

Valley Region of the Appalachian Mountains and Subsequent Karst Regions in the State of Virginia

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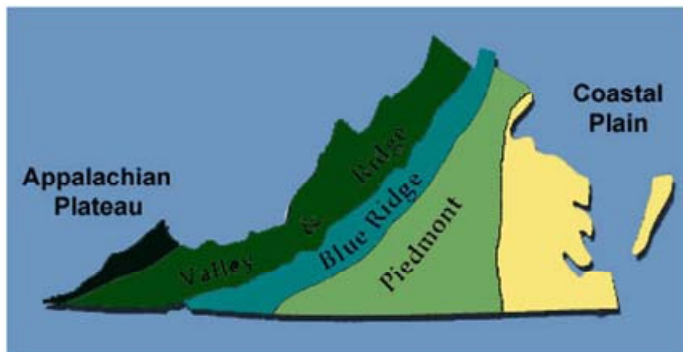


This map which appears on page 402 of *Process Geomorphology* (1995), written by Dale F. Ritter, Craig R. Kochel, and Jerry R. Miller, serves as the basis of my report on the formation of the Appalachian Mountains and its subsequent karst regions in along the Atlantic side of the United States particularly in the state of Virginia. The shaded areas represent generalized karst regions throughout the United States.

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The state of Virginia is divided into five major physiological regions based on similar landscapes and relatively static climates, each region being as diverse as the next.

From the east to west they are respectively named, the Tidewater which stretches from the Atlantic Ocean to the fall line, the Piedmont which lies east of the Blue Ridge Mountains, the Blue Ridge Mountains which exclusively extends to the eastern Appalachian Mountains, and finally the Ridge and Valley region of the Appalachian Mountain chain. In this paper I will pay particular attention to the formation of the Appalachian Mountains and the subsequent karst regions in the western part of the state.



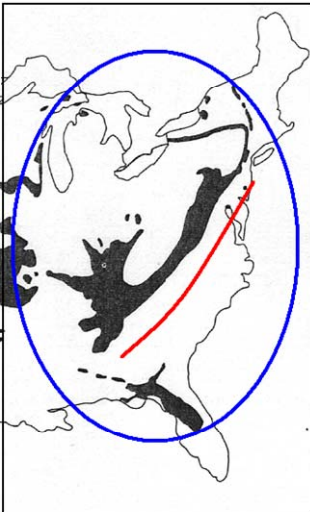
Regions of Virginia

“Ordovician mountain building events in eastern North America are collectively termed Tectonic Orogeny (Stanley, 318).” In short, there were three such orogenic events that helped form the current-day

Appalachian Mountains. This was the first of three orogenic episodes occurred when Laurentia, the North American craton, part of the continental crust, collided with the Iapetus which is composed of oceanic crust. The resulting impact caused mountains to rise up in the east. Over thousands of years, through the process of physical and chemical weathering, the landscape was eroded down to sea level. The second orogenic event

occurred during the Silurian Period, when the mountains that formed during the first orogenic episode eroded creating a carbonate platform along the passive margin on the coast of Laurentia. (Stanley, 349) However, it was not until the third episode, during Cenozoic era, that the “conspicuous fold and thrust belt of the central and southern Appalachians formed” as the result of the mid-carboniferous collision of Euroamerica with Gondwanaland (Stanley, 372).

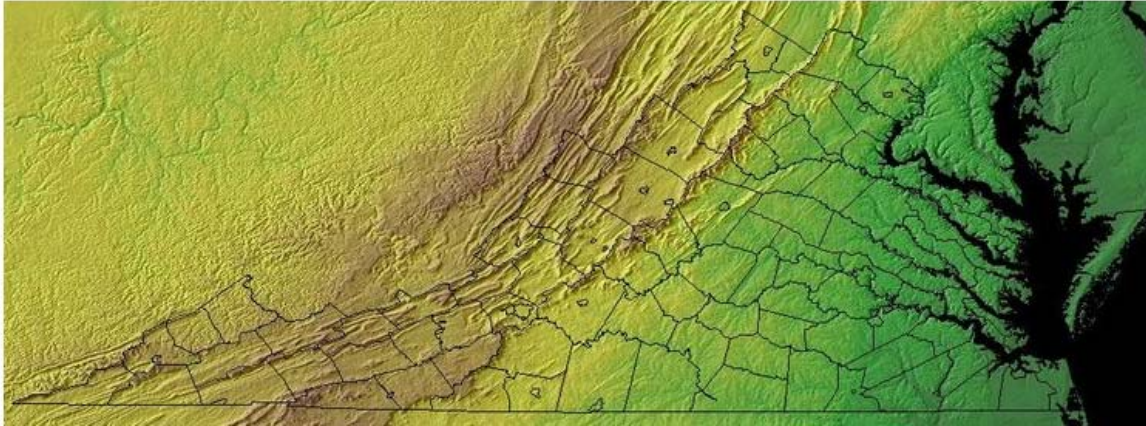
At the point of impact between the Euroamerica and Gondwanaland plates, immense pressure turned igneous and sedimentary rock into metamorphic rock which proceeded to break in numerous places. The resulting fold and thrust belt were exceedingly susceptible to weathering and erosion by means of wind and water. Streams began to flow along weak layers that define the folds and faults and carved the resistant folded rocks of the mountain core creating karst geologic structures.



Process Geomorphology, 1995

The karst regions of Virginia exist today in a “still-mountainous region is a zone of low temperature deformation called the Valley and Ridge Province (Stanley, 372).” The Valley and Ridge Province is said to be the, “most rugged area of the state” as this region consists of both high peaks and low lying valleys extending from present day Virginia, to Maryland, and northwestward to West Virginia, Pennsylvania, and northern New Jersey. The ridges are composed of fairly resistant strata while the valleys depict erodable materials. Patterson describes the terrain as, “corrugated” as the Shenandoah and Tennessee rivers flow both north and south, while

“east flowing rivers like the Potomac are forced to cut through the ridges in a series of gaps.” (Patterson, 8)

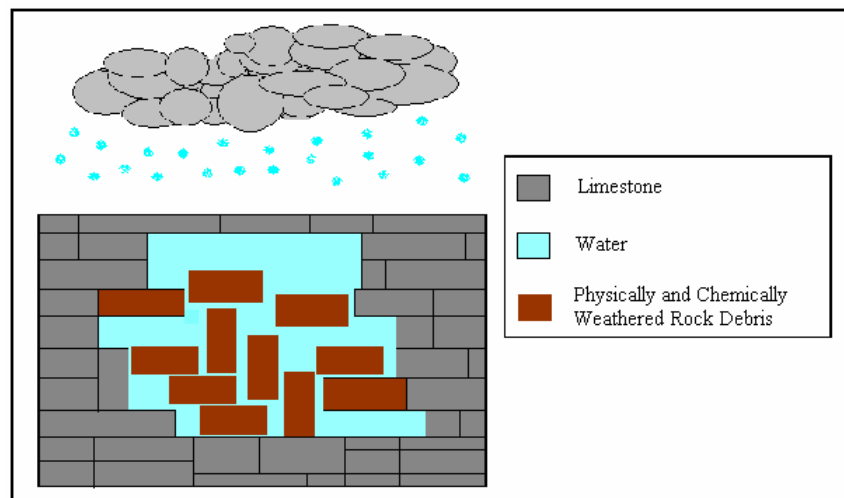


Topographic Map of Virginia

The peaks which range from three to four thousand feet above sea level are arranged in a southeast-northeast pattern. The direction of these mountains is directly correlated with a convergent plate boundary that moved between six and seven million years ago when, “large slices of crust slid westward along thrust faults and were crumpled by pressure from the east (Stanley, 372).” After this orogeny took place, streams began to carry rock debris down slope depositing the eroded material in the nearby lowlands. Accordingly, the resulting Appalachian Mountains are elongated belts of folded and thrust faulted marine sedimentary rocks such as limestone composed of calcium carbonate, volcanic rocks, and slivers of ancient ocean floor.

Subsequently, caves develop in and from soluble rock, such as limestone, found in the fault thrust rock of the Appalachians in western Virginia. The topography which concerns caves and sinkholes are generally referred to as karst which is a word that originally comes from the, “German adaptation of the Slavic word Kras” which literally refers to a “bleak waterless place,” which of course, is just not true (Process

Geomorphology, 401). Water is in fact present, and is a major contributing force in the creation of caves. However, very little water remains on the surface because “once precipitation reaches the ground, it reacts with the soil, rock, and organic debris dissolving still more chemicals naturally (Montgomery, 243).” Any water that is on the surface will quickly seep underground and become involved with the chemical weathering which in turn, forms caves.

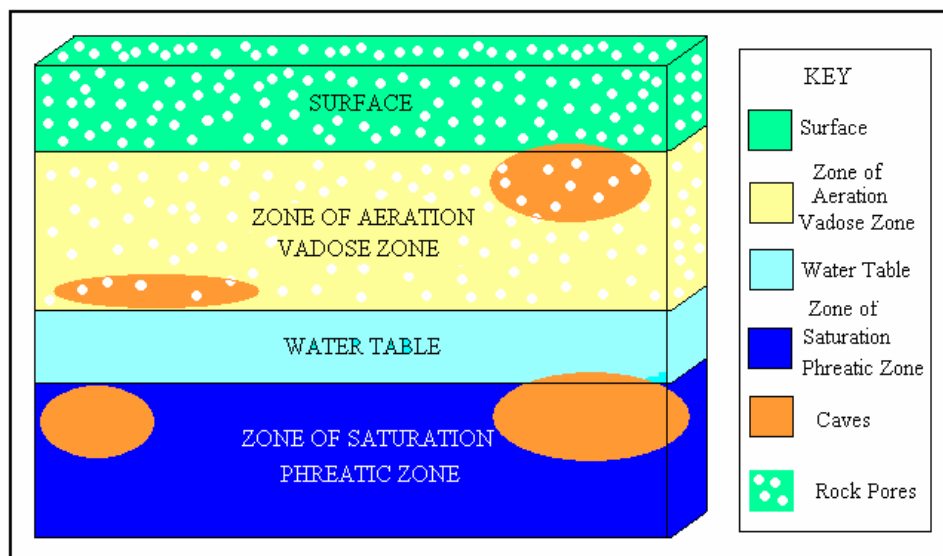


Cave formation resulting from the physical and chemical erosion of limestone.

Caves are formed by a combination of geologic processes including plate tectonics, chemical weathering, and atmospheric forces such as climate and weather. “Jennings (1985) described karst topography as, “terrain with distinctive landforms and drainage arising from greater rock solubility in natural water than found elsewhere (Process Geomorphology, 401).” The soluble rocks most vulnerable to karstification are calcite and dolomite. If more than fifty percent of the rock’s carbonate material is calcite, then the rock is referred to as limestone, whereas if the rock’s composition is more than fifty percent dolomite, then the rock is referred to as such. Limestone most often is

formed from chemical sediments deposited in shallow seas, and limestone beds over broad areas (Process Geomorphology, 402).

In addition to its strict lithology, karst landscape also develops in conjunction with how much water filtrates through the system, as karst landscapes are known for their unique drainage patterns. Porosity measures how much water can not only filter through a specific rock, but be retained in that particular rock in accordance with the specific rock type and subsurface zones. Above the water table, the zone is referred to as the vadose zone which is one of aeration, and below the water table, at the level of saturation, the zone is referred to as the phreatic zone. Caves form near the water table, but exist both above and below the water table.



Cross-section of a karst landscape and the formation of caves.

There are two main ways in which water gets trapped underground. The first is called primary porosity and occurs during the formation of the rock, when water gets trapped within the pores of the rock. “This porosity decreases and compaction and sedimentation occur, and in time older limestone, for example, calcite tends to be replaced by dolomite (Process Geomorphology, 404).” Caves that form during the initial

rock formation are similarly called, primary caves, but are not common near the Appalachians because they would have been disturbed by uplifting and folding of the sediments caused by the tectonic events. Even though evidence of ancient volcanic rock in the Appalachians exist, primary caves are more commonly formed through more recent volcanic activity which is a geological force no longer present today on the Atlantic shore of the United States.

The second way water becomes trapped underground is appropriately called secondary porosity. This happens as water seeps down through bedding planes, fault zones, fractures and joints that occur naturally in the rocks. Secondary caves are formed inside the rocks, after the rock itself has formed. There are many caves on the Atlantic side of the Appalachians resulting from this type of secondary process which removes material through physical and chemical weathering. Erosion, in this case is a mechanical form of weathering that occurs due to the abrasive action of aeolian, but most effectively, fluvial forces.

Atmospherically, climate is also a factor in creating karst landscapes as warmer temperatures foster, “biogenic CO₂” which helps produce and maintain the vegetation that will in turn help the rock erode and where, “free water is available to circulate (Patterson, 427).” The most common process of cave formation is when rocks are eroded by water through the process known as karstification. Caves are formed with both physical and chemical weathering and the availability of relief to, “permit free circulation of water in the system (Geomorphology, 404).” Physically, as water filters through the underground passageways different minerals become soluble, and the solution in its entirety becomes abrasive and psychically weathers the rock. This process is similar to

how streams on the surface physically alter the landscape. Chemically, the water reacts with the calcium carbonate in the limestone, and the rock begins to disintegrate.

Cave formation occurs abundantly on the Atlantic side of the Appalachians because limestone is dissolved by carbonic acid typically found in rainwater. As the rainwater travels through these underwater passages, the water reacts chemically with the calcium carbonate in the rock causing disintegration and voids within the weathered rock. As the water travels through the crevices in the rock, the rocks are weakened and often times collapse into sinkholes and low lying valleys. Gradually the surface openings enlarge and voids within the weakened rock grow large enough that the seeping water comes in contacts with air causing its solutes to precipitate.

Over thousands of years, this precipitous reaction between the air and water causes speleothems to form. These cave deposits, or speleothems develop into rock formations depending on how the water reacts in the cave. Water has the capacity to condense, pool, drip, and flow underground to create a multitude of features. Stalactites, for example are rock formations that hang from the ceiling of the cave and stalagmites, rock formations that appear to grow upward from the floor of the cave. Given enough time, these two structures have the potential to fuse together to forming a column extending from the floor to the ceiling of the cave. This and various other types of rock formation is extremely common in the karst region of Virginia as there is an abundance of free water circulating underground.



Skyline Caverns



Hartley, 2003

Ranging from the lowlands adjacent to the Atlantic Ocean, moving westward to the Appalachian Mountains, the topographic and physiographic characteristics of the landscape changes dramatically the physical regions of Virginia are very unique. Thrust folding of the sedimentary material which subsequently caused uplift and orogeny created the Appalachian Mountains as they appear today.

During its long formation period, erosion and drainage of this system directly resulted in the subsequent karst topography of the Ridge and Valley Province of the Virginian landscape.

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