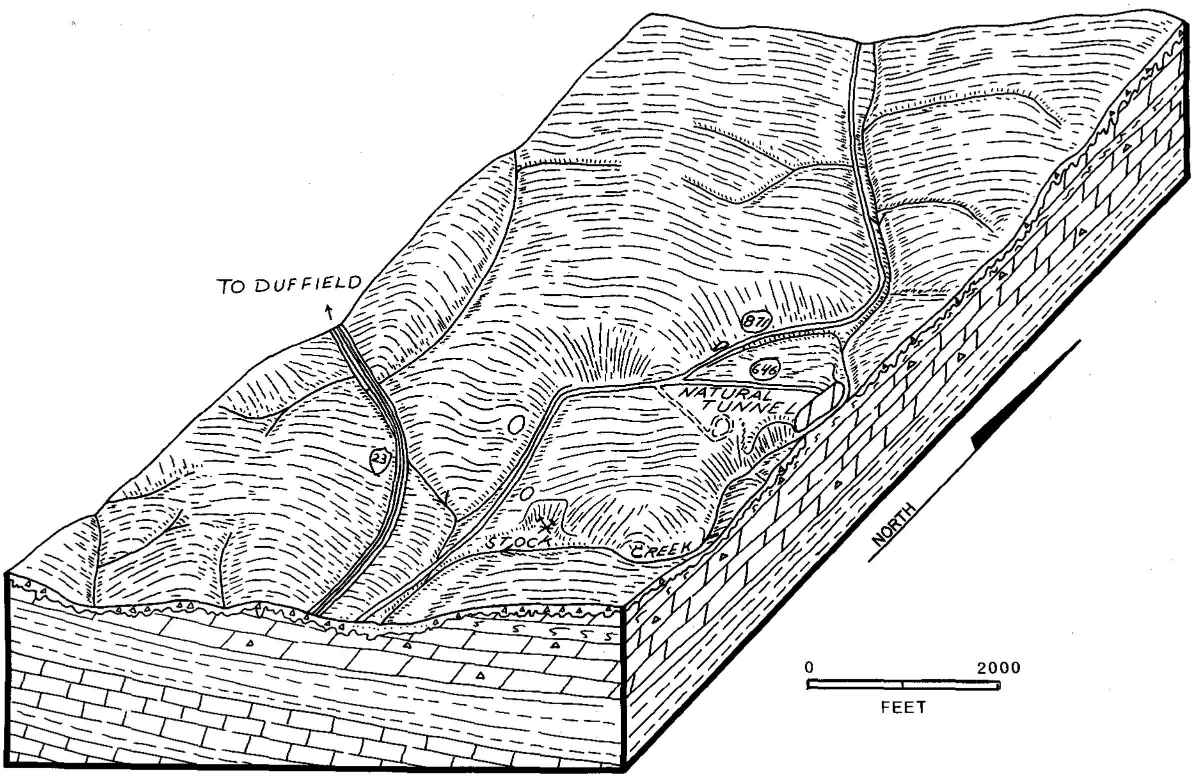


Figure 6 c. Current topography.

comprised of particles ranging in size from clay to cobbles and small boulders as hillsides and mountain slopes were stripped of their colluvial cover by the effects of the more austere periglacial climates (Figure 6b). Flood plains built upward and spread out rapidly as streams were clogged by the sedimentary debris that was being swept from the mountainsides. Remnants of these ancient deposits now are preserved upstream from Natural Tunnel as isolated terraces on small hills generally 60 to 80 feet above the present valley floor. The projected base of these terrace deposits slopes downstream at the approximate gradient of Stock Creek but at elevations that would intersect the bedrock in the roof of Natural Tunnel 50 feet lower than the Natural Tunnel gap. Accordingly, the outlet for the water that transported these coarse-grained deposits was either underground, through the tunnel, or over the gap if ponded drainage created a lake. In the latter case, bedrock in the roof of the tunnel would have served to block the southward flow of Stock Creek. When the subterranean outlet for Stock Creek was plugged with sediment or was not able to transmit water at a rate sufficient to drain upper Stock Creek valley, the upper Valley flooded and at times was filled to the brim with sediment containing quartz pebbles and quartzite cobbles, all apparently derived from the strata of Mississippian and Pennsylvanian age which are exposed in the mountains a few miles to the north. At times, this sediment may have been transported over Natural Tunnel gap; remnants of ancient stream deposits are preserved at elevations of about 1440 to 1470 feet a half-mile to the south of the gap on both sides of Virginia Road 871 near Glenita Church (Figure 7).

In modern times, the north portal of Natural Tunnel has become enlarged sufficiently by downcutting, solution, and roof breakdown to accommodate the flow of Stock Creek without any present threat of damming. A change in climate, however, perhaps similar to late Pleistocene periglacial conditions, could cause Stock Creek to change from its current downcutting mode to one of aggradation. Should the bedload of Stock Creek increase above its capacity to transport the increased amount of sediment efficiently, the sediment would be dropped on its flood plain. Then the flood plain would build upward and outward, perhaps filling the north portal of Natural Tunnel, thereby restricting flow through the passageway, or perhaps even blocking the tunnel once again.

SOUTH PORTAL AMPITHEATRE

A spectacular semicircular ampitheatre, comprised almost entirely of carbonate rock, towers above Stock Creek where it emerges from Natural Tunnel. In gross appearance the ampitheatre resembles that of a large cap-rock waterfall. In cap-rock falls, relatively resistant or tough strata constitute the resistent cap over which a stream falls, whereas underlying softer and more erodible strata occupy the lower part of the ampitheatre. Under suitable conditions, such falls migrate headward chiefly by the preferential removal of the substrate and subsequent collapse of the unsupported cap. Eventually the falls decay into a series of cascades or rapids.

In the case of Natural Tunnel ampitheatre, there is little difference in the relative erodibility of the strata from the top to the bottom of the ampitheatre—and hence no cap rock. The strata consist almost entirely of carbonate rock, with minor amounts of sandstone and sandy dolomite. In the not too distant past, however, ancestral Stock Creek flowed through the upper elevations of the future park site, through the gap (G on Figure 5a) now located between the chair lift and superintendents residence, and then descended cascade-like into the gorge below. The evidence for this interpretation is that a small part of the bed load of ancestral Stock Creek, consisting of pebbles, gravels, and small cobbles of far-transported quartzite, is mixed with angular cobbles and small boulders of locally derived carbonate rock in the colluvial regolith on the steep slopes below the gap.

In the even more distant past, ancestral Stock Creek may have plunged over the upper part of the amphitheatre when ancestral Stock Creek stood at a much higher level and when its underground outlet through the tunnel was plugged. The main part of the present amphitheatre is swept clean of sediment, however, and there no longer remains any direct evidence of an ancient waterfall there.

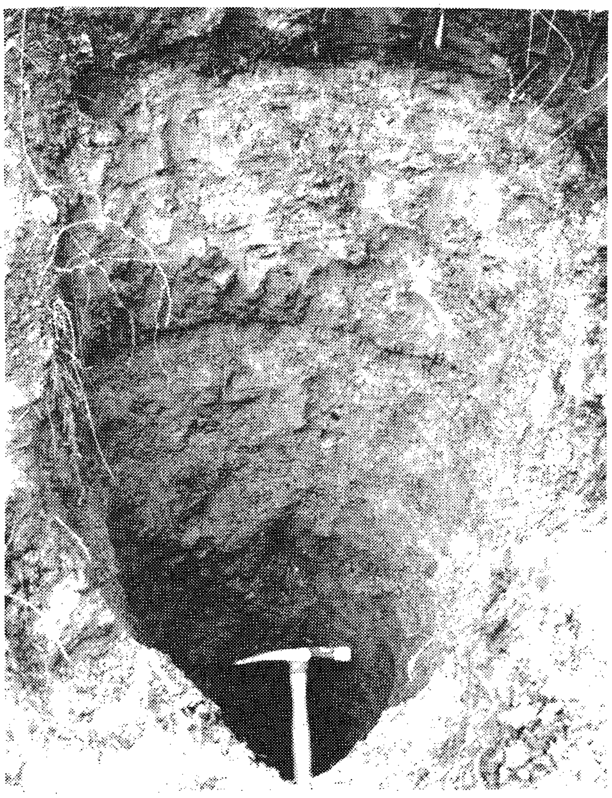


Figure 7. Pit dug in stream terrace deposits near Glenita Church. Note rounded pebbles in lower part of pit.

SOUTH PORTAL OUTLET

The present outlet (or spring) of Stock Creek through Natural Tunnel, near the northwestern corner of the amphitheatre, may occur beneath the location of a large spring that existed many thousands of years ago when ancestral Stock Creek Valley stood at a higher level. Water draining the upper reaches of ancestral Stock Creek apparently entered a large sink above the current position of the north portal of the Tunnel, descended underground, flowed southward through solution-enlarged fractures associated with the Glenita fault zone, and then rose and emerged as a spring above the vicinity of the south portal (Figure 6). At that time, the lower elevations of present Stock Creek gorge below the tunnel were filled with bedrock, and Stock Creek flowed upon a flood plain of clay, sand, and gravel that overlay the bedrock.

Perhaps the large opening and north-sloping roof of the south portal reflects the differential solution of rock effected by the flow of water along these ancient passageways as it migrated upward toward a surface spring.

The rock deformation conspicuous in the lowermost strata exposed in the south portal is tectonic in origin and is the result of movement along the Glenita fault (Figure 8). These rocks were deformed when the Appalachian Mountains were constructed at the end of the Paleozoic by the collision of the African continent with North America approximately along the edge of the modern continental shelf. The upper boundary of the deformed rock in the lower part of the tunnel with the overlying undeformed strata is abrupt, is almost planar, and bears some resemblance to a sedimentary unconformity (Brent, 1963). More recent work in the Appalachians, however, has shown that subplanar roof faults commonly are associated with this type of tectonic deformation (Harris and Milici, 1977). Furthermore, deformed rocks associated with the Glenita fault zone crop out above the north portal of the tunnel, where the rock above the fault plane (the hanging wall) is folded and where the deformation clearly is of tectonic origin as is shown by the truncation and brecciation of bedding surfaces below the fault (footwall) (Figure 9).

Natural Tunnel is oriented generally north-south and the main sense of tectonic movement along the Glenita fault is to the west. In essence, when you are standing at the level of the railway track in and near the tunnel, the hanging wall of the Glenita fault—all of the strata exposed in the ampitheatre above you—has moved to the west, perhaps several thousand feet or more, relative to the footwall strata beneath Stock Creek.

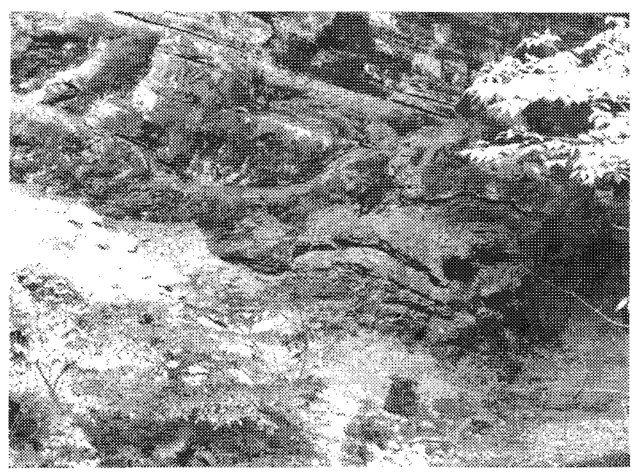


Figure 8. Deformation along the Glenita fault near stream level in the south portal of Natural Tunnel; illustration is about 50 feet across.

NORTH PORTAL AND AMPITHEATRE

When compared with the south portal, the lowest part of the natural entrance near the north portal of Natural Tunnel is very small, less than 10 feet high above Stock Creek, and is only a few tens of feet wide (Figure 10). The railroad accesses

Natural Tunnel through a man-made cut nearby. It is the small size of this natural aperture and associated open fractures that have controlled the hydrodynamics of the local surface- and groundwater-circulating systems in the past. When underground flow was curtailed or stopped by a plug of sediment, ancestral Stock Creek simply backed up, its valley filled with sediment, and it discharged to the south above the ampitheatre through Natural Tunnel gap. Stream terrace pebbles, gravels, and cobbles, preserved on the hillslopes a half mile south of Natural Tunnel gap near Glenita Church, may have been deposited under these overflow conditions or perhaps during earlier times when ancestral Stock Creek stood at a higher level. In the exposure some 50 feet higher than the church and about 150 feet higher than Stock Creek, clays containing far transported and rounded quartz and sandstone clasts overlie residuum containing angular clasts of carbonate rock and chert that were derived locally.

The Glenita fault is exposed in the north portal, in the bedrock a few feet above the opening into the tunnel (Figure 9). The fault rises moderately to the west (right when looking south) and may be traced readily to the west and south through the wooded bluffs between the tunnel and State Road 871. Footwall strata are inclined slightly to the east but are otherwise little deformed. In contrast, the hanging wall above the Glenita fault is folded sharply into an anticline, which attests from its asymmetry to the relative westward movement of the great mass of carbonate strata which are exposed above the tunnel. The vertical beds on the west limb of the anticline become less steeply inclined upward and flatten across the crest of the structure. The strata near the top of the ampitheatre are almost horizontal.

SUMMARY

Several geologic factors have combined to create the Natural Tunnel and the rugged topography associated with it. The zone of structural weakness between the openly folded Rye Cove syncline and more tightly compressed Purchase Ridge syncline (Figure 5a), expressed in part by the Glenita fault, localized the southward-flowing course of Stock Creek over Cambrian- and Ordovician-age rocks. These rocks consist chiefly of shale (a few miles north of Natural Tunnel) and carbonate rock. At the tunnel, most of the carbonate strata are subhorizontal or are only gently dipping, a requirement for the construction and maintenance of a large, long-standing arch. If all of the strata were greatly deformed or steeply inclined, it is unlikely that they could span a gap of any great width for a long period of time. Differential fracturing and folding of the dolostone strata where the Glenita fault passes into or beneath the tunnel, however, were instrumental in creating the means by which the waters of ancestral Stock Creek could be diverted from the surface stream through the underground passageway as the topography was lowered progressively through the carbonate terrane during the Quaternary Period.

ACKNOWLEDGMENTS

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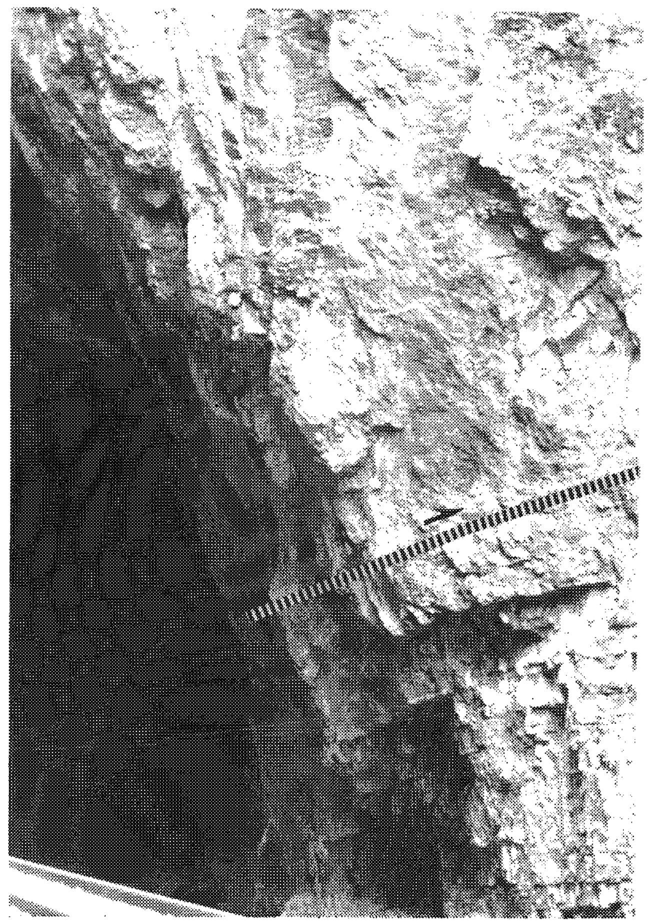

Figure 9. Exposure of the Glenita fault in the north portal of Natural Tunnel. Footwall beds dip gently to the left; hanging wall beds on the west limb of the anticline are vertical; arrow shows direction of movement of hanging wall relative to the footwall.

REFERENCES CITED

Brent, W.B., 1963, Geology of the Clinchport quadrangle, Virginia: Virginia Division of Mineral Resources Report of Investigations 5, 47 p.

Harris, L.D., and Milici, R.C., 1977, Characteristics of thin-skinned style of deformation in the southern Appalachians and potential hydrocarbon traps: U.S. Geological Survey Professional Paper 1018, 40 p.

Harris, L.D., and Miller, R.L., 1958, Geology of the Duffield quadrangle, Virginia: U.S. Geological Survey geologic quadrangle map GQ 111, scale 1:24,000.

Long, S.H., 1832, Description of a natural tunnel, in Scott County, Va.: Monthly American Journal of Geology, v. 1, n. 8, p 347-355.

Woodward, H.P., 1936, Natural Bridge and Natural Tunnel, Virginia: Journal of Geology, v. 44, n. 5, p. 604-616.

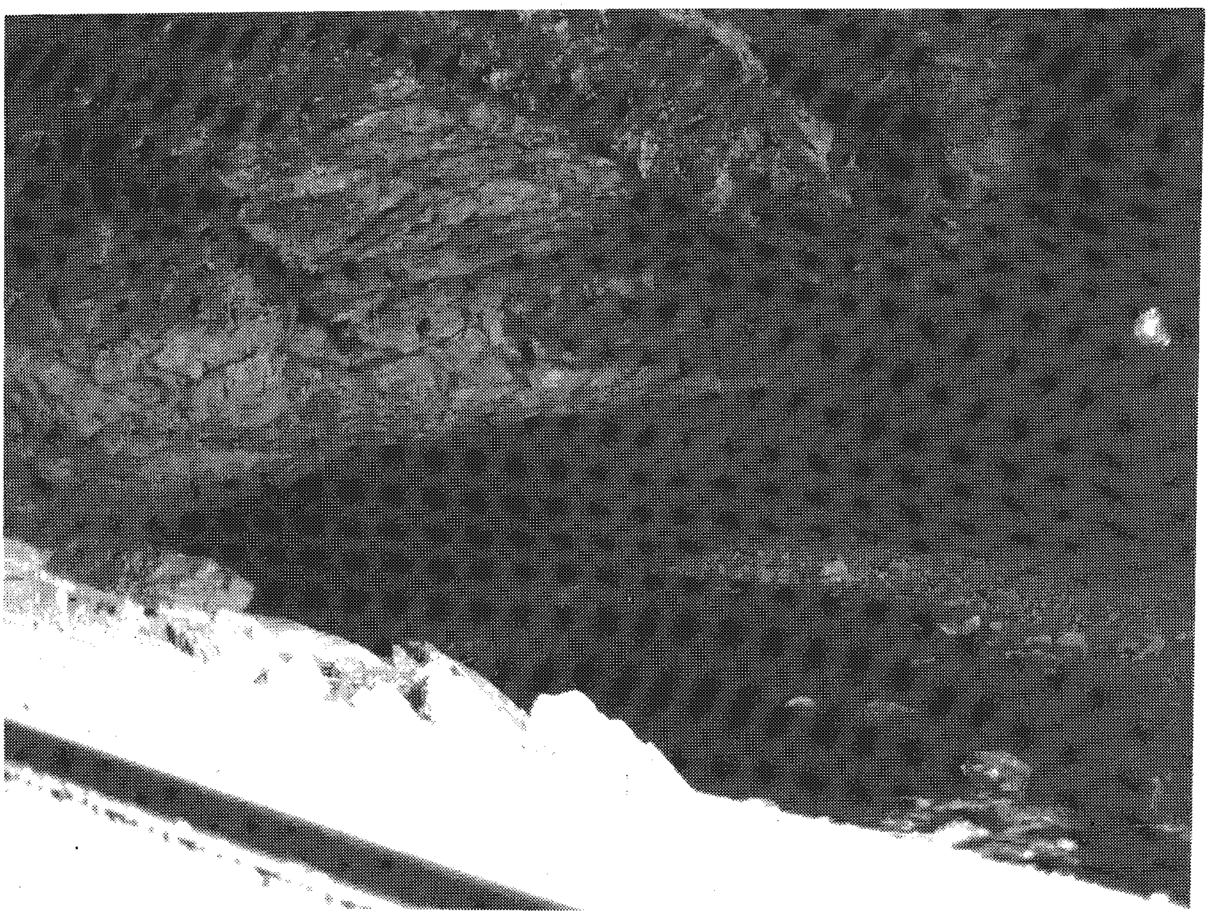

Figure 10. Low arch of Natural Tunnel near the north portal. Photograph taken from railroad bed. Note fault deformation in roof, upper right of photograph.

HARRY W. WEBB, JR.
(1930-1990)

Harry Webb, our friend and associate, died on Monday, June 11, 1990. Harry worked for the Division of Mineral Resources for more than 20 years. During most of that time he was Head of the Information Services Section. Harry managed the Division's topographic mapping program, in cooperation with the U.S. Geological Survey. He was interested greatly in the development of new map products to meet the ever-changing needs of the public.

Much of his work was concerned with presenting and interpreting information on Virginia's complex geology and mineral resources to the lay public, governmental agencies at all levels, and to many, many interested teachers and students. He was an outstanding speaker. "Scenic Landforms of Virginia", which he published in 1988 (*Virginia Minerals*, v. 34, n. 3), is an excellent review of the many magnificent geomorphic features of the Commonwealth, together with their locations. Harry had retired in 1988.

NEW PUBLICATIONS

Publication 102. Geologic map of Clarke County, Virginia — Plate 1; Map of hydrogeologic components for Clarke County, Virginia — Plate 2; by David A. Hubbard, Jr., scale 1:50,000, 1990. **Price:** $12.00

Geology and Virginia, by Richard V. Dietrich, second printing with new Preface, 213 p., 1990. **Price:** $12.75

Minerals of Virginia — 1990, by Richard V. Dietrich, expanded and updated edition of the 1970 edition of Minerals of Virginia, includes 111 mineral species not included in the previous edition, 474 p., 1990. **Price:** $11.75

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STAFF NOTES

Alfred R. Taylor rejoined the Division of Mineral Resources, Department of Mines, Minerals and Energy, on March 1, 1990, as a Supervisory Geologist in the Division's Southwestern Field Office in Abingdon. He is married and has two daughters.

He attended Staunton Military Academy before joining the U.S. Marine Corps. While serving as a Staff Sergeant in the Marine Corps, he received a commission in the Navy as an Intelligence Officer. His education includes service schools, the University of North Carolina, Chapel Hill, where he received a B.S. degree in geology, the Wisconsin Institute of Technology, Platteville, Wisconsin, and Somerset Community College, Somerset, Kentucky. Alfred taught geology and geography at Somerset Community College for 13 years.

Upon graduation in 1955, he started his professional career as a geologist with the U.S. Geological Survey (USGS), Department of Interior. He was with the U.S. Geological Survey until 1982. In 1983 he was employed by the Mineral Management Service (MMS) and Bureau of Land Management (BLM). He retired from federal service in December of 1983. While with the USGS, MMS, and BLM his assignments included geologic mapping projects and stratigraphic, structural, geohazard, geophysical, mineral deposit, and energy investigations, and editing in the United States and overseas. His foreign work included a geophysical oversnow traverse in Antarctica and energy-related mineral studies in Argentina. He was an Environmental Impact Team Leader for a large coal mine in the Powder River Basin, Wyoming. Alfred consulted in oil, gas, coal, gold, and geohazards from 1984 to January 1988 when he joined the Division as a geologist (restricted status position) for the GEOHY project. He left Division employment at the end of the GEOHY project in July 1989.

NOTICE

Your cooperation is solicited in up-dating the *Virginia Minerals* mailing list. If you want to receive *Virginia Minerals* send your name and current address to Virginia Minerals, Division of Mineral Resources, P.O. Box 3667, Charlottesville, Virginia 22903 by January 15, 1991.

MICROTEKTITES ?

Small glassy spheroids (microtektites ?) have been found in samples from wells drilled in the Virginia Coastal Plain. These spheroids are in beds of the Pamunkey Group (Paleocene-Eocene). They are similar to those described as having been caused by the bolide impact that led to the extinction of the dinasaurs at the end of the Cretaceous.

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