Introduction

Gambrill State Park is located along the eastern edge of the Blue Ridge Physiographic Province. The Blue Ridge Mountains stretch from northern Georgia to southern Pennsylvania. The Blue Ridge is made up of folded rocks that are broken in places by faults. In Maryland, the Blue Ridge consists of two separate ridges-Catoctin Mountain, locally known as Braddock Mountain on the east, and South Mountain to the west. The Blue Ridge is bordered on the east by the Piedmont Physiographic Province. The Piedmont is underlain by metamorphic rocks that were formed when the Appalachian Mountains were uplifted more than 250 million years ago (hereafter *Ma*). What we see from Catoctin Mountain today is the result of millions of years of erosion of those mountains.

Bedrock Layers

Nearly all of the rocks present in the park are assignable to three geologic rock units, called formations. These are the Catoctin, the Loudoun, and the Weverton formations. The oldest rocks present in the park are assignable to the Catoctin Formation. This unit consists of greenish gray metamorphosed basalts. These ancient basalts occur on top of 1.1 billion-year-old granites that underlie the adjacent Middletown Valley. The granites were part of an ancient supercontinent that geologists call Rodinia. Approximately 600 Ma, large cracks formed in the granites of Rodinia and huge blocks of the Earth's crust collapsed to form broad valleys. Basaltic lava welled up from deep within the earth along these cracks and then spread out onto the surface of these valleys. Today, geologists recognize these ancient lava flows as the Catoctin Formation. Although the Catoctin is not well-exposed in the park, rocks belonging to this unit can be seen along Alternate Route 40 between Gambrill Park Road and Ridge Road, and along Interstate 70 at the crest of Catoctin (i.e., Braddock) Mountain.

Overlying the green basalts of the Catoctin Formation are gray to dark gray phyllites and conglomerates of the Loudoun Formation②. The phyllites often display a shiny surface and contain deformed and stretched pebbles. These characteristics, along with other textures tell geologists that these rocks were formed as ash falls associated with the volcanic activity that took place during the formation of the Catoctin lava flows. Thin conglomerate layers also are present in the Loudoun Formation. These conglomerates were formed by high-velocity streams that carried pebbles and cobbles from upland areas into the valleys where the Catoctin was being deposited.

The youngest rock unit found in Gambrill State Park is the Weverton Formation①. The Weverton consists of layers of dense, light gray sandstone and thin layers of greenish gray shale. The sandstone layers often exhibit an internal feature called cross-bedding⑨. Cross-bedding forms when sand and pebbles are moved by water or wind. In the Weverton the cross-bedding indicates that these sands were moved and deposited by ancient rivers. The greenish shale layers were formed along the banks of these rivers. Because the sand grains in these sandstones are so tightly cemented together, they create durable rock ledges that are tough and resistant

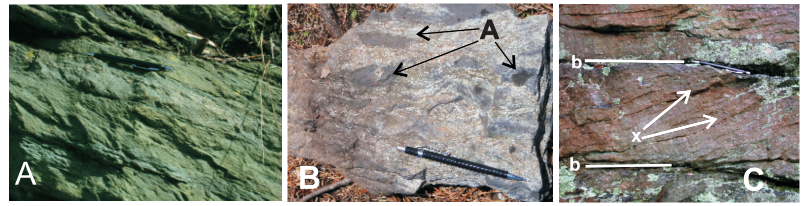

Figure 1. Rocks of Gambrill State Park. A, Catoctin Formation. Greenish metamorphosed basalts. B, Loudoun Formation. Volcanic ash containing pebbles of lava (at A). C, Weverton Formation. Cross-bedded sandstone (b=bedding, x=cross-bedding) ⑨.

to weathering and erosion. As a result of this durability, the Weverton Formation represents the main ridge-forming layer on both Catoctin and South mountains of the Blue Ridge of Virginia, Maryland, and Pennsylvania. These ridges are erosional features left standing high after the softer or more soluble rocks on either side were worn down by weathering and erosion.

Geologic History

About 1 billion years ago many of Earth's continents collided to form a supercontinent called Rodinia. Rocks formed during this event underlie all of Maryland and are exposed at the surface to the south of Middletown and in the Baltimore area as the Baltimore Gneiss. Approximately 600 Ma, Rodinia began to break apart, as large faults cut through the supercontinent. These faults produced immense down-dropped blocks that formed valleys, known as rift valleys. The Central African Valley is a modern example of a rift valley. Oddly enough, Catoctin Mountain has its beginning in the formation of such a rift valley. As the faults developed, lava, from deep within the Earth, flowed up along these cracks and out onto the valley floor. These lava flows are the Catoctin Formation that we see today (Figure 2A). As the volcanoes continued to erupt, the lava layers were covered by volcanic ash of the Loudoun Formation (Figure 2B). Along the edges of the lava-filled valleys, rivers carried boulders, cobbles, and finer sediment down the steep slopes from the surrounding higher areas. This interlayering of ash and conglomerates is typical in the Loudoun Formation. Over millions of years, the rivers flowing from the adjacent highlands flooded the valley with sands and muds that they were carrying. These river deposits became the Weverton Formation. The faults along the border of the valley were constantly active and the valley continued to subside. As it did, marine waters ultimately filled the valley and a narrow sea was formed. This early sea was similar to today's Red Sea. Over time, the valley continued to broaden until a new ocean was formed. Geologists call this ancient ocean, Iapetus.

Millions of years later, about 250 Ma, the east coast of this ancestral North American continent collided with the African continent. As these two continents crushed against one another, the intervening Iapetus Ocean was eliminated and the Appalachian Mountains were uplifted. Rock layers deposited during the previous 400 million years were bent into large folds or were broken by fractures and faults.

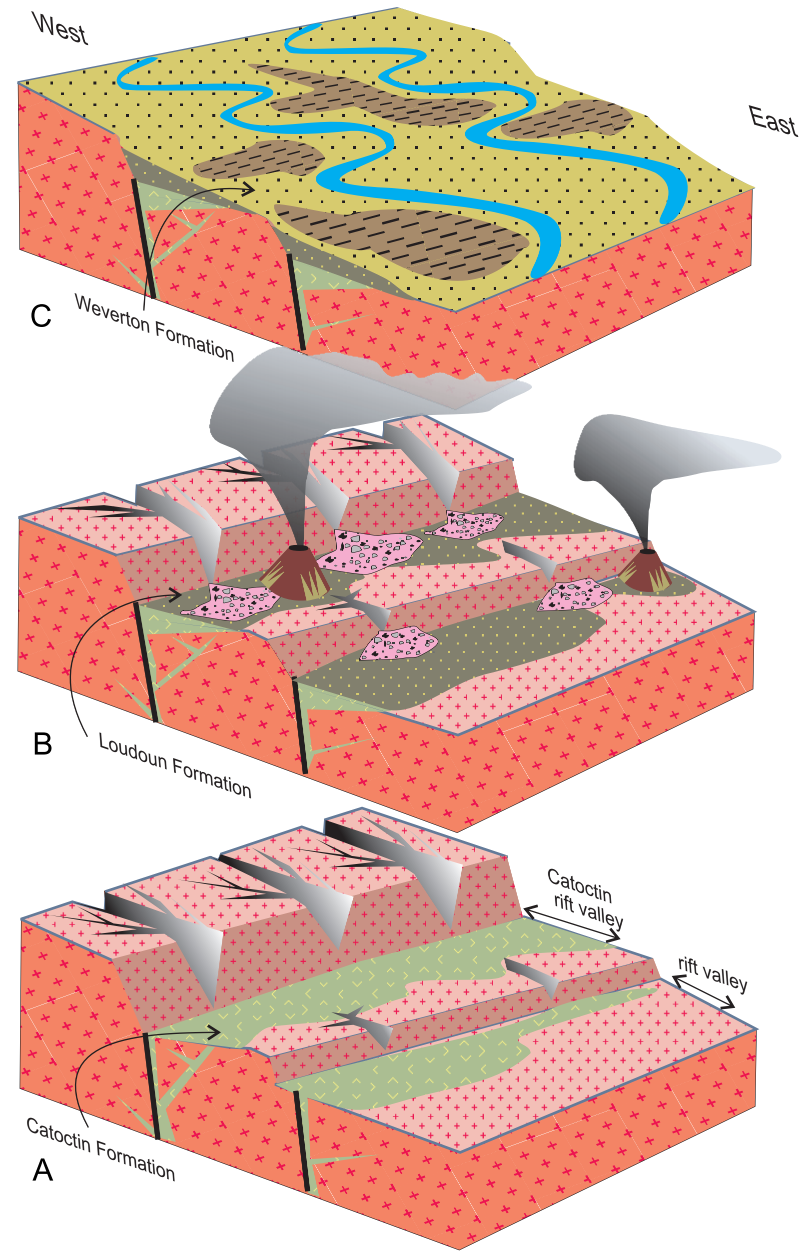

Figure 2. A, Creation of the Catoctin Formation. 600 Ma fracturing and faulting of Earth's crust allowed the formation of large fault-formed valleys called rift valleys. Rift valleys bottoms are covered by lava welled up along fracture surfaces. B, Deposition of the Loudoun Formation. Volcanic ash and conglomerates from adjacent uplands cover Catoctin lavas. C, Deposition of the Weverton Formation. Rivers carrying sand and mud bury the rift valleys and deposit a blanket of sandstones.

Figure 3. Geology from the Middletown Overlook③. Reconstruction of what the Blue Ridge anticline might have looked like prior to its erosion. Catoctin Mountain in the east and South Mountain to the west were once formed by a continuous rock layer, the Weverton Formation. The intervening Middletown Valley is underlain by older rocks of the Catoctin Formation, which is in turn underlain by the 1.1 billion year old Middletown granite.

In the Baltimore region the intense pressure and heat that changed the rocks into metamorphic rocks. These altered rocks underlie all of Maryland's Piedmont Province. The amount of heat and pressure that these rocks endured tends to increase to the east. In western Frederick County, the mountain-building forces bent the Catoctin-Loudoun-Weverton succession of rocks into a broad upfold in the Earth's crust called the Blue Ridge anticline (Figure 3). Evidence of the folding and movement of these rock layers can be seen in outcrop as the contorted white quartz layers within the Loudoun Formation (Figure 4A). These white layers formed when hot, quartz-rich fluids were injected into the folding and fracturing. The compression that formed this anticline also produced parallel fracture planes, called cleavage (Figure 4B). Cleavage planes are well-developed within all rock layers in Gambrill State Park. The Blue Ridge anticline was then pushed westward, along large faults. It finally came to rest against the rocks of the Hagerstown Valley.

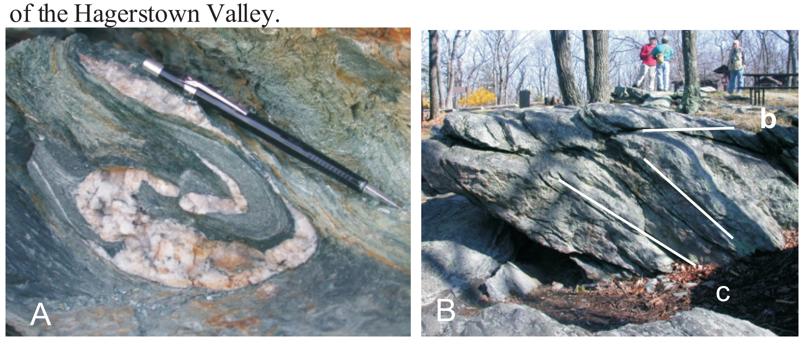

Figure 4. The results of multiple mountain-building episodes. A, Folded vein of quartz in crinkled Loudoun Formation②. Look carefully and you might be able to see that the folded quartz vein is refolded. B, Fractures formed during folding. Outcrop of Weverton Formation on top of High Knob. Bedding (b) is nearly horizontal, but the inclined fractures, called cleavage (c), were formed when the Blue Ridge was folded①.

Erosion of the Blue Ridge

Over the ensuing 250 million years, weather and erosion have removed much of the original rocks that were uplifted to form the Blue Ridge anticline. All that remains are low ridges of sandstone and the intervening valley of volcanics (Figure 3). Remnants of the Catoctin and Loudoun formations underlie much of the intervening Middletown Valley. From the Middletown overlook on High Knob③ it is difficult to imagine the immense amounts of rock that have been eroded from this once great fold (Figure 3). This material, as well as the rocks eroded from the core of the Appalachian Mountains, which is the Piedmont Province to the east ⑤, have been carried by streams and rivers eastward and deposited as sediments of the Coastal Plain. The Coastal Plain Province extends from Baltimore and Washington D.C. to Ocean City, Maryland. The view eastward from the Frederick Overlook is over the gentle topography of the Piedmont. The topography of High Knob demonstrates how the rock units possess varying resistance to erosion (Figure 5).

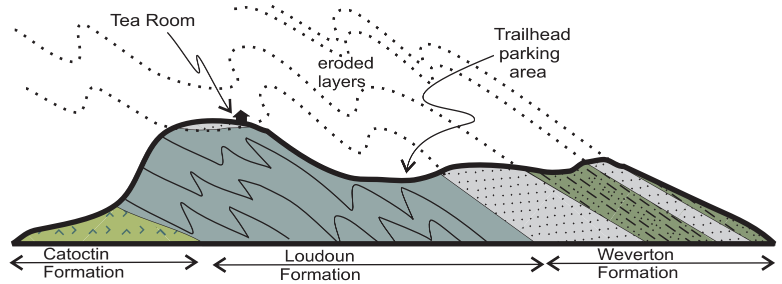

Figure 5. Geology of High Knob. Sketch of distribution of rock layers underlying High Knob illustrates how different rock units exhibit different degrees of erosion.

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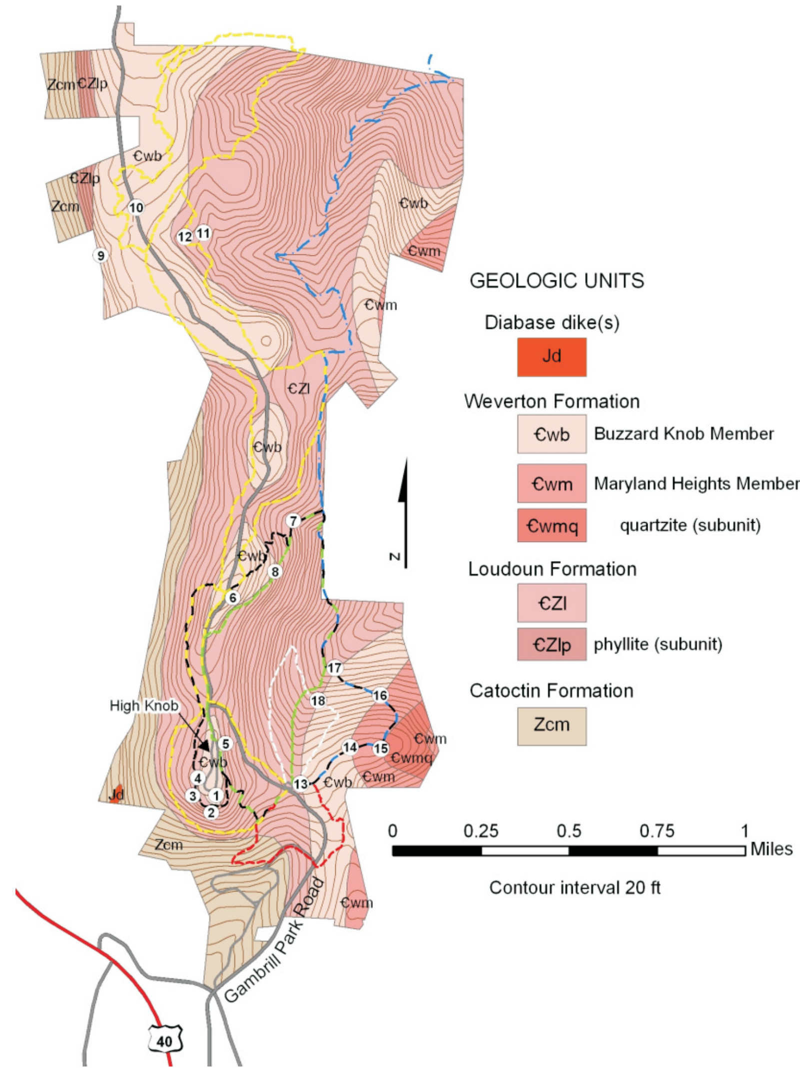
GEOLOGY OF GAMBRILL STATE PARK



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