Notes on the Geology of Catoctin Mountain Park, Maryland

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Setting and Historical Notes

Catoctin Mountain Park comprises approximately 2351 ha of federal land in Frederick County, Maryland (plus a small sliver in Washington County to the west). Relatively compact in its dimensions with a northwest-southeast axis, the land lies just west of the town of Thurmont, bounded by an envelope formed by Maryland Route 77 (Foxville Road/Rocky Ridge Road), Maryland Route 550 (Sabillasville Road), Buck Lantz Road, Maryland Route 491 (Raven Rock Road), Mount Zion Road, Quirauk School Road, and Foxville Church Road. Most of its area falls within the Blue Ridge Summit Quadrangle [USGS85]. The main entrance and visitors center, along Route 77, lie at approximately 39° 38' N 77° 27' W. The Park is a relatively short drive from metropolitan Washington, D.C., as well as other cities of the mid-Atlantic region. It is part of a nearby group of public lands that lie on the eponymous Catoctin Mountain, including the Maryland state parks of Cunningham Falls and Gambrill and the city of Frederick Municipal Forest. Geologically, the parklands lie in the Blue Ridge Province; ecologically, it is part of the Temperate Forest biome, more specifically the Oak-Hickory community of the Eastern Deciduous Forest [Kricher88].

In the 18th and 19th centuries, iron was manufactured at Catoctin Furnace (south of Thurmont), thanks to abundant timber, limestone, and iron ores (hematite and limonite).

Once the forests were depleted, the federal government acquired land for the Park during the Great Depression under the auspices of the National Industrial Recovery Act. The Resettlement Administration (later merged into the Farm Security Administration) was authorized to purchase "submarginal" agricultural land, in an effort—bold and controversial at the time—to move farmers away from unproductive farms and unsustainable practices and toward group-run, efficient operations. The property was organized into the Catoctin Recreational Demonstration Area in 1936, one of 46 such RDAs intended to provide outdoor activities to disadvantaged urban children (the first campers at Catoctin were a group of disabled kids), as well as jobs for the ex-farmers and other residents of the region. Catoctin provided jobs under the Works Progress Administration, the Civilian Conservation Corps (both of which groups built the first cabins there), and the 1960s-era Job Corps. Catoctin was the only RDA in Maryland, but in neighboring Virginia there were six others, including the property that became Prince William Forest Park.

Perhaps due to its proximity to the capital, a camp at Catoctin was used by Franklin Roosevelt as a presidential getaway, a venue that was both easily secured and conducive to the executive's health. In 1954, the southern half of the property was ceded to the state of Maryland, to become Cunningham Falls State Park, while the portion north of Route 77 became part of the National Parks Service system. The retreat area, informally dubbed Camp David by Dwight Eisenhower, continues to be used by American chief executives to this day. Though part of the NPS, Catoctin does not bear the National Park designation.

Nearly all (95%) of the Park is given over to secondary successional forest, a striking rebound from the farmed- and logged-over land that was acquired only 75 years ago. The trees are typical of Eastern deciduous woods, among them oaks (*Quercus* sp.), hickories (*Carya* sp.), maples (*Acer* sp.), and Tuliptree (*Liriodendron tulipifera*). American Chestnuts (*Castanea dentata*) fell victim to the blight that devastated Eastern forests in the first half of the century, and they persist only as understory shoots today [NPS09].

Topography, Surface Drainage

Fig. 1

The terrain is modestly rugged, described as "rolling hills and narrow ridgetops separated by steep-sloped valleys and ravines." [Thornberry-Ehrlich09, p. 2] The steepest slopes are to the northeast down into the Owens Creek valley. In the northwest, especially on the far side of Foxville-Deerfield Road, slopes are gentler. Peaks and other points of interest are at Chimney Rock (432 m) (Fig. 1), Wolf Rock (427 m), Hog Rock (491 m), Thurmont Vista (457 m), Blue Ridge Summit Overlook (463 m), Hightop (573 m), and an unnamed high point (491 m) in the northwest part. A network of hiking trails connects most of these attractions (except for Hightop within the Camp David facility). By contrast, the railroad grade along the northeast park boundary climbs from Thurmont's elevation of about 165 m to 320 m at the locality of Lantz.

Longitudinal and cross joints separate bedrock into large blocks called tors; examples include Wolf Rock and Chimney Rock. Contact zones between the Catoctin Formation and Chilhowee Group rocks form linear valleys. Slopes are littered with boulders creeping downward under the influence of gravity, plant roots, and freeze-thaw cycles.

The area is drained by the aforementioned Owens Creek in the north and Hunting Creek (also called Big Hunting Creek) in the south. Route 77 follows the valley of Hunting Creek, and an unnamed branch of it forms a canyon followed by the park entrance road. Both of these streams are tributary to the Monocacy River. Drainage preferentially follows cross and longitudinal joints and fractures in the folded bedrock, showing a moderate trellis pattern [Cvancara95]. Water in the Monocacy thence moves through the Potomac River to Chesapeake Bay. There are no sizable lakes or ponds within the Park, but a dam forms Hunting Creek Lake in Cunningham Falls SP. In addition, there are 18 wetland areas, comprising approximately 58 ha.

Threats to water quality are a concern to park management, as the headwaters of Hunting Creek lie outside the Park, and a sewage treatment plant near the Owens headwaters would be harmful in the event of malfunction. A water quality monitoring program was begun in 1978 with chemical sampling, and benthic macroinvertebrate sampling was added in 1981. As of the present, water quality remains good [NPS09]. Owens Creek also supports a fish hatchery downstream [DeLorme93].

However, water quality in the encompassing Monocacy River watershed remains under the pressure of nutrient enrichment, sedimentation, and contamination by pathogens [MSRAB90].

From a soils perspective, the land is stony and steeply sloped. Roughly 38.0% of the Park is characterized as the Ravenrock-Highfield-Rock outcrop complex, of various subgrades with slopes from 0 to 65%; another 14.8% is Highfield gravelly silt loam, 3-25% slopes; 10.4% is Ravenrock-Rohrersville complex, 3-15% slopes; and 10.3% is Stumptown-Bagtown-Rock outcrop complex, 25-65% slopes. 35.1% of the Park is rated at 25% slopes or greater [NRCS09]. Characteristics of Ravenrock gravelly loam include:

- Parent material: Gravelly colluvium derived from greenstone
- Surface area covered with cobbles, stones, or boulders: 9.0%
- Depth to restrictive feature: 60 in (150 cm) to lithic bedrock
- Well drained
- Depth to water table: About 42 to 72 in (105 to 185 cm)
- Land capability (non-irrigated): 6s
    - Class 6 soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover; subclass s soils have limitations within the rooting zone, such as shallowness of the rooting zone, and others [NRCS07].
- Typical profile:
    - 0 to 4 in (0 to 10 cm): Extremely stony loam
    - 65 to 80 in (165 to 200 cm): Weathered bedrock

Geologic Formations and Structures

The Park consists of several folded formations of old metamorphic rocks from Cambrian and earlier time periods [Southworth06, Thornberry-Ehrlich09].

Basement rocks that do not crop out within the Park are Precambrian granodiorite and biotite granite gneiss.

The greatest surface area is accounted for by the Catoctin Formation's Metabasalt (map unit Zc); it forms the bedrock for the central mountain whose apex is Hightop. To the northwest, it is replaced by the Catoctin Metarhyolite (Zcr). To the southeast, the bedrock for Wolf Rock and Chimney Rock is made up of various members of the Weverton Formation: Owens Creek (Ꞓwo), Maryland Heights (Ꞓwm), and Buzzard Knob (Ꞓwb). These two predominant Formations are separated by a band of Loudoun Formation Conglomerate (Ꞓlc) and Phyllite (Ꞓlp). At the Park's eastern boundary is a quantity of Harpers Formation (Ꞓh), and just outside the Park, in the vicinity of Cunningham Falls, is a quantity of Catoctin Porphyritic (Zcp). Harpers and Weverton comprise part of the Chilhowee Group. A small amount of Quaternary Alluvium (Qa) and Terrace Deposits (Qt) are found in the stream valleys.

In a cross section from southeast to northwest, all of the formations mentioned above are second-order folds that verge northwest in regular fashion up the east limb of the Blue Ridge-South Mountain Anticlinorium. Beginning in the southeast, the formations are Ꞓh, Ꞓwo, Ꞓwm, Ꞓwb, Ꞓlc, Ꞓlp, Zc, Zcr, Zc, Zcr, Zc, Zcr, Zc.

The Catoctin Metarhyolite constitutes the oldest rocks to be found in the parks of the national capital region, dated to about 560 Ma by examining zircon samples with the Sensitive High-Resolution Ion Micro-probe mass spectrometer. These lavas originally erupted from fissures during rifting of Laurentia (in perhaps ten flows over a short period of time [3 to 5 million years]), and they were soon overlain by quartz-rich sediments of the continental margin and metamorphosed. Whereas elsewhere in the province, the Metabasalt is more prevalent, across the state of Maryland the Metarhyolite predominates.

Fig. 2

The green Metabasalt consists of massive, schistose rock containing vesicles, some filled with secondary minerals and some void. The Metabasalt, rich in Ca and Mg, weathers to an orange, clay-rich soil. Locally, the rock contains light-green masses of quartz and epidosite.

The foliated Metarhyolite is a fine-grained, blue-black rock that weathers to slabs of light gray. It is locally intercalated with tan phyllite and quartz-sericite schist. The cryptocrystalline rock was prized by Native Americans for its use as projectile points. Overall thickness of the entire Catoctin Formation is estimated at 600 m. Its erosion resistance is described as "moderately high, depending on the degree of alteration."

The Loudoun Formation dates to the Lower Cambrian. The basal Conglomerate consists of quartz (mostly milky white, but some is gray or dusky red) and red jasper. It probably represents local channel and fan deposits. The Phyllite is dark, variegated, tuffaceous, locally vesicular, and amygdaloidal, and is probably volcanoclastic fluvial deposits. Loudoun Formation rocks, showing moderately high resistance to erosion, reflect the transition between the dominantly volcanic environment of the Proterozoic and the fluvial Cambrian.

Also of the Lower Cambrian, moderately erosion-resistant Weverton Formation rocks include the basal Buzzard Knob Member, a light-gray combination of metagraywacke, quartzite, meta-arkose, and metasiltstone.

Fig. 3

Gray quartzite interbedded with metasiltstone makes up the Maryland Heights Member, which forms Chimney Rock and Wolf Rock (Fig. 3 shows a detail).

Fig. 4

Above this unit is the Owens Creek Member, a dark-gray quartzite and pebble conglomerate interpreted as alluvial-plain deposits.

Apart from Quaternary deposits, the youngest rocks in the Park are the Cambrian Harpers Formation, phyllite and metasandstone interbedded with more metasandstone, read as delta and tidal flat rocks. Burrow trace fossils of *Skolithos linearis* can be found.

As noted above, the rocks of the Park are part of the east limb of the Blue Ridge-South Mountain Anticlinorium. The axial surface of the fold is inclined to the southeast and the fold plunges at a low angle to the northeast.

A large normal fault just to the east of the Park forms the border fault to the Gettysburg Basin and the Frederick Valley in the Piedmont Province.

Geologic History

The history of the Blue Ridge Province and the mid-Atlantic region in general can be understood as the buildup and erosion of four chains of mountains over four respective long spans of time [Fichter00, PRI09]. Each chain is the result of a collision of North America (more specifically, the plates that became identified as North America in our time) with other plates underlying bits of today's Europe, Africa, and South America.

The narrative begins with the earliest rocks to leave a record that we can read today, the mountains called Grenville. About 1.1 Ga (i.e., in the Precambrian), a plate (tentatively identified as Africa) overrode North America, scraping sedimentary rock and buckling the crust to form this range. The mountain peaks themselves are long gone, eroded away in the course of 500 million years, but the batholithic roots of the mountains are still exposed here and there.

In the late Precambrian and early Cambrian (ca. 565 Ma), rifting opened up between America and Africa that when filled with water became the Iapetus Ocean. Basalt flows associated with this event, later metamorphosed, are described as the Catoctin Formation. At about 550 Ma, further rifting and sedimentary filling of the consequent grabens created the rocks identified as the Chilhowee Group: the Weverton, Harpers, and Antietam Formations.

While carbonate rocks formed at the shelf along the Iapetus, tectonic calm reigned for a time. Then, in the middle to later Ordovician (450-435 Ma), a combination volcanic arc/microcontinent known as the Taconic Terrane struck a pair of glancing blows against the irregular coastline. The overthrusting terrane formed the Taconic Mountains, and the subducted continent formed foreland basins (including the Queenston in Pennsylvania) that filled in with flysch.

A period of slow erosion during the Silurian and early Devonian (435-370 Ma) wore the mountains down to a peneplain; the period culminated in the buildup of layers of pure-quartz sandstone, the Oriskany Formation. Next, at 380-350 Ma, proto-Europe (called

Baltica or Armorica) slid into Laurentia[1] from the southeast to form the Acadian Mountains. As with the Taconic orogeny, much of the record of this event is in the clastic sediments left behind, among them the Old Red Sandstone.

The Mississippian (350-320 Ma) was another period of quiet erosion. Then, over a period of 70 million years during the late Paleozoic, the Iapetus Ocean closed up and Africa (now part of the supercontinent Gondwanda) collided with North America, riding up over it perhaps as far west as today's Allegheny Front. All the rocks heretofore formed were subducted (and underwent metamorphosis, and heavy folding, faulting, and translation) while Africa's leading edge crumpled into the Alleghanian Mountains. Once again, these mountains leave no direct trace, but have eroded into sediments (transported westward, in this case).

Thereafter, an unconformity appears in the geologic record, but by the Triassic (about 245 Ma), evidence appears associated with ocean formation: Gondwana separated from Laurasia (North America and Eurasia) and the Atlantic Ocean opened. Rift valleys opened from this event include Culpeper and Gettysburg, just to the east of our park of interest. On a smaller scale, half-grabens developed throughout the Piedmont Province.

The remaining 175 million years of geology are taken up with the gradual distribution of sediment to the east to form the Coastal Plain Province. Jumping forward to much more recent times, the most recent glaciations during the Pleistocene came close (150 km to the north in Pennsylvania) but did not reach our study site [Southworth06].

Today's Appalachian Mountains are not the worn-down remnants of the last of the four great chains of mountains created here, but rather the uplifted bits and pieces of their roots.

References

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[1] Echoes of that collision can be heard in this passage from the twentieth century's great literary experiment in tectonic stratification, [Joyce59], p. 3: "Sir Tristram, violer d'amores, fr'over the short sea, had passencore rearrived from North Armorica on this side the scraggy isthmus of Europe Minor to wielderfight his penisolate war: nor had topsawyer's rocks by the stream Oconee exaggerated themselse to Laurens County's gorgios while they went doublin their mumper all the time..."

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Includes a map redrawn from [Southworth06] with slightly greater coverage.

[USGS85] U.S. Geological Survey, *Blue Ridge Summit, Pa. – Md.*, quadrangle map 39077-F4-TF-024, published 1953, photorevised 1985, accessed online 17 November 2009.

Supplementary Information: Enlargements

Fig. 1 (Chimney Rock): <http://www.flickr.com/photos/32054489@N00/4125870951/>

Fig. 2 (greenstone exposure): <http://www.flickr.com/photos/32054489@N00/4125870941/>

Fig. 3 (Wolf Rock detail): <http://www.flickr.com/photos/32054489@N00/4125870943/>

Fig. 4 (conglomerate cobble): <http://www.flickr.com/photos/32054489@N00/4125870963/>