National Park Service
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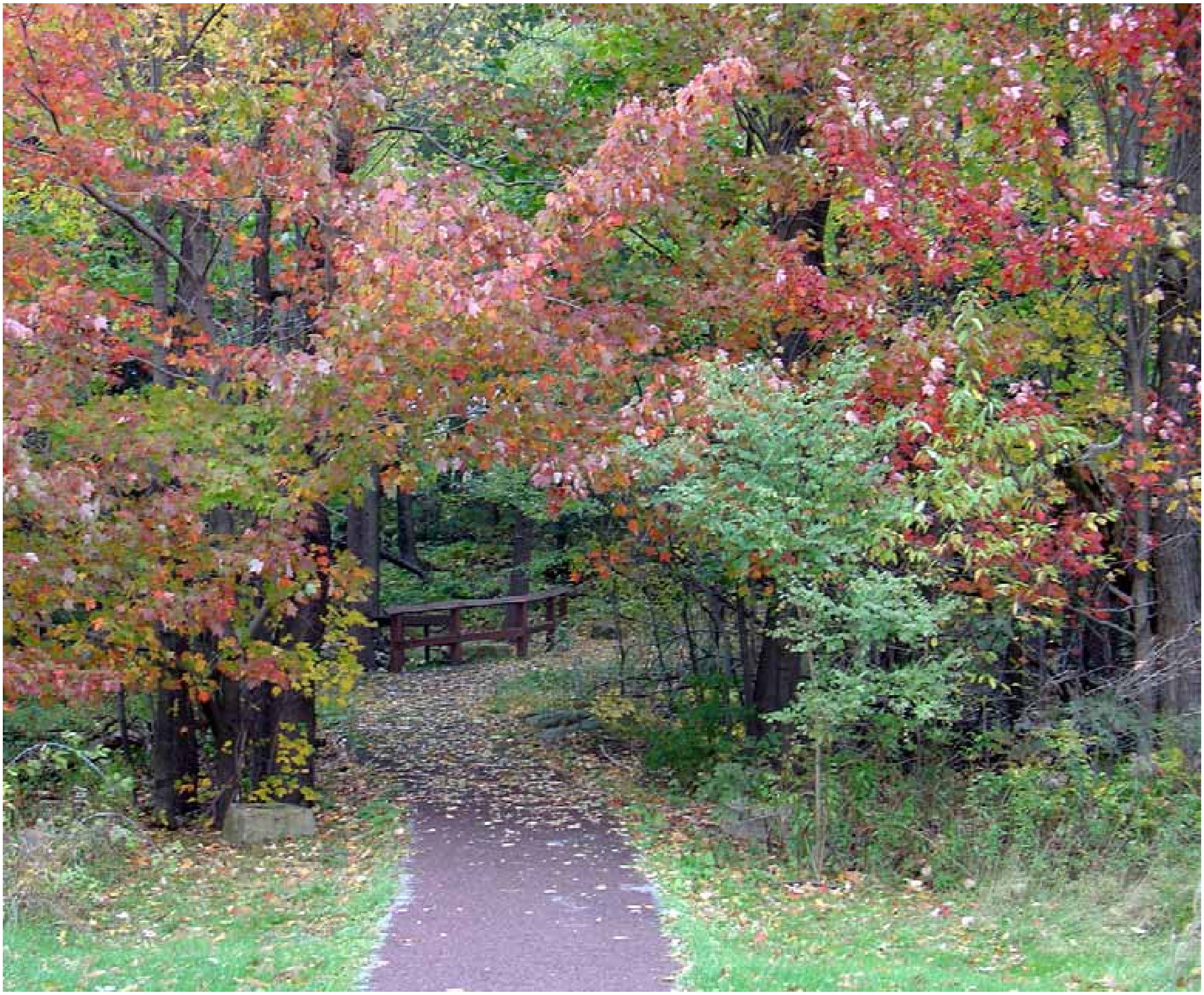
Natural Resource Program Center

Allegheny Portage Railroad National Historic Site

Geologic Resource Evaluation Report

Natural Resource Report NPS/NRPC/GRD/NRR—2008/045



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Park trail, Allegheny Portage Railroad NHS

ON THE COVER:
Skew arch bridge, Allegheny Portage Railroad NHS

NPS Photos

Allegheny Portage Railroad National Historic Site

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Geologic Resources Division
Natural Resource Program Center
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Executive Summary

This report accompanies the digital geologic map for Allegheny Portage Railroad National Historic Site in Pennsylvania, which the Geologic Resources Division produced in collaboration with its partners. It contains information relevant to resource management and scientific research.

Allegheny Portage Railroad National Historic Site commemorates the pioneering lifestyle and highlights the 19th-century engineering effort that resulted in the construction of a railroad through the Allegheny Mountains. This railroad included 10 inclined planes and the nation's first railroad tunnel. The Allegheny Portage Railroad allowed the transport of boats from the Pennsylvania canal over the Allegheny Mountains.

The park protects the landscape in part of the Allegheny Front in central Pennsylvania. The park is located along the boundary between the Valley and Ridge and the Appalachian Plateaus physiographic province. This area displays a sharp contrast between the folded and faulted rocks on the eastern edge of the mountains versus the eroded, horizontal beds (plateaus) of the western side.

The geologic substrate, as well as surficial processes (geologic, hydrologic, and biologic), determine the features of every landscape. Geologic processes gave rise to rock formations, mountains and valleys, escarpments and ridges, dissected plateaus, and coal deposits at Allegheny Portage Railroad National Historic Site. The landscape played a prominent role in the history of central Pennsylvania with respect to early settlement, mining activity, and the development of trade and transportation routes. Knowledge of the park's natural and cultural resources, including the geology, directly influences resource management decisions in the park.

Geologic processes and the features these processes produce can be interpreted to enhance the visitor experience. The park's richness in geological, biological, historical, and cultural resources are key elements in land-use planning and in planning visitor uses in the park. A detailed geologic map, interpretive exhibits, and a road or trail log would enhance the visitor's appreciation of the geologic history and dynamic processes that created the park's natural landscape.

In addition to natural processes, human activities have played a significant role in determining the surficial features at the park, as well as affecting the ecological response to natural changes. Mining, railroad construction, tunnel blasting, and human settlement have changed the landscape and its response to erosion and other surficial processes and can create noticeable changes to the landscape within a human's life span.

The following features, issues, and processes (discussed in the "Geologic Issues" section of this report) have geological importance and a high level of management significance within the park:

- Mining and Energy
  Allegheny Portage Railroad is located in areas of central Pennsylvania known for coal mining. Abandoned and inactive mines pose health, safety, and environmental problems in the vicinity of the park. Geologic Resources Division (GRD) records indicate that the park has at least four abandoned mine land (AML) sites with 17 openings. All known shafts and adits in the park are sealed and do not present an immediate hazard (John Burghardt GRD, personal communication 2008). However, there is a history of and the potential for subsidence due to the collapse of underground mine workings in the park. Future construction activities need to consider the location of underground mines to minimize this hazard. Additionally, the acid mine drainage and heavy metal contamination that accompanies low pH runoff from sources outside the park is a serious resource management concern.
- Water
  The historic site protects large parts of several watersheds, including important tributaries to the Ohio and Susquehanna Rivers. Intense seasonal thunderstorms and high runoff cause flooding along these waterways. This flooding threatens many of the historical structures and natural features at the park. It is crucial for resource management staff to understand the hydrogeologic system at the park, including ground-water movement.
- Geologic hazards
  The steep terrain that characterizes the Allegheny Front region is prone to landslides, slumps, and rockfalls. In particular, areas containing resistant rock units undercut by erosion of weaker underlying units or areas altered by human use are susceptible to geologic hazards. Though not common, seismic activity is possible in central Pennsylvania. Even minor seismic tremors can trigger massive landslides and debris flows on steep and/or water-saturated slopes.
- Recreational demands
  The site preserves natural lands for recreational use. Without proper management, overuse of certain areas can lead to contamination from human waste and trash, and degradation of the ecosystem, such as trampling and removal of vegetation, soil compaction, and increased erosion.

Introduction

The following section briefly describes the National Park Service Geologic Resource Evaluation Program and the regional geologic setting of Allegheny Portage Railroad National Historic Site.

Purpose of the Geologic Resource Evaluation Program

The Geologic Resource Evaluation (GRE) Program is one of 12 inventories funded under the NPS Natural Resource Challenge designed to enhance baseline information available to park managers. The program carries out the geologic component of the inventory effort from the development of digital geologic maps to providing park staff with a geologic report tailored to a park's specific geologic resource issues. The Geologic Resources Division of the Natural Resource Program Center administers this program. The GRE team relies heavily on partnerships with the U.S. Geological Survey, Colorado State University, state surveys, and others in developing GRE products.

The goal of the GRE Program is to increase understanding of the geologic processes at work in parks and provide sound geologic information for use in park decision making. Sound park stewardship relies on understanding natural resources and their role in the ecosystem. Geology is the foundation of park ecosystems. The compilation and use of natural resource information by park managers is called for in section 204 of the National Parks Omnibus Management Act of 1998 and in NPS-75, Natural Resources Inventory and Monitoring Guideline.

To realize this goal, the GRE team is systematically working towards providing each of the identified 270 natural area parks with a geologic scoping meeting, a digital geologic map, and a geologic report. These products support the stewardship of park resources and are designed for non-geoscientists. During scoping meetings the GRE team brings together park staff and geologic experts to review available geologic maps and discuss specific geologic issues, features, and processes.

The GRE mapping team converts the geologic maps identified for park use at the scoping meeting into digital geologic data in accordance with their innovative Geographic Information Systems (GIS) Data Model. These digital data sets bring an exciting interactive dimension to traditional paper maps by providing geologic data for use in park GIS and facilitating the incorporation of geologic considerations into a wide range of resource management applications. The newest maps come complete with interactive help files. As a companion to the digital geologic maps, the GRE team prepares a park-specific geologic report that aids in use of the maps and provides park managers with an overview of park geology and geologic resource management issues.

For additional information regarding the content of this report and up to date GRE contact information please refer to the Geologic Resource Evaluation Web site (http://www.nature.nps.gov/geology/inventory/).

Geologic Setting

Allegheny Portage Railroad National Historic Site is located at the junction of the Appalachian Plateaus and the Valley and Ridge physiographic provinces. These provinces are divided into sections. The park is located within the transition zone between the Appalachian Mountain and Allegheny Front sections (fig. 1), extending from the eastern edge of the Appalachian Plateaus province (the Allegheny Front) to the summit of Cresson Ridge.

Stream valleys dividing high, rounded ridges characterize the topography in the park. The ridgetops are composed of resistant Paleozoic sandstone. Valleys separate the ridgetops and are underlain by less-resistant units, such as carbonate rocks and shale that have been preferentially eroded.

A general east-to-west description of several of the different physiographic provinces of the Appalachian Mountains follows. This information is relevant to understanding the geologic history of Allegheny Portage Railroad National Historic Site.

Piedmont Province

The "Fall Line," or "Fall Zone," marks a transitional zone where the softer, less- consolidated sedimentary rocks of the Atlantic Coastal Plain to the east intersect the harder, more resistant metamorphic rocks to the west forming an area of ridges, waterfalls, and rapids. Examples of the transition are present in the Potomac Gorge of the Chesapeake and Ohio Canal National Historic Park. The Piedmont physiographic province encompasses the Fall Line westward to the Blue Ridge Mountains. The eastward-sloping Piedmont formed through a combination of folds, faults, uplifts, and erosion. The resulting eastern landscape of gently rolling hills starting at 60 m (197 ft) in elevation becomes gradually steeper westward toward the western edge of the province and reaches 300 m (984 ft) above sea level. The Piedmont Plateau is composed of hard, crystalline igneous and metamorphic rocks, such as schist, phyllite, slate, gneiss, and gabbro.

Blue Ridge Province

The Blue Ridge province is located along the eastern edge of the Appalachian Mountains and includes the highest elevations in the Appalachian Mountain system, in Great Smoky Mountains National Park in North Carolina and Tennessee. Precambrian and Paleozoic igneous, sedimentary, and metamorphic rocks were uplifted during several orogenic events forming the steep, rugged terrain. Resistant Cambrian quartzite forms most of the high ridges, whereas Precambrian metamorphic rocks underlie the valleys.

The elongate belt of the Blue Ridge stretches from Georgia to Pennsylvania. Eroding streams have narrowed the northern section of the Blue Ridge Mountains into a thin band of steep ridges that rise to heights of approximately 1,200 m (3,937 ft).

Valley and Ridge Province

Long, parallel ridges separated by valleys 100–200 m (330–660 ft) below the ridges characterize the landscape of the Valley and Ridge physiographic province (also referred to as the "Ridge and Valley province"). The valleys formed in areas of more easily eroded shale and carbonate formations, and the ridges are commonly composed of more resistant sandstone units. The province contains strongly folded and faulted sedimentary rocks in central Pennsylvania. The Valley and Ridge province averages approximately 80 km (50 mi) in width. The eastern part of the Valley and Ridge province is the Great Valley section, a rolling lowland formed on folded carbonate rocks and shale. It is connected to the Piedmont province by streams that cut through the Blue Ridge Mountains.

Appalachian Plateaus Province

Compared to the eastern Appalachian physiographic provinces, the Appalachian Plateaus province is relatively undeformed. Instead of the highly folded and inclined strata of the Valley and Ridge province, the rock layers are nearly flat. A steep scarp known as the Allegheny Front bounds the plateau on the east. This escarpment rises abruptly from 300 to 900 m (1,000 to 3,000 ft). Maximum elevations at this front are generally greater than those of the ridges in the Valley and Ridge province. In Pennsylvania, elevations range from 530 to 900 m (1,750 to 3,000 ft). Deep ravines carved into the horizontal sedimentary rock layers characterize the topography of this province. Geologic units are typically repetitious sequences of shale, coal, limestone, and sandstone. Erosion of these units has created a rugged, jumbled topographic surface. The northern parts of the province in Pennsylvania and New York are typically more rounded hills with gentle slopes.

History of the Allegheny Portage Railroad

Allegheny Portage Railroad National Historic Site preserves parts (1,296 acres) of the 1834–54 inclined-plane railroad system. This type of railroad was the first constructed over the Allegheny Mountains of Pennsylvania. The inclined-plane railroad (with 10 planes) helped establish the interior of the United States as a trade and settlement center (fig. 2).

The main unit, designated as a national historic site on August 31, 1964, is located approximately 19 km (12 mi) west of Altoona, Pennsylvania, and the Staple Bend Tunnel unit is located approximately 6 km (4 mi) east of Johnstown, Pennsylvania. The historic Staple Bend Tunnel was the first railroad tunnel in the country (fig. 3). The site's boundaries changed November 10, 1978, and December 19, 2002.

The park stretches 59 km (37 mi) through the Allegheny Mountains in Blair and Cambria Counties. The mountains there range in elevation from 346 m (1,135 ft) to 734 m (2,408 ft) above sea level. Prior to construction of the railroad, the mountains were a significant obstacle to boat trade between the eastern and western divisions of the Pennsylvania Mainline Canal. After the railroad was built, trains portaged the boats across mountain slopes of more than 5 degrees.

The main unit of the park lies on the divide between the Chesapeake Bay watershed to the east and the Ohio River basin on the west. Blair Gap Run flows from Cresson Summit towards the Juniata River, and Bradley Run flows towards the West Branch of the Susquehanna River on the Chesapeake Bay side and on the Ohio River side water flows parallel to the Little Conemaugh River.

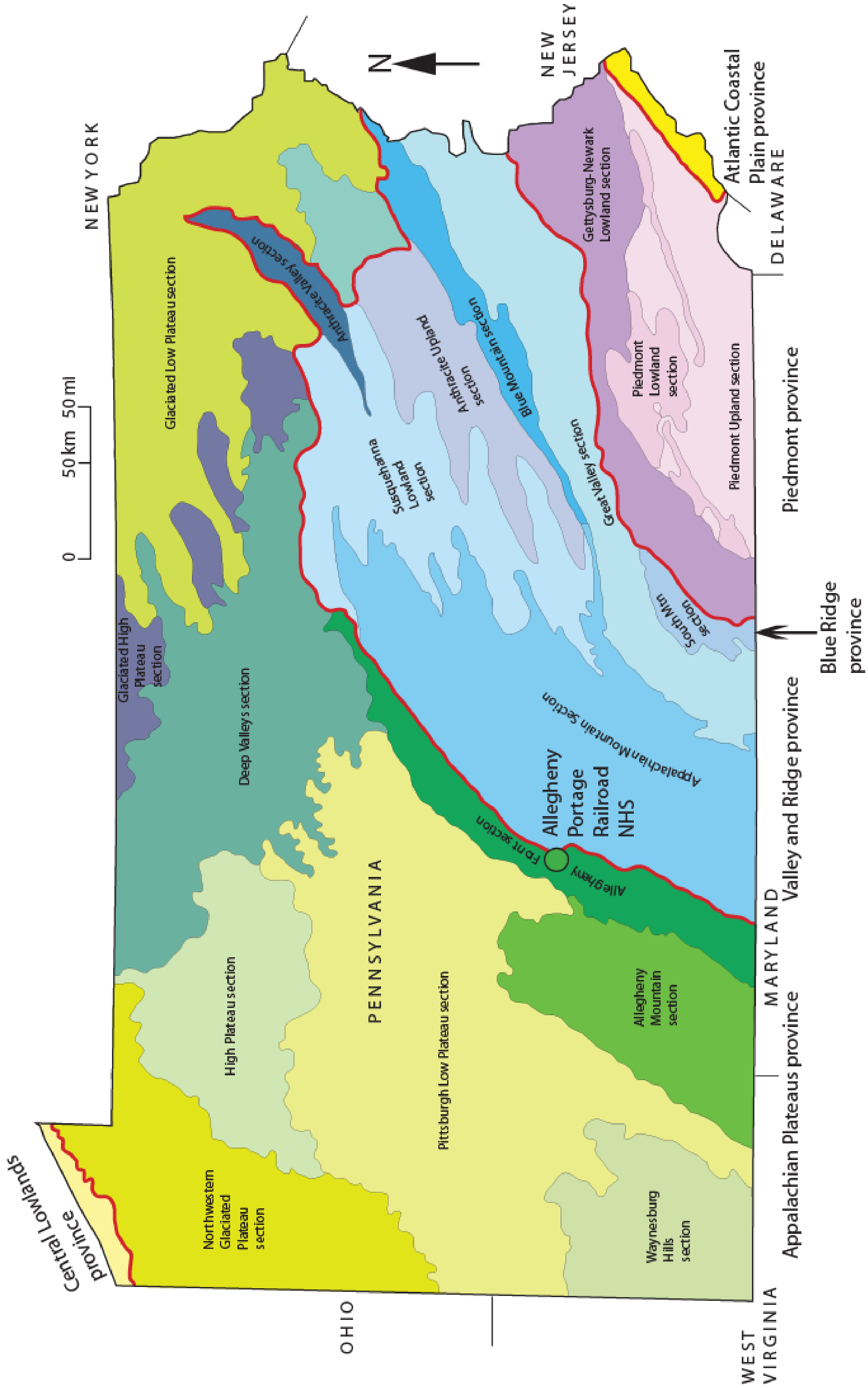


Figure 1. Map of Pennsylvania showing physiographic setting of Allegheny Portage Railroad National Historic Site (National Historic Site). Red lines indicate boundaries between major physiographic provinces. Northern terminus of Blue Ridge province is located by the black arrow. Location of park is indicated by a green circle. Map information modified from Pennsylvania Geological Survey (map 13, 2000). Graphic by Trista L. Thornberry-Ehrlich (Colorado State University).

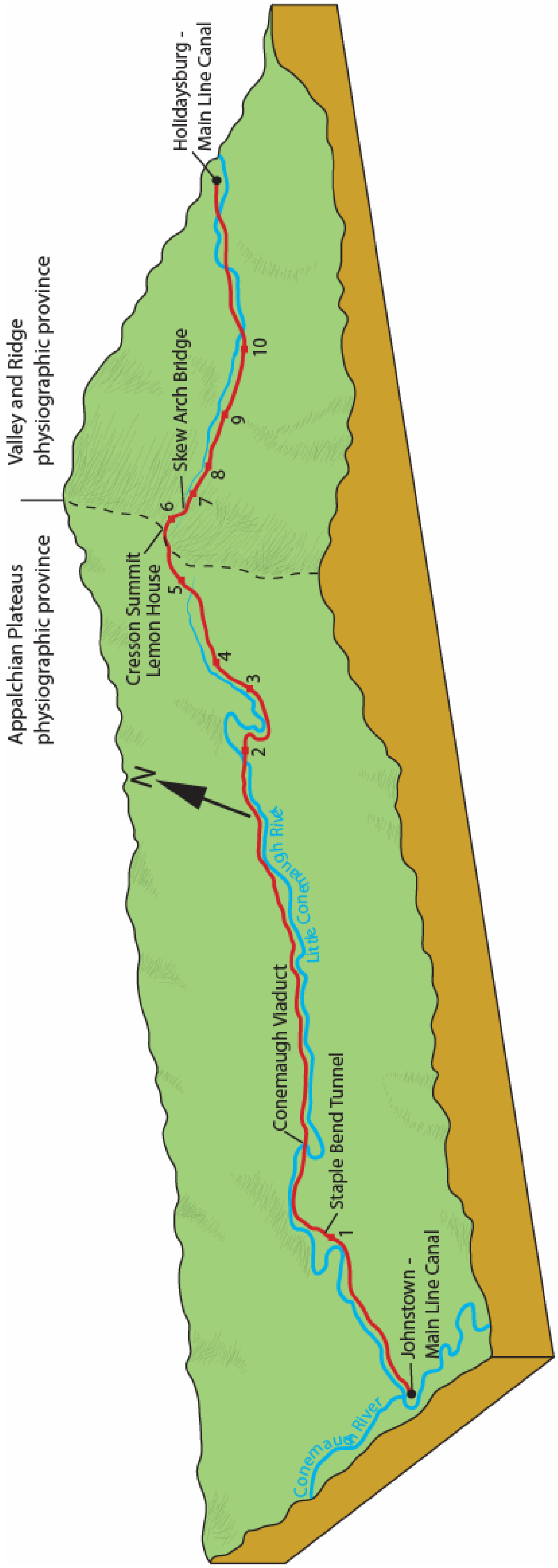


Figure 2. Map showing the 10 inclined planes (numbered) of the Allegheny Portage Railroad (red line) over the Cresson Summit of the Allegheny Front between the Valley and Ridge and Appalachian Plateaus physiographic provinces. Note locations of Staple Bend Tunnel, Conemaugh Viaduct, Skew Arch Bridge, and Lemon House. Map is not to scale. Graphic revised from http://www.cr.nps.gov/nr/twhp/wwwlps/lessons/23allegheny/23visual1.htm by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 3. Historic Staple Bend Tunnel at Allegheny Portage Railroad National Historic Site before and after its restoration in 2000–2001. The tunnel linked inclined planes numbers 1 and 2. Top photograph is courtesy of the Railroad Museum of Pennsylvania. Bottom photograph is from http://www.todayinsci.com/cgi-bin/indexpage.pl?http://www.todayinsci.com/3/3_18.htm (accessed August 24, 2006)

Geologic Issues

A Geologic Resource Evaluation scoping session was held for Allegheny Portage Railroad National Historic Site on June 22, 2004, to discuss geologic resources, address the status of geologic mapping, and assess resource management issues and needs. This section synthesizes the scoping results, in particular those issues that may require attention from resource managers.

Mining and Energy

Although there are no current mining operations in Allegheny Portage Railroad National Historic Site, coal mining has long been associated with central Pennsylvania. The Pennsylvanian Allegheny Group includes the commercially viable Freeport, Kittanning, and Brookville-Clarion coal seams within the park. Extensive underground coal mines in the park, including 4 sites with 17 openings, produce acid mine drainage and have the potential for subsidence and collapse of mine workings. The Pennsylvania Department of Environmental Protection maps show mines and document subsidence associated with the historic mining. In 1992 it was reported that subsidence related to historic mining occurred between Lemon House, a historic structure, and Highway22. Future construction activities need to consider the location of underground mines to minimize this hazard. It would also be prudent for park staff to develop contingency plans for temporary fencing, warning signs, and backfilling to reduce hazards following subsidence.

GRD records indicate that all known shafts and adits in the park are sealed and do not present an immediate hazard (John Burghardt GRD, personal communication 2008). However, a formal AML inventory is needed to identify potential threats.

Abandoned and inactive mines pose environmental and health problems for the Allegheny Portage Railroad area. Foremost among these is acid mine drainage and residual heavy metal contamination of ground water, surface water, and soil. Mine areas within and upstream from the Allegheny Portage Railroad units produce acid mine drainage. Fluvial sediments (sediments carried by streams and rivers) can contain metals and other waste materials. Springs and seeps in the Staple Bend Tunnel unit are being monitored for acid mine drainage due to their proximity to local coal mines.

The acidity of coal-mine drainage is caused primarily by the oxidation of the mineral pyrite, which is found in coal, coal overburden, and mine waste piles. The rate of pyrite oxidation depends on the following: reactive surface area of the pyrite, the oxygen concentration and pH of the water, the forms of pyrite, and the presence of iron-oxidizing bacteria (Thiobacillus ferroxidans) (http://energy.er.usgs.gov/health_environment/acid_mine_drainage/index.htm Accessed September 2008).

Acid mine drainage can leach major elements such as aluminum, calcium, and magnesium and trace elements such as copper and zinc from surrounding rocks. Newly-formed acidic, metal-rich waters can then flow into receiving streams. These metals are transported from the vicinity of a mine by ground and surface water as dissolved ions, suspended sediment, or as part of the bedload in a stream (Madison et al. 1998).

Iron ore was locally mined from the Silurian Clinton Group rock units, where it was present in limestone as siderite (iron carbonate). Limestone necessary for smelting was also available and locally abundant. Effects of this mining are unknown at the park. The area also has local sandstone quarries for building materials. Stones from these quarries were used in the construction of Staple Bend Tunnel.

In addition, research that GRD conducted in 1996 indicates that two oil and gas pipelines cross Allegheny Portage National Historic Site. Pipeline locations should be considered when planning park construction or resource management activities (Kerry Moss, GRD personal communication 2008)

Inventory, Monitoring, and Research Suggestions for Mining Issues

- Determine pathways for the contaminants and work with mine owners, regulatory agencies and others to remediate the acid mine drainage and other problems associated with the upstream mines.
- Work closely with state officials and owners of adjacent mining operations to ensure that blasting activities and off-site acid mine drainage do not increase the likelihood of subsidence or resource damage in the park.
- Continue mine remediation in the park.
- Monitor biota (e.g., aquatic insects) for heavy-metal contamination.
- Incorporate Pennsylvania Department of Environmental Protection maps of mine features into a GIS database.
- Have a trained inspector investigate mine features (shafts and drainage) at all park units, including collapsed features at Staple Bend Tunnel unit.

Water

It is crucial for resource management to understand the hydrogeologic system at the park. Understanding ground-water flow is necessary to predict hydrologic response to inputs such as contaminants and other wastes. The movement of nutrients and contaminants in aquifers can be modeled by monitoring the composition of hydrologic inputs, such as rainfall, and outputs, such as streamflow. Other sources of inputs include windblown materials, surface runoff, sewage outfalls, landfills, and fill dirt. Surface and ground-water flow are interconnected, and contamination in one part of the system may be transferred to, and detected in, other parts of the hydrogeologic system. Thus, streams provide a measure of the chemical status of the hydrologic system in a watershed. Consistent measurement of these parameters is crucial to establishing baseline conditions that can be used during monitoring.

Blair Gap Run is a mountain stream that is regularly monitored by the park. The headwaters of this Susquehanna River tributary are within the main unit of the park. The trace of the railroad followed Blair Gap across the mountains. Water quality of the Little Conemaugh River at the Staple Bend Tunnel unit has been degraded by acid mine drainage from sources within and adjacent to parklands. Park staff are currently taking steps to remediate the contamination of water flowing through the park.

There is a risk of damage and loss of resources due to flooding associated with the rivers and streams at Allegheny Portage Railroad National Historic Site. Floods are most common during spring runoff and seasonal storm events.

There are several springs and seeps within Allegheny Portage Railroad National Historic Site. Seeps within the Staple Bend Tunnel unit are fed from collapsed mines and have high concentrations of heavy metals. These seeps are associated with the formation of iron mounds on park property.

Inventory, Monitoring, and Research Suggestions for Water Issues

- Research the influence of bedrock and topography on local watersheds at Allegheny Portage Railroad National Historic Site.
- Develop a park-wide flood-warning system and evacuation plan.
- Consult Pennsylvania Geological Survey water reports to obtain further data on the hydrologic system in the park.

Geologic Hazards

The steep terrain in the Allegheny Front that prompted construction of the Allegheny Portage Railroad is prone to geologic hazards, including landslides, slumps, and rockfalls. Historic features in the park, including the railroad and Staple Bend Tunnel, are at risk of damage from slope failures, frost wedging, and seismic activity.

The geologic units in the park are a heterogeneous mix of shale, sandstone, siltstone, limestone, dolomite, conglomerate, and mudstone. Clay-rich units such as shale and mudstone may deteriorate when saturated with water and are prone to fail when exposed on steep slopes. When more resistant rock units such as sandstone and limestone overlie weaker units preferential erosion may undercut the resistant rocks and result in rockfalls.

The relationship between, active faulting, moderate or low levels of seismicity, and the risks to structures and human interests in the eastern United States is poorly established (Jacob 1989). Though not common, there is seismic activity in central Pennsylvania. Some historic earthquakes in the area have been attributed to blasting during mining (in 1893 and 1939). However, a natural ~5 magnitude quake did occur in northwest Pennsylvania in 1986 (Scharnberger, 1987). Even minor seismic tremors can trigger massive landslides and debris flows on steep and/or water-saturated slopes. Risks associated with seismic activity should be assessed at Allegheny Portage Railroad.

Inventory, Monitoring, and Research Suggestions for Geologic Hazards

- Investigate clay-rich layers exposed on slopes for vulnerability to slope failure.
- Monitor steep slopes along the Allegheny Front for signs of landslides (seeps, springs, cracks, or scarps).
- Monitor potential for roof fall in Staple Bend Tunnel; remediate potential problem areas.
- Work with geologic societies and others to encourage seismic monitoring in the park and throughout central Pennsylvania.

Recreational Demands

Allegheny Portage Railroad National Historic Site provides numerous recreational opportunities: hiking, cross-country skiing, bird watching, picnicking, photography, and other activities. The park receives many visitors, especially during the summer months. As many as 123,215 people visited the park in 2007. These visitors place increasing demands on the resources of the park, and management concerns include trail erosion, waste treatment, water quality, and potential danger from slope hazards (landslides, rockfalls).

Many trails wind through preserved biological, historical, and geological environments at the park. Many of these are especially fragile, and the wandering of visitors off trails may degrade park resources, placing delicate ecosystems at risk for contamination from human waste and garbage. To minimize the impact, the park directs visitors to designated trails and established picnic areas.

Several streams, including Blair Gap Run and the Little Conemaugh River, enhance the natural beauty of the park. As with hiking, overuse of certain areas can lead to degradation of the ecosystem and increased erosion of riparian areas.

Inventory, Monitoring, and Research Suggestions for Recreational Demands

- Inventory and monitor geologic and other natural resources to further identify human impacts to resources, including springs, wetlands, and marsh flora within the park.
- Design wayside exhibits to encourage responsible use of park resources.

General Geology, Paleontology, and Miscellaneous Issues

The unique geology of the Allegheny Front region and the Valley and Ridge physiographic province has sparked research interest among geologists for many years. Railroad cuts and other developments have exposed excellent outcrops for geologic research (Inners 1989). Additional research would help resource managers at the park better understand the geology and the relationships among physical processes in the ecosystem.

Rocks in the park area contain fossils that record the beginnings of ancient life (fossil algae called stromatolites) through the evolution of land plants (Stoher 1992), and the mass extinction following the Permian Period. These paleontological resources could be displayed at the park for the education of visitors.

In addition to its interest for general research, the park serves as an outdoor classroom and provides an opportunity to interpret the engineering efforts and reasons behind the construction of Allegheny Portage Railroad. This area has been a trade corridor since prehistoric times and continues today as part of the larger Susquehanna Valley corridor (Suciu et al. 1992).

Inventory, Monitoring, and Research Suggestions for General Geology and Miscellaneous Issues

- Map the geomorphology of the park.
- Study cultural resources to better understand landscape evolution, focusing on Native American sites, early settlement activities, and trade (transportation).
- Study paleontological resources within the park. (Interested parties can refer to Vince Santucci's report on Eastern Rivers and Mountains Network paleontology.)

Geologic Features and Processes

This section describes the most prominent and distinctive geologic features and processes in Allegheny Portage Railroad National Historic Site.

Connections between Geology and History

One of the major goals of the park is to preserve the historical context of the area; this includes preserving and restoring the inclined railroad planes (fig. 4), historic buildings, and the landscape around them. Maintaining the cultural landscape often means controlling natural processes, which presents several management challenges.

Geologic processes that affect slopes, such as landsliding, slumping, chemical weathering, block sliding, and slope creep, constantly change the landscape at the park. Runoff erodes sediments from open areas and carries them down streams and gullies. Erosion naturally lowers higher areas, and the lower areas are filled in with sediments, modifying the historic context of the landscape.

The history of the park is heavily influenced by its geology. The valleys and ravines carved into the Allegheny Front region made travel and farming difficult. This natural barrier led to many transportation innovations that allowed safe and relatively easy passage through the mountains. Transportation growth continues in the present day with development of the Pennsylvania interstate corridors.

Allegheny Portage Railroad National Historic Site highlights the engineering marvel of the construction of 10 inclined railroad planes that allowed the portage of boats from the Pennsylvania canal over the Allegheny Mountains (fig. 4). This was the first rail crossing of the Allegheny Mountains, and Staple Bend Tunnel, at 275 m (900 ft), was the first railroad tunnel in the country.

The portage railroad and tunnel were part of a larger system of canals and railroads that connected the trade route between Philadelphia and Pittsburgh and operated until 1900. Coal and iron mines dotted the landscape, as well as regional furnaces to smelt the iron ore. These features document the early industrial development of the area. However, they pose environmental and safety hazards in the park and region (see “Geologic Issues” above).

The history of the area begins long before the development of the railroad in the mid-1800s. Native American settlements and tool quarries predate local European settlement. Earliest known evidence of Native American activity nearby dates from 10,000 years ago at Sheep rock, near Huntingdon, Pennsylvania. Even the name “Allegheny” stems from the mound-building Alligewi, or Allegheny Indians, from western Pennsylvania (Wells 1973).

The Native Americans left artifacts and morphological changes in the landscape, such as terraced campsites, tool quarries, and other archaeological sites in the Susquehanna River Valley and the Allegheny Mountains (Suciu et al. 1992).

It is a challenge to balance the management of cultural and natural resources. For example, the restoration of a historic building (such as the Lemon House or the Engine House) may require altering or removing surrounding terrain, or planting non-native plant species. In order to preserve cultural sites in the park, such as the Lemon House (fig 5), Engine House, Skew Arch Bridge, and Staple Bend Tunnel, geologic and other natural physical processes may be affected.

The Allegheny Front

The Allegheny Front is a sharp escarpment that divides the Appalachian Plateaus and the Valley and Ridge physiographic provinces. This topographic feature extends from northern Pennsylvania into southeastern West Virginia. Overall, the front has an elevation change of roughly 610 m (2,000 ft) and is approximately 280 km (174 mi) long. Historically, the Allegheny Front was an imposing barrier to east-west trade and transportation routes. Thus, this topographic feature was the reason for the construction of the Allegheny Portage Railroad.

The eastern side of the Allegheny Front consists of rounded and linear hills dissected by narrow valleys. These hills step up to the top of the escarpment and are composed of rocks that are highly folded, faulted, and deformed as a result of the Alleghenian orogenic event. In stark contrast, the western side of the front has undulating hills sloping away from the escarpment and is composed of relatively undeformed, horizontally layered rocks that resemble the sediments as they were deposited.

Predominant rock types of the Allegheny Front include sandstone (with some local conglomerate), siltstone, and shale (Whitfield et al. 2001). Geologic features associated with the front in Pennsylvania include Blue Knob, Horse Shoe Curve, Hunter Rocks, Turtle Rocks, Wolf Rocks, and Wopsononock Lookout.

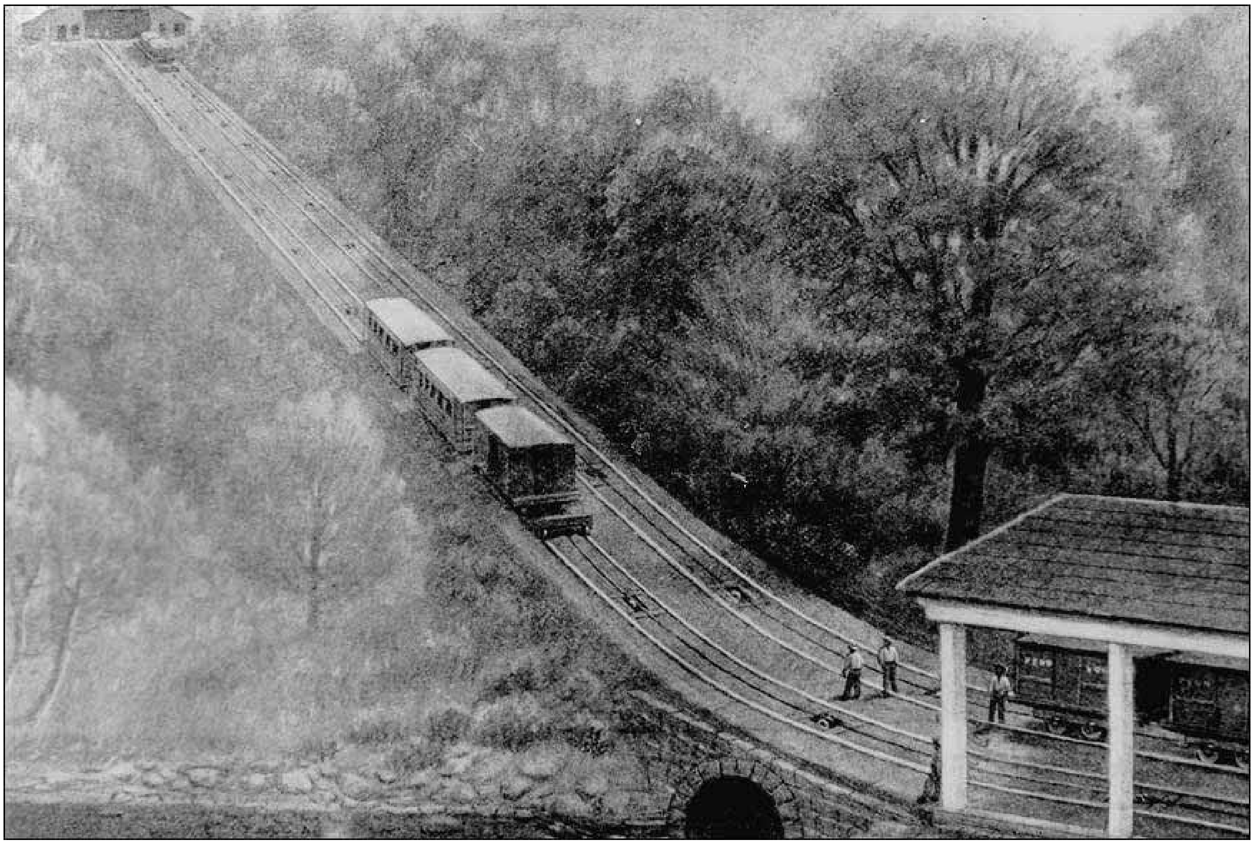


Figure 4. Inclined plane number 8 of the Allegheny Portage Railroad., Painting by George Storm, date unknown; photograph is courtesy of the National Park Service.

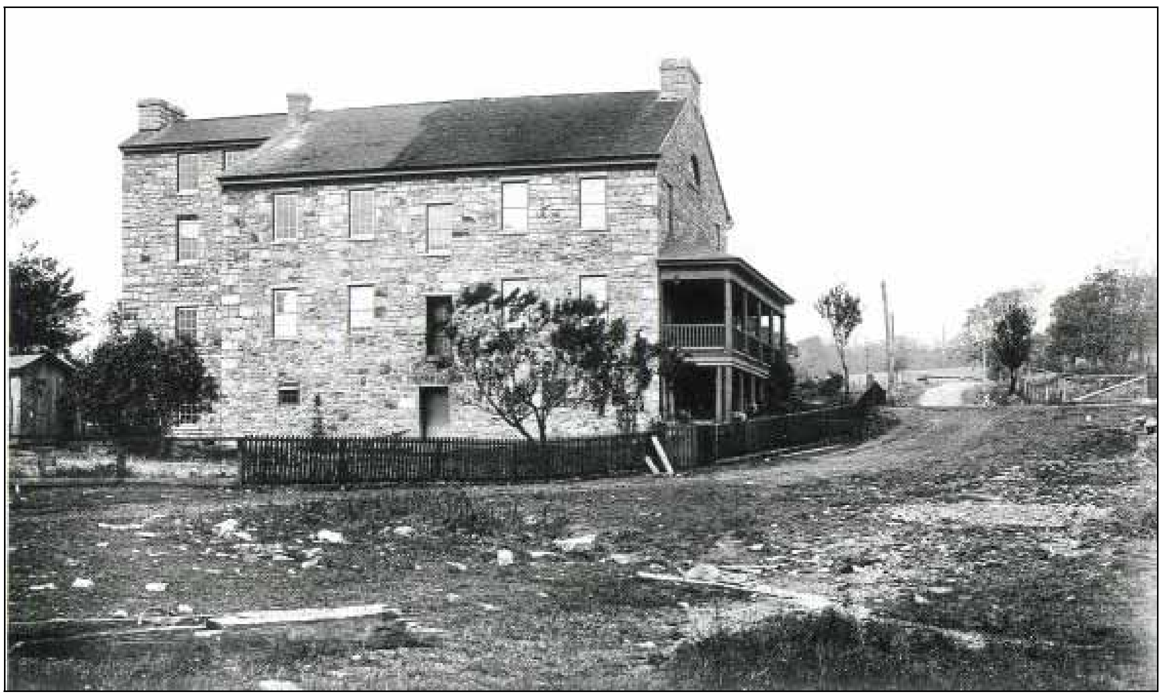


Figure 5. Historic Lemon House inn and tavern near the top of inclined plane number 6 at Allegheny Portage Railroad National Historic Site. Photograph is courtesy of the Railroad Museum of Pennsylvania.

Map Unit Properties

This section identifies characteristics of map units that appear on the Geologic Resource Evaluation digital geologic map of Allegheny Portage Railroad National Historic Site. The accompanying table is highly generalized and is provided for background purposes only. Ground-disturbing activities should not be permitted or denied on the basis of information in this table.

Geologic maps facilitate an understanding of Earth, its processes, and the geologic history responsible for its formation. Hence, the geologic map for Allegheny Portage Railroad National Historic Site informed the "Geologic History," "Geologic Features and Processes," and "Geologic Issues" sections of this report. Geologic maps are essentially two-dimensional representations of complex three-dimensional relationships. The various colors on geologic maps represent rocks and unconsolidated deposits. Bold lines that cross and separate the color patterns mark structural features such as faults and folds. Point symbols indicate features such as dipping strata, sample localities, mine features, wells, and cave openings.

Incorporation of geologic data into a geographic information system (GIS) increases the utility of geologic maps and clarifies spatial relationships to other natural resources and anthropogenic features. Geologic maps are indicators of water resources because they show which rock units are potential aquifers and are useful for finding seeps and springs. Geologic maps do not show soil types and are not soil maps, but they do show parent material, a key factor in soil formation. Furthermore, resource managers have used geologic maps to make correlations between geology and biology; for instance, geologic maps have served as tools for locating threatened and endangered plant species.

Although geologic maps do not show where future earthquakes will occur, the presence of a fault indicates past movement and possible future seismic activity. Geologic maps will not show where the next landslide, rockfall, or volcanic eruption will occur, but mapped deposits show areas that have been susceptible to such geologic hazards. Geologic maps do not show archaeological or cultural resources, but past peoples may have inhabited or been influenced by various geomorphic features that are shown on geologic maps: alluvial terraces may preserve artifacts, and inhabited alcoves may occur at the contact between two rock units.

The features and properties of the geologic units in the following table correspond to the accompanying digital geologic data. Map units are listed from youngest to oldest. Please refer to the geologic time scale (fig. 6) for the age associated with each time period. This table highlights characteristics of map units such as susceptibility to hazards; the occurrence of fossils, cultural resources, mineral resources, and caves; and the suitability as habitat or for recreational use. The following are source data for the GRE digital geologic map:

Whitfield, T.G. and others. 2001. *Digital Bedrock Geology of Pennsylvania, Johnstown and Tyrone 30' x 60' quadrangles, Pennsylvania*. Scale 1:250,000. PAGS 30'x60' Digital Quadrangle maps. Pennsylvania Geological Survey.

McElroy, T.A. 1998. *Groundwater resources of Cambria County, Pennsylvania*. Scale 1:50,000. Water Resource Report W 67. Pennsylvania Geological Survey.

Using ESRI ArcGIS software, the Geologic Resource Evaluation team created a digital geologic map from this source. GRE digital geologic-GIS map products include data in ESRI personal geodatabase, shapefile, and coverage GIS formats, layer files with feature symbology, FGDC metadata, a Windows HelpFile that contains all of the ancillary map information and graphics, and an ESRI ArcMap map document file that easily displays the map. GRE digital geologic data are included on the attached CD and are available through the NPS Data Store (http://science.nature.nps.gov/nrdata/).

Allegheny Portage Railroad National Historic Site lies near the boundary between the Valley and Ridge and Appalachian Plateaus physiographic provinces. The oldest rocks in the park area are the Cambrian Waynesboro, Pleasant Hill, Warrior, and Gatesburg Formations. These units are deformed sedimentary rocks, including dolomite, limestone, sandstone, and shale. The limestone and dolomite units locally contain fossil algae (stromatolites) from early Cambrian seas (Berg et al. 1980; Whitfield et al. 2001).

Ordovician units such as the Nittany, Stonehenge/Larke, Bellefonte, Axemann, Coburn through Loysburg, Reedsville, Bald Eagle, and Juniata Formations were deposited atop the Cambrian units. Cherty dolomite, shale, and fossiliferous limestone dominate the lower units. Siltstone, sandstone, and conglomerate (in the Bald Eagle Formation) become more abundant upwards in the Ordovician stratigraphic sequence.

Following the Taconic orogeny, Silurian units such as the Tuscarora Formation, Clinton Group, Bloomsburg, Mifflintown, and Wills Creek Formations recorded the gradual return to tectonic quiescence and intense erosion of the newly formed Taconic highlands. Sediments changed from largely terrigenous sandstone to mud, and eventually to marine carbonate units with occasional storm-deposited layers as sea level rose and the mountains were beveled (Cotter 1983).

The Keyser and Tonoloway Formations contain fossiliferous limestone and mud-cracked shale that record the transition between the Silurian and Devonian Periods. Marine deposition continued throughout the Devonian as seen in the calcareous shale, siltstone, chert, and fossiliferous limestone of the Onondaga and Old Port Formations, the Hamilton Group, and the Braillier and Harrell Formations.

Sandstone and mudstone become more prevalent in the Scherr, Foreknobs, and Catskill Formations, whereas the argillaceous sandstone and shale with local conglomerate of the Rockwell and the Shenango through Oswayo Formations recorded the transition from the Devonian to the Mississippian Periods (Berg et al. 1980; Whitfield et al. 2001).

Map units from the Mississippian and Pennsylvanian Periods include the Pocono Formation, Burgoon Sandstone, Loyalhanna, and Mauch Chunk Formations, the Pottsville and Allegheny Groups, and the Glenshaw and Casselman Formations. These units contain abundant sandstone and siltstone, some conglomerate layers, shale, and limestone; they are also fossiliferous, containing remains of vast marshy peat swamps and wetlands. They contain significant amounts of coal, including the commercially valuable Freeport, Kittanning, and Brookeville-Clarion coals (Whitfield et al. 2001).

Mesozoic and all but the most recent Cenozoic rock units are missing from the landscape surrounding Allegheny Portage Railroad. Recent, Quaternary alluvium deposits were deposited in the river valleys. These consist of unconsolidated clay, silt, sand, gravel, and sparse boulder deposits (McElroy 1998).

The following pages present a tabular view of the stratigraphic column and an itemized list of features for each map unit. Map units are listed from youngest to oldest; please refer to the geologic time scale (fig. 6) for the age associated with each time period. This table includes properties of each map unit such as map symbol, name, description, resistance to erosion, suitability for development, hazards, potential paleontologic resources, cultural and mineral resources, potential karst issues, potential for recreational use, and global significance.

Map Unit Properties Table

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Development	Hazards	Paleontologic Resources	Cultural Resources	Mineral Specimens	Karst Issues	Mineral Resources	Habitat	Recreation	Global Significance
QUATERNARY	Alluvium (Qal)	Located in river valleys with poorly sorted to well-sorted, unconsolidated sediments of clay, silt, sand, gravel, and boulders.	Low	Suitable for most development unless undercut, exposed on a slope, or highly permeable, in which case waste-treatment facility development is not advised.	Slumps, slides, and slope creep possible in this unit.	Fossils weathered from older units may be present in valley fill.	Terraces of larger rivers may contain campsites for Native Americans.	Iron mounds near seeps associated with mine waste.	None	Sand, gravel, clay.	Modern land surface, supports heavy oak forests.	Good for most recreation unless exposed on a steep slope or undercut by erosion.	None documented.
PENNSYLVANIAN	Casselman Formation (PNcc); Glenshaw Formation (PNcg); Allegheny Group (PNa); Pottsville Group (PNp).	Upper formations have sequence of shale, siltstone, sandstone, red beds, and thin impure limestone; coal beds are present locally. Four prominent shale or limestone marine layers in Glenshaw. Lower formations include sequences of sandstone, shale, limestone, claystone, and coal beds. Lowermost unit is sandstone and conglomerate rich with some thin beds of black shale, claystone, limestone, and coal.	Low to medium in upper beds, medium in lower beds.	Units yield very hard water with excessive iron, manganese, and sulfate. Heterogeneity of layers may lead to instability on slopes.	Ledge-forming sandstone layers may be undercut by softer shale units and pose rockfall hazard.	Marine fossils	None documented	Nodular limestone, siderite.	Some dissolution in limestone interbeds.	Coal (Freeport, Kittanning, and Brookville-Clarion), high-alumina clay deposits.	Dissolution features may provide burrow and nesting habitat.	Good for most recreation unless soft shale units are exposed along slopes.	Classic coal deposits
MISSISSIPPIAN	Mauch Chunk Formation (Mmc); Burgoon Sandstone (Mb); Pocono Sandstone (Mp).	Upper units of grayish-red shale, siltstone, sandstone, and several limestone members. Middle beds contain buff, medium-grained sandstone with some coal and shale interbeds, some conglomerate at base. Lower beds contain light-gray to buff, medium-grained sandstone with minor siltstone, several conglomeratic layers.	Medium overall, medium to high in lower unit.	Iron-rich groundwater from these units. Suitable for most development unless highly fractured or on shale-rich slopes.	Rockfall is possible if units are undercut on a slope; slumping possible in shale-rich units.	Plant fossils	None documented	None documented	Some dissolution in limestone members.	Coal beds	None documented.	Good for most recreation unless soft shale units are exposed along slopes.	Mississippian coal deposits.
MISSISSIPPIAN – DEVONIAN	Shenango Formation through Oswayo Formation, undivided (Mdso); Rockwell Formation (MDr).	Upper units contain greenish-gray, olive, and buff sandstone and siltstone with some gray shale interbeds. Lower unit contains fine- to medium-grained, crossbedded argillaceous sandstone and dark-gray shale with some carbonate cement, conglomerate, and diamictite locally	Medium to high.	Suitable for most developments unless highly fractured.	Carbonate cement may weather to friable sandstone, having potential for rockfall in these units.	Marine fossils	None documented	Diamictite	Not enough carbonate present.	Sandstone for building materials.	Dissolution features may provide burrow and nesting habitat.	Good for most recreation unless highly fractured and undercut.	Records Devonian–Mississippian transition in Pennsylvania.
DEVONIAN	Catskill Formation (Dck); Foreknobs Formation (Df); Scherr Formation (Ds); Brallier and Harrell Formations, undivided (Dbh); Hamilton Group (Dh); Onondaga and Old Port Formations, undivided (Doo).	Upper unit contains fining-upward cycles of grayish-red sandstone, siltstone, shale, and mudstone with few conglomerate lenses. Next lowest unit contains interbedded sandstone, siltstone, and shale bounded by conglomerate beds. Unit Ds is predominantly siltstone, with some fine-grained sandstone, shale, and mudstone interbeds. Lower units dominated by dark-gray shale and planar-bedded siltstone. Lowermost units characterized by coarsening-upward cycles of shale and siltstone to sandstone and gray, brown, and olive limestone. Fossils increase in lowermost units of shale and medium-gray argillaceous limestone, chert, and siltstone.	Medium to high in upper units, medium to low in lower units.	Heterogeneous nature of the layered units may be unstable for development. Tioga bentonite member has potential for shrinking and swelling.	Fractured sandstone and siltstone have potential for rockfall when weaker shale units are undercut. Clays that shrink and swell may cause buckling and warping of roads and trails.	Some marine fossils.	Chert in lower units may have provided tool material for Native Americans.	Siderite concretions	Lack of carbonate in upper beds precludes karst formation, some dissolution possible in unit Doo.	Tioga Ash beds (clays) for industrial material fabrication.	Weaker units may provide burrowing habitat; supports climax forests	Avoid clay units because of slippery conditions for trails and other visitor-use areas.	Widespread Devonian units for correlation throughout the Appalachians; Tioga ash marker bed records major Middle Devonian volcanic activity.
DEVONIAN – SILURIAN	Keyser and Tonoloway Formations, undivided (DSkt).	Unit contains medium-gray, crystalline to nodular, fossiliferous limestone, with laminations and mudcracks common. Some olive-gray, dark shale interbeds are present.	Medium	Suitable for most development unless highly fractured or contain karst features, in which case, developments of waste-treatment facilities should be avoided.	Rockfall associated with fractured limestone underlain by eroded shale beds.	Fossiliferous (Devonian flora and fauna).	None documented	Mudcracks in laminated layers.	Caves and karst present.	Crystalline limestone building stone.	Dissolution features may provide burrowing and nesting habitat.	Avoid fissile mudcrack units for trails.	Widespread, well-known Tonoloway Limestone unit.

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Development	Hazards	Paleontologic Resources	Cultural Resources	Mineral Specimens	Karst Issues	Mineral Resources	Habitat	Recreation	Global Significance
SILURIAN	Wills Creek Formation through Mifflintown Formation, undivided (Swm); Wills Creek Formation (Swc); Bloomsburg and Mifflintown Formations, undivided (Sbm); Clinton Group (Sc); Tuscarora Formation (St).	Upper unit is gray to reddish, yellowish, and greenish-gray, interbedded calcareous shale, siltstone, shaly limestone, and dolomite. Beds contain more very fine grained to coarse-grained sandstone lower in column. Lower units contain light-olive-gray to brownish-gray shale and local limestone, rare ferruginous and oolitic sandstone. Lowermost unit is quartzite and quartzitic sandstone, in places conglomeratic, with minor shale and siltstone interbeds.	Low to medium.	Upper units may prove too fissile and erodable for significant development; lower units should be avoided if highly fractured.	Slumps and slides associated with upper units; rockfall possible in lower units.	Fossiliferous, oolites.	None documented	Hematite, oolites, and ferruginous sandstone.	Karst is possible in upper units.	Sandstone for building material, iron ore in unit Sc.	Fissile and weak upper units may provide burrowing habitat.	Good for most recreation unless soft shale units are exposed along slopes.	None documented.
ORDOVICIAN	Juniata Formation (Oj); Bald Eagle Formation (Obe); Reedsville Formation (Or); Coburn Formation through Loysburg Formation, undivided (Ocl); Bellefonte and Axemann Formations, undivided (Oba); Nittany and Stonehenge/Larke Formations, undivided (Ons).	Upper two units contain grayish-red, very fine grained to medium-grained, crossbedded sandstone with siltstone and shale and some conglomerate in lower beds. Unit Or contains dark shale, siltstone, and fine-grained, thin-bedded sandstone with graded bedding. Middle units contain more limestone, with dark-gray, shaly limestone; some chemically pure limestone present. Lower beds contain brownish-weathering, medium-bedded dolomite and minor sandstone. Lowermost units contain medium to dark-gray, thick-bedded dolomite with chert and siliceous oolites, and some conglomerate.	Medium to high in upper beds, medium in lower beds, high in lowermost unit Ons.	Shale-rich units should be avoided if exposed on slopes because of potential for slumping.. Metabentonite layers that can shrink and swell are common in lower units.	Slumps and slides associated with upper units, heterogeneous layering may lead to rockfall hazards if massive units are fractured and undercut	Fossiliferous in conspicuous sandstone layer (unit Or), oolites.	Chert in dolomite may have provided tool material for Native Americans.	Pure limestone in unit Ocl, calcilutite (thick-bedded limestone), dolomite striped "tiger-striped" layers.	Limestone and dolomite susceptible to dissolution karst.	Sandstone for building material.	Dissolution features may provide burrowing and nesting habitat.	Avoid clay units because of slippery conditions for trails and other visitor-use areas.	Records Ordovician conditions for widespread units across Appalachians.
CAMBRIAN	Gatesburg Formation (Cg); Warrior Formation Cw); Pleasant Hill Formation (Cph); Waynesboro Formation (Cwb).	Upper unit contains cyclic sandstone and dolomite units, fossiliferous, laminated to massive limestone and dolomite, and thick-bedded, crystalline dolomite. Middle units contain cyclic limestone and dolomite with minor amounts of sandstone to gray, thin-bedded argillaceous limestone with shale, siltstone, and sandstone. Lowermost unit contains greenish-gray and grayish-purple shale interbedded with sandstone and conglomerate.	High in upper beds, medium in lower beds.	Suitable for most development unless highly fractured or contain karst features.	Rockfall potential is high if resistant sandstone – limestone units are undercut by weaker shale units	Stromatolites in unit Cw	None documented	Stromatolites	Caves and karst present.	Massive limestone and crystallized dolomite for building stone.	Alternating beds of sandstone and carbonate may provide ledges for nesting habitat.	Good for most uses unless highly fractured and undercut.	Unit Cwb is widespread Cambrian unit; units contain fossil algae of post-Grenville ocean basin.

Geologic History

This section describes the rocks and unconsolidated deposits that appear on the digital geologic map of Allegheny Portage Railroad National Historic Site, the environment in which those units were deposited, and the timing of geologic events that created the present landscape.

Allegheny Portage Railroad National Historic Site is on the ridge that forms the drainage divide between the Chesapeake Bay and Ohio River watersheds. This area corresponds with the boundary between the Valley and Ridge and Appalachian Plateaus physiographic provinces in central Pennsylvania. Physiographic features associated with the long geologic history of the Appalachian Mountains and the evolution of the eastern coast of the North American continent can be seen in the park. A regional perspective is presented here to connect the landscape and geology of the park to its surroundings.

The recorded history of the Appalachian Mountains begins in the Proterozoic (fig. 6). During the Grenville orogeny (mid-Proterozoic), a supercontinent formed that consisted of most of the continental crust in existence at that time. This included the crust of North America and Africa. Sedimentation, deformation, plutonism, and volcanism are all apparent in the metamorphic granite and gneiss in the core of the modern Blue Ridge Mountains to the south and east of Allegheny Portage Railroad (Harris et al. 1997). These rocks formed over a period of approximately 100 million years and are more than a billion years old, making them among the oldest rocks in this region. They were later uplifted and thus exposed to erosion for hundreds of millions of years. Their leveled surface forms a basement upon which all other rocks of the Appalachians were deposited (Southworth et al. 2001).

The late Proterozoic, roughly 800–600 million years ago (Ma), brought extensional rifting to the area. The crustal extension created fissures through which massive volumes of basaltic magma were extruded (fig. 7A). The volcanism lasted tens of millions of years and alternated between flood basalt flows and ash falls. The volcanic rocks covered the granitic/gneissic basement in central Pennsylvania.

Continued crustal extension caused the supercontinent to break up, and a basin formed that eventually became the Iapetus Ocean. This basin subsided, and sediments that would eventually form the rock units of the Appalachian Mountains were deposited (fig. 7B). Some of the sediments were deposited as alluvial fans, large submarine landslides, and turbidity flows, which today preserve their depositional features.

These late Proterozoic sediments are exposed throughout eastern Pennsylvania. There is a good exposure of these rocks on South Mountain some 100 km (60 mi) southeast of the site (Chilhowee Group: Loudoun Formation, Weverton Formation, Harpers Formation, and Antietam Formation) (Southworth et al. 2001).

Extensive sand, silt, and mud deposited in near-shore, deltaic, barrier island, and tidal-flat areas were associated with the shallow marine setting along the eastern continental margin of the Iapetus Ocean (Schwab 1970; Kauffman and Frey 1979; Simpson 1991). In addition, widespread carbonate sediments, sand, and mud, such as the Cambrian Waynesboro, Pleasant Hill, and Gatesburg Formations in the Allegheny Portage Railroad area, were deposited on top of the Chilhowee Group. They represent part of a grand platform that thickened to the east and that persisted during the Cambrian and Ordovician Periods (545–480 Ma) (Means 1995). Ordovician units such as the Nittany, Bellefonte, Reedsville, and Juniata Formations recorded the transition from a carbonate platform to a more near-shore terrestrial deposition associated with the beginning of the Taconic orogeny.

Igneous plutons intruded the sedimentary rocks along the eastern edge of the continent intermittently (540, 470, and 360 Ma). During several episodes of mountain building and continental collision (described below), the entire sedimentary section, intrusive rocks, and basalt were deformed and metamorphosed into schist, gneiss, marble, slate, and migmatite (Southworth et al. 2000).

Taconic Orogeny

From Early Cambrian through Early Ordovician time, orogenic activity along the eastern margin of the continent began again. The Taconic orogeny (≈440–420 Ma in the central Appalachians) was associated with a volcanic arc–continent convergence. Oceanic crust and the volcanic arc from the Iapetus basin were thrust onto the eastern edge of the North American continent. The Taconic orogeny resulted in the closing of the ocean, subduction of oceanic crust, creation of volcanic arcs, and uplift of continental crust (Means 1995). Initial metamorphism of the basalt of the Catoctin Formation into metabasalt and metarhyolite, as well as the Chilhowee Group rocks into quartzite and phyllite, occurred during this orogenic event.

The crust bowed downwards in response to the overriding plate that was thrust westward onto the continental margin of North America, creating a deep basin that filled with mud and sand eroded from the highlands to the east (fig. 7C) (Harris et al. 1997). This so-called Appalachian basin was centered on what is now West Virginia. These in-filling sediments covered the

Cambrian carbonate platform and are today represented by the Ordovician (505–440 Ma) units (Southworth et al. 2001).

The oceanic sediments of the shrinking Iapetus Ocean were thrust westward along the Pleasant Grove fault during the Late Ordovician onto other deep-water sediments of the western Piedmont. Sand, mud, silt, and carbonate sediment of the Tuscarora Formation, Clinton Group, Bloomsburg Formation, and other Silurian rocks were then deposited in a shallow marine to deltaic environment of the Appalachian basin. These rocks, now metamorphosed, underlie the Valley and Ridge physiographic province (Fisher 1976).

Shallow marine to fluvial sedimentation continued intermittently for a period of about 200 million years during the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian Periods. This resulted in a thick sedimentary section. The source of these sediments was the highlands to the east that were rising during the Taconian orogeny (Ordovician) and the Acadian orogeny (Devonian). The Keyser and Tonoloway Formations contain widespread limestone and shale that reflect the transition from the Silurian to the Devonian periods.

Acadian Orogeny

The Acadian orogeny (≈360 Ma) continued the mountain building of the Taconic orogeny as the African continent drifted towards North America (Harris et al. 1997). The Acadian event involved collision of land masses, mountain building, and regional metamorphism similar to the preceding Taconic orogeny (Means 1995). This event was focused north of present-day central Pennsylvania.

The Acadian event caused further uplift of Taconic highlands in central Pennsylvania. Erosion of these highlands provided more sediments, leading to the basin-wide deposition of the Onondaga, Catskill, Foreknobs, and Old Port Formations, the Hamilton Group, and other Devonian units.

The tectonic quiescence between the Acadian and Alleghenian orogenic events (see below) led to the deposition of the vast marsh and wetland deposits of the Mississippian and Pennsylvanian periods. Burial and compression of these deposits created the vast coal-bearing units of the Mississippian Burgoon Sandstone, the Pennsylvanian Casselman and Glenshaw Formations, and the Allegheny and Pottsville Groups (Berg et al. 1980; Whitfield et al. 2001).

Alleghenian Orogeny

During the Late Paleozoic and following the Acadian orogeny, the proto-Atlantic Iapetus Ocean was closed as the North American continent collided with the African continent. This formed a supercontinent named Pangaea and the Appalachian mountain belt we see today. This mountain-building episode is called the Alleghenian orogeny (≈325–265 Ma), the last major orogeny that affected the Appalachians (fig. 7D) (Means 1995). The rocks deformed during as many as seven phases of folding and faulting, producing the Sugarloaf Mountain anticlinorium and the Frederick Valley synclinorium in the western Piedmont, the Blue Ridge–South Mountain anticlinorium, and the numerous folds of the Valley and Ridge province in the Allegheny Portage Railroad area (Nickelsen 1983; Southworth et al. 2001). Many of the faults and folds associated with the Alleghenian orogeny are exposed today around the Allegheny Portage Railroad National Historic Site.

During this orogeny, rocks of the Great Valley, Blue Ridge, and Piedmont provinces were transported along the North Mountain fault as a massive block (Blue Ridge–Piedmont thrust sheet) westward onto younger rocks of the Valley and Ridge. The amount of crustal shortening was very large: estimates of 20–50 percent shortening would amount to 125–350 km (80–220 mi) (Harris et al. 1997).

Deformed rocks in the eastern Piedmont were also folded and faulted, and existing thrust faults were reactivated as both strike-slip and thrust faults during the Alleghenian orogeny (Southworth et al. 2001). Paleoelevations of the Alleghenian Mountains are estimated at approximately 6,000 m (20,000 ft), analogous to the modern-day Himalaya Range in Asia. These mountains have been beveled by erosion to elevations less than 734 m (2,408 ft) above sea level in the Allegheny Portage Railroad area (Means 1995).

Triassic Extension to the Present

Following the Alleghenian orogeny, during the late Triassic (230–200 Ma), a period of rifting began as the deformed rocks of the joined continents started to break apart. The supercontinent Pangaea was segmented into roughly the same continents that persist today. This episode of rifting initiated the formation of the current Atlantic Ocean and caused many block-fault basins to develop with accompanying volcanism (fig. 7E) (Harris et al. 1997; Southworth et al. 2001).

The Newark Basin system, to the east of Allegheny Portage Railroad, is a large part of this tectonic setting. Large streams carried debris shed from the uplifted Blue Ridge and Piedmont provinces depositing them in alluvial fans. These were deposited as non-marine mud and sand in fault-created troughs such as the Frederick Valley in central Maryland and the Culpeper basin in the western Piedmont of central Virginia. Many of these rifted areas became lacustrine basins and were filled with thick silt and sand deposits.

Thick deposits of unconsolidated gravel, sand, and silt were shed from the eroded Alleghenian mountains. These were deposited eastward at the base of the mountains as alluvial fans and became part of the Atlantic Coastal Plain (Duffy and Whittecar 1991; Whittecar and Duffy 2000; Southworth et al. 2001). The amount of material that was deposited has been inferred from the now-exposed metamorphic rocks in the Blue Ridge province to have been immense. Many of the rocks exposed at the surface must have been at least 20 km (≈10 mi) below the surface prior to regional uplift and erosion. Erosion continues to create the present landscape, the Susquehanna, Juniata, and Delaware rivers and their tributaries are eroding sediments and depositing alluvial terraces along the rivers (fig. 7F).

The North American plate has continued to drift toward the west since the breakup of Pangaea and the uplift of the Appalachian Mountains. The isostatic adjustments that uplifted the continent after the Alleghenian orogeny continued at a lesser rate throughout the Cenozoic Period (Harris et al. 1997).

The landscape and geomorphology of the greater Allegheny Front area are the result of erosion and deposition along the rivers from about the mid-Cenozoic Period to the present, or at least the last 5 million years. The distribution of floodplain alluvium and ancient river terraces reflects the historical development of the local drainage systems. It seems the rivers have cut downward through very old, resistant rocks, overprinting their early drainageways (Southworth et al. 2001). The steep ridges and ravines present at Allegheny Portage Railroad attest to this downward cutting and overprinting.

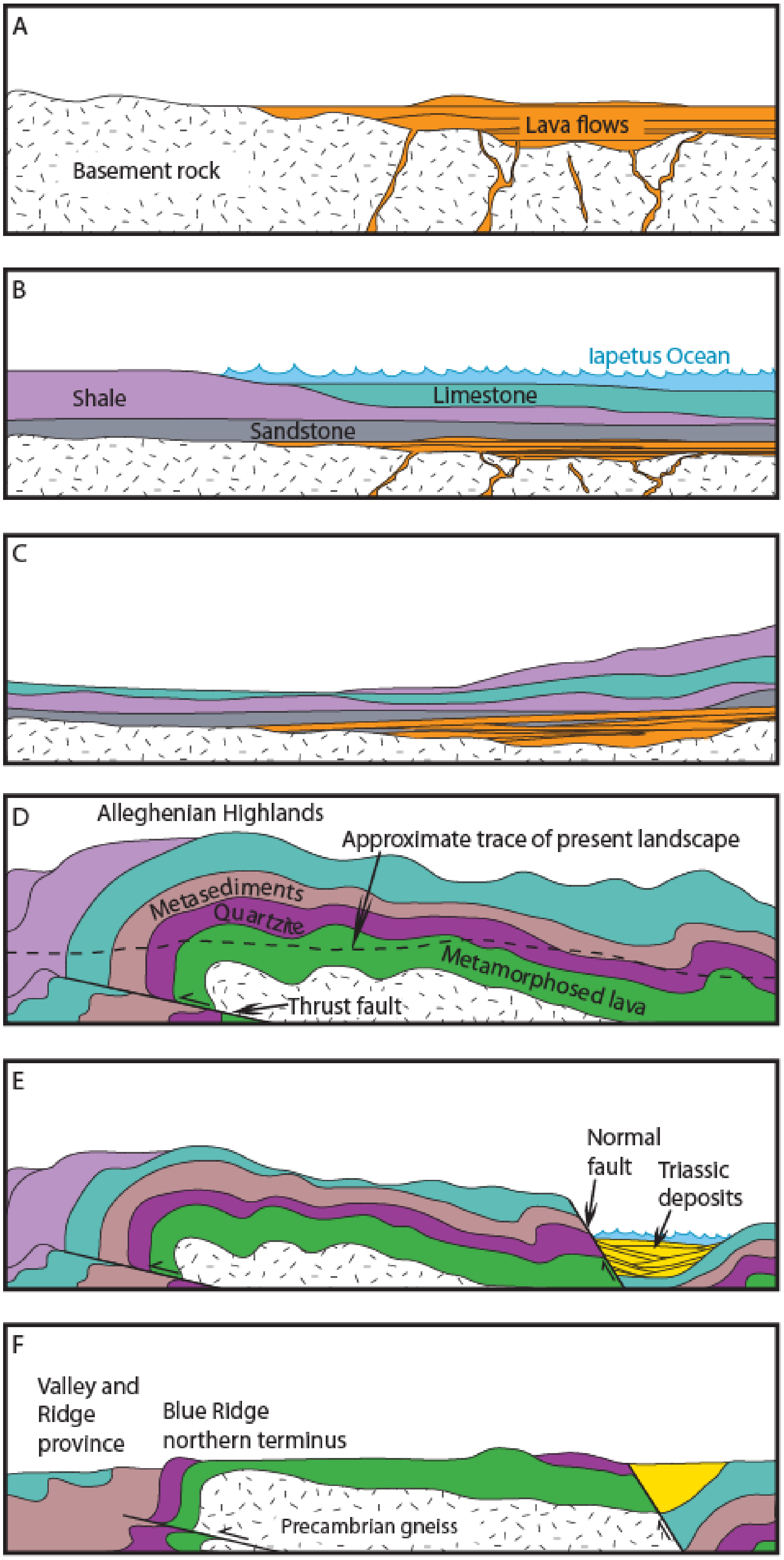
Glaciers from the Pleistocene Ice Ages never reached central Pennsylvania. The southern terminus of Pleistocene glaciers was at 365–610 m (1,200–2,000 ft) in elevation in northwestern and northeastern Pennsylvania. In the northern part of Pennsylvania, upland surfaces have been glaciated to rounded ridges and sand- and gravel-filled valleys (Davies 2005). However, the colder climates of the Ice Ages played a role in the formation of the landscape at Allegheny Portage Railroad.

The Allegheny Mountains developed periglacial conditions that included discontinuous permafrost, tundra-like vegetation, and many freeze-thaw cycles due to its proximity to the glacial environment as well as its high elevation. These freeze-and-thaw cycles led to the ice wedging of thousands of boulders and small rocks from the mountains. Water would melt during the day and seep into cracks, freeze at night, expand, and force the rocks apart. Downslope movement of these rocks created talus piles, and larger, water-saturated rock masses slid over the partially frozen layer below in a process known as solifluction (Means 1995). Frost wedging continues in the area today (fig. 8 and 9).

The Ice Age climate may have affected the morphology of the river valleys as well. The periglacial conditions at high altitudes intensified weathering and other erosional processes (Harris et al. 1997). The landforms and deposits are probably late Tertiary to Quaternary, when a wetter climate, sparse vegetation, and frozen ground caused increased precipitation to drain into the ancestral river channels, enhancing downcutting and erosion by waterways such as Blair Gap Run (Means 1995). The several water gaps through the resistant ridges throughout the Valley and Ridge province are examples of these incised waterways.

Eon	Era	Period	Epoch	Ma		Life Forms	N. American Tectonics
Phanerozoic (Phaneros = "evident"; zoic = "life")	Cenozoic	Quaternary	Holocene	0.01	Age of Mammals	Modern humans	Cascade volcanoes (W)
			Pleistocene	1.8		Extinction of large mammals and birds	Worldwide glaciation
		Tertiary	Pliocene	5.3		Large carnivores	Uplift of Sierra Nevada (W)
			Miocene	23.0		Whales and apes	Linking of N. and S. America
			Oligocene	33.9			Basin-and-Range extension (W)
			Eocene	55.8		Early primates	Laramide Orogeny ends (W)
			Paleocene	65.5			
	Mesozoic	Cretaceous		145.5	Age of Dinosaurs	**Mass extinction** Placental mammals Early flowering plants	Laramide Orogeny (W) Sevier Orogeny (W) Nevadan Orogeny (W)
		Jurassic		199.6		First mammals	Elko Orogeny (W)
		Triassic		251		**Mass extinction** Flying reptiles First dinosaurs	Breakup of Pangaea begins Sonoma Orogeny (W)
	Paleozoic	Permian		299	Age of Amphibians	**Mass extinction** Coal-forming forests diminish	Supercontinent Pangaea intact Ouachita Orogeny (S) Alleghenian (Appalachian) Orogeny (E)
		Pennsylvanian		318.1		Coal-forming swamps Sharks abundant	Ancestral Rocky Mts. (W)
		Mississippian		359.2		Variety of insects First amphibians First reptiles	
		Devonian		416	Fishes	**Mass extinction** First forests (evergreens)	Antler Orogeny (W) Acadian Orogeny (E-NE)
		Silurian		443.7		First land plants	
		Ordovician		488.3	Marine Invertebrates	**Mass extinction** First primitive fish Trilobite maximum Rise of corals	Taconic Orogeny (NE)
		Cambrian		542		Early shelled organisms	Avalonian Orogeny (NE) Extensive oceans cover most of N. America
Proterozoic ("Early life")		Precambrian		2500		First multicelled organisms Jellyfish fossil (670 Ma)	Formation of early supercontinent Grenville Orogeny (E) First iron deposits Abundant carbonate rocks
Archean ("Ancient")				≈4000		Early bacteria and algae	Oldest known Earth rocks (≈3.96 billion years ago)
Hadean ("Beneath the Earth")				4600		Origin of life?	Oldest moon rocks (4-4.6 billion years ago) Earth's crust being formed
						Formation of the Earth	

Figure 6. Geologic time scale; adapted from the U.S. Geological Survey (http://pubs.usgs.gov/fs/2007/3015/). Red lines indicate major unconformities between eras. Included are major events in life history and tectonic events occurring on the North American continent. Absolute ages shown are in millions of years.



800-600 Ma—Following the Grenville orogeny and erosion, crustal extension leads to volcanism, producing flood basalt and ash flows.

650-450 Ma—Iapetus Ocean continues to widen and the basin subsides; deposits of sand, silt, and clay, shed from the nearby highlands, and marine limestone fill the basin atop the flood basalt.

450-350 Ma—Inland-sea deposition continues as the Taconic and Acadian highlands rise to the east, providing more sediment.

325-265 Ma—Alleghenian orogeny leads to metamorphism of the rocks, which are fractured, folded, and overturned to form high mountains over the present landscape.

225-200 Ma—Following continental collision, the extensional environment creates fault-bounded basins along the eroding front of the mountain ranges, which provide sediment to the basins.

Present—Erosion bevels the mountains to the present topographic surface, deposition continues toward the eastern coast. and resistant rocks form local ridges.

Figure 7. Evolution of the landscape in the area of the Allegheny Portage Railroad National Historic Site from the Precambrian through the present. Graphic adapted from Means (1995). Ma, millions of years (mega-annum). Drawings not to scale.

Figure 8. View of railroad grade at Allegheny Portage Railroad National Historic Site. Note talus boulders visible along left edge of photograph, which can be the result of frost-wedge weathering, described in "Geologic History" section below. Photograph is courtesy of the National Park Service.

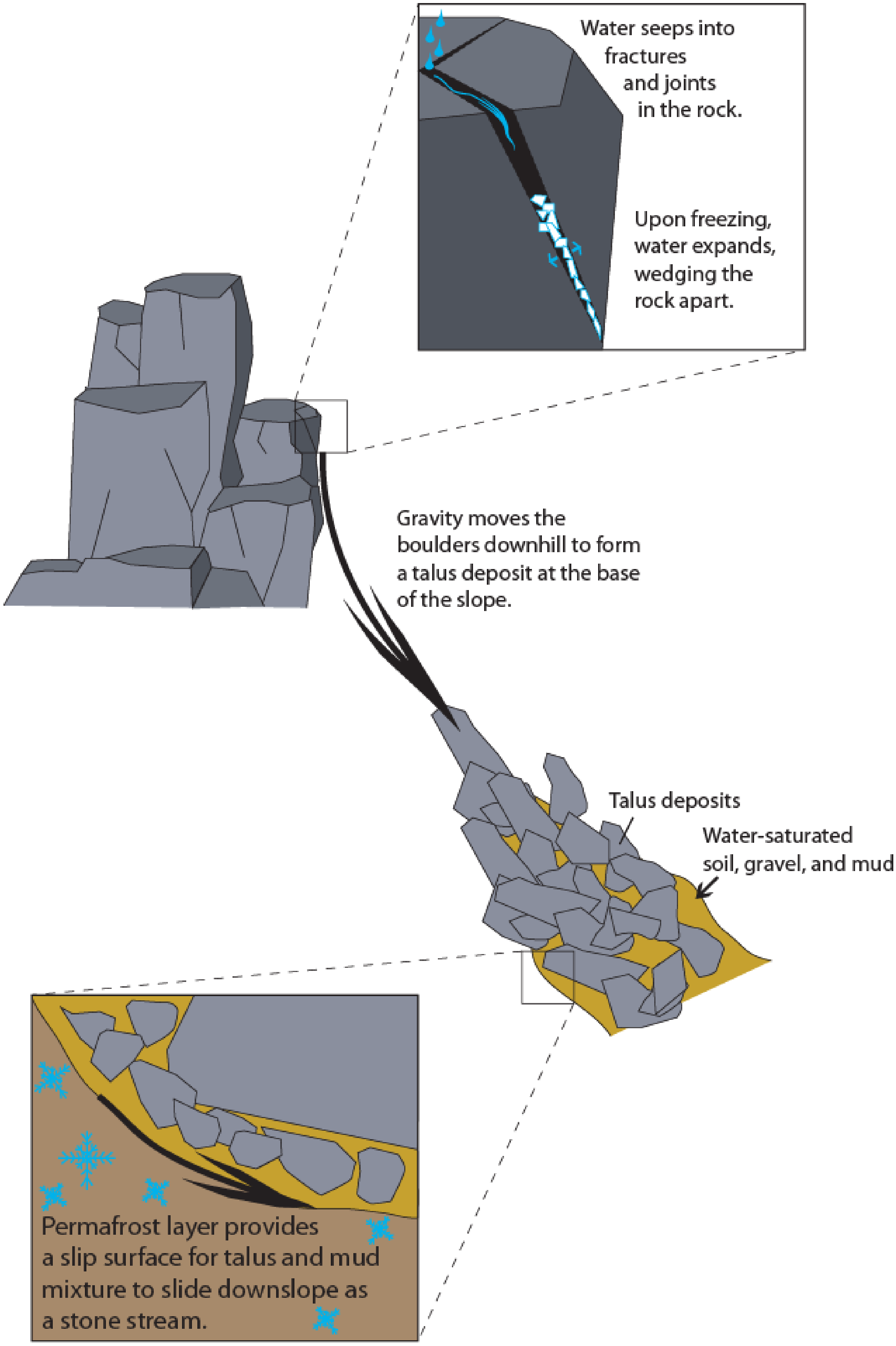


Figure 9. Diagram showing frost-wedge weathering and subsequent formation of talus piles in a typical outcrop in the Allegheny Mountains. Graphic is by Trista L. Thornberry-Ehrlich (Colorado State University).

Glossary

This glossary contains brief definitions of technical geologic terms used in this report. Not all geologic terms used are referenced. For more detailed definitions or to find terms not listed here please visit: http://wrgis.wr.usgs.gov/docs/parks/misc/glossarya.html.

active margin. A continental margin where significant volcanic and earthquake activity occurs; commonly a convergent plate margin.

alluvial fan. A fan-shaped deposit of sediment that accumulates where a high-gradient stream flows out of a mountain front into an area of lesser gradient, such as a valley.

alluvium. Stream-deposited sediment that is generally rounded, sorted, and stratified.

angular unconformity. An unconformity where the strata above and below are oriented differently; generally caused by structural deformation and erosion prior to deposition of the upper bed.

anticlinorium. A composite anticlinal structure of regional extent composed of lesser folds.

aquifer. Rock or sediment that are sufficiently porous, permeable, and saturated to be useful as a source of water.

ash (volcanic). Fine pyroclastic material ejected from a volcano (also see "tuff").

asthenosphere. Weak layer in the upper mantle below the lithosphere where seismic waves are attenuated.

basement. The undifferentiated rocks, commonly igneous and metamorphic, that underlie the rocks of interest.

basin (structural). A doubly-plunging syncline in which rocks dip inward from all sides (also see "dome").

basin (sedimentary). Any depression, from continental to local scales, into which sediments are deposited.

bed. The smallest sedimentary strata unit, commonly ranging in thickness from one centimeter to a meter or two and distinguishable from beds above.

bedding. Depositional layering or stratification of sediments.

bedrock geology. The geology of underlying solid rock as it would appear with the sediment, soil, and vegetative cover stripped away.

block (fault). A crustal unit bounded by faults, either completely or in part.

braided stream. A stream, clogged with sediment that forms multiple channels that divide and rejoin.

calcareous. A rock or sediment containing calcium carbonate.

carbonaceous. A rock or sediment with considerable carbon, especially organics, hydrocarbons, or coal.

cementation. Chemical precipitation of material into pores between grains that bind the grains into rock.

chemical sediment. A sediment precipitated directly from solution (also called "nonclastic").

chemical weathering. The dissolution or chemical breakdown of minerals at Earth's surface via reaction with water, air, or dissolved substances.

clastic. Rock or sediment made of fragments or pre-existing rocks.

clay. Clay minerals or sedimentary fragments the size of clay minerals (>1/256 mm).

cleavage (rock). The tendency of rock to break along parallel planes that correspond to the alignment of platy minerals.

concordant. Strata with contacts parallel to the attitude of adjacent strata.

conglomerate. A coarse-grained sedimentary rock with clasts larger than 2 mm in a fine-grained matrix.

continental crust. The type of crustal rocks underlying the continents and continental shelves; having a thickness of 25–60 km (16–37 mi) and a density of approximately 2.7 grams per cubic centimeter.

continental drift. The concept that continents have shifted in position over Earth (see and use "plate tectonics").

continental rise. Gently sloping region from the foot of the continental slope to the abyssal plain.

continental shelf. The shallowly submerged part of a continental margin extending from the shoreline to the continental slope with water depths of less than 200 m (656 ft).

continental shield. A continental block of Earth's crust that has remained relatively stable over a long period of time and has undergone only gentle warping compared to the intense deformation of bordering crust

continental slope. The relatively steep slope from the outer edge of the continental shelf down to the more gently sloping ocean depths of the continental rise or abyssal plain.

convergent boundary. A plate boundary where two tectonic plates are moving together (i.e., a zone of subduction or obduction).

craton. The relatively old and geologically stable interior of a continent (also see "continental shield").

cross-bedding. Uniform to highly varied sets of inclined sedimentary beds deposited by wind or water that indicate distinctive flow conditions.

cross section. A graphical interpretation of geology, structure, and/or stratigraphy in the third (vertical) dimension based on mapped and measured geological extents and attitudes depicted in an oriented vertical plane.

crust. The outermost compositional shell of Earth, 10–40 km (6–25 mi) thick, consisting predominantly of relatively low-density silicate minerals (also see "oceanic crust" and "continental crust").

crystalline. Describes the structure of a regular, orderly, repeating geometric arrangement of atoms

debris flow. A rapid and often sudden flow or slide of rock and soil material involving a wide range of types and sizes.

deformation. A general term for the process of faulting, folding, shearing, extension, or compression of rocks as a result of various Earth forces.

delta. A sediment wedge deposited at a stream's mouth where it flows into a lake or sea.

dike. A tabular, discordant igneous intrusion.

dip. The angle between a structural surface and a horizontal reference plane measured normal to their line of intersection.

disconformity. An unconformity at which the bedding of the strata above and below are parallel.

discordant. Having contacts that cut across or are set an angle to the orientation of adjacent rocks.

divergent boundary. A tectonic plate boundary where the plates are moving apart (e.g., a spreading ridge or continental rift zone).

drainage basin. The total area from which a stream system receives or drains precipitation runoff.

eustatic. Relates to simultaneous worldwide rise or fall of sea level in Earth's oceans.

evaporite. Chemically precipitated mineral(s) formed by the evaporation of solute-rich water under restricted conditions.

exfoliation. The breakup, spalling, peeling, flaking, etc., of layers or concentric sheets from an exposed rock mass due to differential stresses resulting from thermal changes or pressure unloading.

extrusion. The emission of relatively viscous lava onto the Earth's surface; also, the rock so formed.

extrusive. Of or pertaining to the eruption of igneous material onto the surface of Earth.

facies (metamorphic). The pressure-temperature regime that results in a particular, distinctive metamorphic mineralogy (i.e., a suite of index minerals).

facies (sedimentary). The depositional or environmental conditions reflected in the sedimentary structures, textures, mineralogy, fossils, etc. of a sedimentary rock.

fault. A subplanar break in rock along which relative movement occurs between the two sides.

formation. Fundamental rock-stratigraphic unit that is mappable and lithologically distinct from adjoining strata and has definable upper and lower contacts.

fracture. Irregular breakage of a mineral; also any break in a rock (e.g., crack, joint, fault)

frost wedging. The breakup of rock due to the expansion of water freezing in fractures.

geology. The study of Earth including its origin, history, physical processes, components, and morphology.

igneous. Refers to a rock or mineral that originated from molten material; one of the three main classes or rocks—igneous, metamorphic, and sedimentary.

intrusion. A body of igneous rock that invades older rock. The invading rock may be a plastic solid or magma that pushes its way into the older rock.

island arc. A line or arc of volcanic islands formed over and parallel to a subduction zone.

isostasy. The process by which the crust "floats" at an elevation compatible with the density and thickness of the crustal rocks relative to underlying mantle.

isostatic adjustment. The shift of the lithosphere of the Earth to maintain equilibrium among units of varying mass and density; excess mass above is balanced by a deficit of density below, and vice versa.

joint. A semi-planar break in rock without relative movement of rocks on either side of the fracture surface.

karst topography. Topography characterized by abundant sinkholes and caverns formed by the dissolution of calcareous rocks.

lacustrine. Pertaining to, produced by, or inhabiting a lake or lakes.

lamination. The finest stratification or bedding as seen in shale and siltstone (syn: lamina or laminae) or the formation of laminae.

landslide. Any process or landform resulting from rapid mass movement under relatively dry conditions.

lava. Magma that has been extruded out onto Earth's surface, both molten and solidified.

levees. Raised ridges lining the banks of a stream; may be natural or artificial.

limbs. The two sides of a structural fold on either side of its hingeline.

lineament. Any relatively straight surface feature that can be identified via observation, mapping, or remote sensing, commonly representing tectonic features.

lithification. The conversion of sediment into solid rock.

lithology. The description of a rock or rock unit, especially the texture, composition, and structure of sedimentary rocks.

lithosphere. The relatively rigid outmost shell of Earth's structure, 50–100 km (31–62 mi) thick, that encompasses the crust and uppermost mantle.

loess. Silt-sized sediment deposited by wind, generally of glacial origin.

mafic. A rock, magma, or mineral rich in magnesium and iron.

magma. Molten rock generated within the Earth that is the parent of igneous rocks.

mantle. The zone of Earth's interior between crust and core.

matrix. The fine-grained interstitial material between coarse grains in porphyritic igneous rocks and poorly sorted clastic sediments or rocks.

meanders. Sinuous lateral curves or bends in a stream channel.

mechanical weathering. The physical breakup of rocks without change in composition (syn: physical weathering).

member. A lithostratigraphic unit with definable contacts that subdivides a formation.

metamorphic. Pertaining to the process of metamorphism or to its results.

metamorphism. Literally, "change in form." Metamorphism occurs in rocks through mineral alteration, genesis, and/or recrystallization from increased heat and pressure.

mid-ocean ridge. The continuous, generally submarine, seismic, median mountain range that marks the divergent tectonic margin(s) in the world's oceans.

mineral. A naturally occurring, inorganic crystalline solid with a definite chemical composition or compositional range.

mud cracks. Cracks formed in clay, silt, or mud by shrinkage during subaerial dehydration.
nonconformity. An erosional surface preserved in strata in which crystalline igneous or metamorphic rocks underlie sedimentary rocks.
normal fault. A dip-slip fault in which the hanging wall moves down relative to the footwall.
obduction. The process by which the crust is thickened by thrust faulting at a convergent margin.
oceanic crust. Earth's crust formed at spreading ridges that underlies the ocean basins. Oceanic crust is 6–7 km (3–mi) thick and generally of basaltic composition.
orogeny. A mountain-building event, particularly a well-recognized event in the geological past (e.g., the Laramide orogeny).
outcrop. Any part of a rock mass or formation that is exposed or "crops out" at Earth's surface.
overbank deposits. Alluvium deposited outside a stream channel during flooding.
paleogeography. The study, description, and reconstruction of the physical geography from past geologic periods.
paleontology. The study of the life and chronology of Earth's geologic past based on the phylogeny of fossil organisms.
Pangaea. A theoretical, single supercontinent that existed during the Permian and Triassic Periods (also see "Laurasia" and "Gondwana").
parent (rock). The original rock from which a metamorphic rock or soil was formed.
passive margin. A tectonically quiet continental margin indicated by little volcanic or seismic activity.
pebble. Generally, small, rounded rock particles from 4 to 64 mm in diameter.
permeability. A measure of the ease or rate that fluids move through rocks or sediments.
plateau. A broad, flat-topped topographic high of great extent and elevation above the surrounding plains, canyons, or valleys (both land and marine landforms).
plate tectonics. The theory that the lithosphere is broken up into a series of rigid plates that move over Earth's surface above a more fluid aesthenosphere.
pluton. A body of intrusive igneous rock.
plutonic. Describes igneous rock intruded and crystallized at some depth in the Earth.
porosity. The proportion of void space (cracks, interstices) in a volume of a rock or sediment.
Principal of Original Horizontality. The concept that sediments are originally deposited in horizontal layers and that deviations from the horizontal indicate post-depositional deformation.
Principle of Superposition. The concept that sediments are deposited in layers, one atop another, i.e., the rocks on the bottom are oldest with the overlying rocks progressively younger toward the top.
progradation. The seaward building of land area due to sedimentary deposition.
provenance. A place of origin. The area from which the constituent materials of a sedimentary rock were derived.
radioactivity. The spontaneous decay or breakdown of unstable atomic nuclei.
radiometric age. An age in years determined from radioisotopes and their decay products.
recharge. Infiltration processes that replenish ground water.
red beds. Sedimentary strata composed largely of sandstone, siltstone, and shale that are predominantly red due to the presence of ferric oxide (hematite) coating individual grains.
regression. A long-term seaward retreat of the shoreline or relative fall of sea level.
relative dating. Determining the chronological placement of rocks, events, fossils, etc. from geological evidence.
reverse fault. A contractional, high-angle (>45°), dip-slip fault in which the hanging wall moves up relative to the footwall (also see "thrust fault").
rift valley. A depression formed by grabens along the crest of an oceanic spreading ridge or in a continental rift zone.
ripple marks. The undulating, subparallel, usually small-scale ridge pattern formed on sediment by the flow of wind or water.
rock. A solid, cohesive aggregate of one or more minerals or mineraloids.
roundness. The relative amount of curvature of the "corners" of a sediment grain, especially with respect to the maximum radius of curvature of the particle.
sandstone. Clastic sedimentary rock of predominantly sand-sized grains.
scarp. A steep cliff or topographic step resulting from vertical displacement on a fault or by mass movement.
seafloor spreading. The process by which tectonic plates diverge and new lithosphere is created at oceanic ridges.
sediment. An eroded and deposited, unconsolidated accumulation of lithic and mineral fragments.
sedimentary rock. A consolidated and lithified rock consisting of detrital and/or chemical sediment(s).
sequence. A major informal rock-stratigraphic unit that is traceable over large areas and defined by a major sea level transgression-regression sediment package.
shale. A clastic sedimentary rock made of clay-sized particles that exhibit parallel splitting properties.
silt. Clastic sedimentary material intermediate in size between fine-grained sand and coarse clay (1/256–1/16 mm).
siltstone. A variably lithified sedimentary rock composed of silt-sized grains.
slickenside. A smoothly polished and commonly striated surface representing deformation of a fault plane.
slope. The inclined surface of any geomorphic feature or rational measurement thereof (syn: gradient).
slump. A generally large, coherent mass movement with a concave-up failure surface and subsequent backward rotation relative to the slope.
soil. Surface accumulation of weathered rock and organic matter capable of supporting plant growth and commonly overlying the parent rock from which it formed.
spring. A site where water flows out at the surface due to the water table intersecting the ground surface.
strata. Tabular or sheetlike masses or distinct layers (e.g., of rock).

stratigraphy. The geologic study of the origin, occurrence, distribution, classification, correlation, age, etc. of rock layers, especially sedimentary rocks.

stream. Any body of water moving under gravity flow and confined within a channel.

strike. The compass direction of the line of intersection that an inclined surface makes with a horizontal plane.

strike-slip fault. A fault with measurable offset where the relative movement is parallel to the strike of the fault.

subduction zone. A convergent plate boundary where oceanic lithosphere descends beneath a continental or oceanic plate and is carried down into the mantle.

subsidence. The gradual sinking or depression of part of Earth's surface.

suture. The linear zone where two continental landmasses become joined due to obduction.

syncline. A fold of which the core contains the stratigraphically younger rocks; it is generally concave upward.

synclinorium. A composite synclinal structure of regional extent composed of lesser folds.

tectonic. Relating to large-scale movement and deformation of Earth's crust.

tectonics. The geological study of the broad structural architecture and deformational processes of the lithosphere and aesthenosphere (also see "structural geology").

terraces (stream). Step-like benches surrounding the present floodplain of a stream due to dissection of previous flood plain(s), stream bed(s), and/or valley floor(s).

terrane. A region or group of rocks with similar geology, age, or structural style.

terrestrial. Relating to Earth or Earth's dry land.

theory. A hypothesis that has been rigorously tested against further observations or experiments to become a generally accepted tenet of science.

thrust fault. A contractional, dip-slip fault with a shallowly dipping fault surface ($<45^o$) where the hanging wall moves up and over relative to the footwall.

topography. The general morphology of Earth's surface including relief and location of natural and anthropogenic features.

trace (fault). The exposed intersection of a fault with Earth's surface.

trace fossils. Sedimentary structures, such as tracks, trails, burrows, etc., that preserve evidence of organisms' life activities, rather than the organisms themselves.

transgression. Landward migration of the sea due to a relative rise in sea level.

trend. The direction or azimuth of elongation of a linear geological feature.

type locality. The geographic location where a stratigraphic unit is well displayed, is formally defined as a typical section, and derives its name.

unconformity. A surface within sedimentary strata that marks a prolonged period of nondeposition or erosion.

uplift. A structurally high area in the crust, produced by movement that raises the rocks.

volcanic. Related to volcanoes; describes igneous rock crystallized at or near Earth's surface (e.g., lava).

water table. The upper surface of the saturated (phreatic) zone.

weathering. The set of physical, chemical, and biological processes by which rock is broken down in place.

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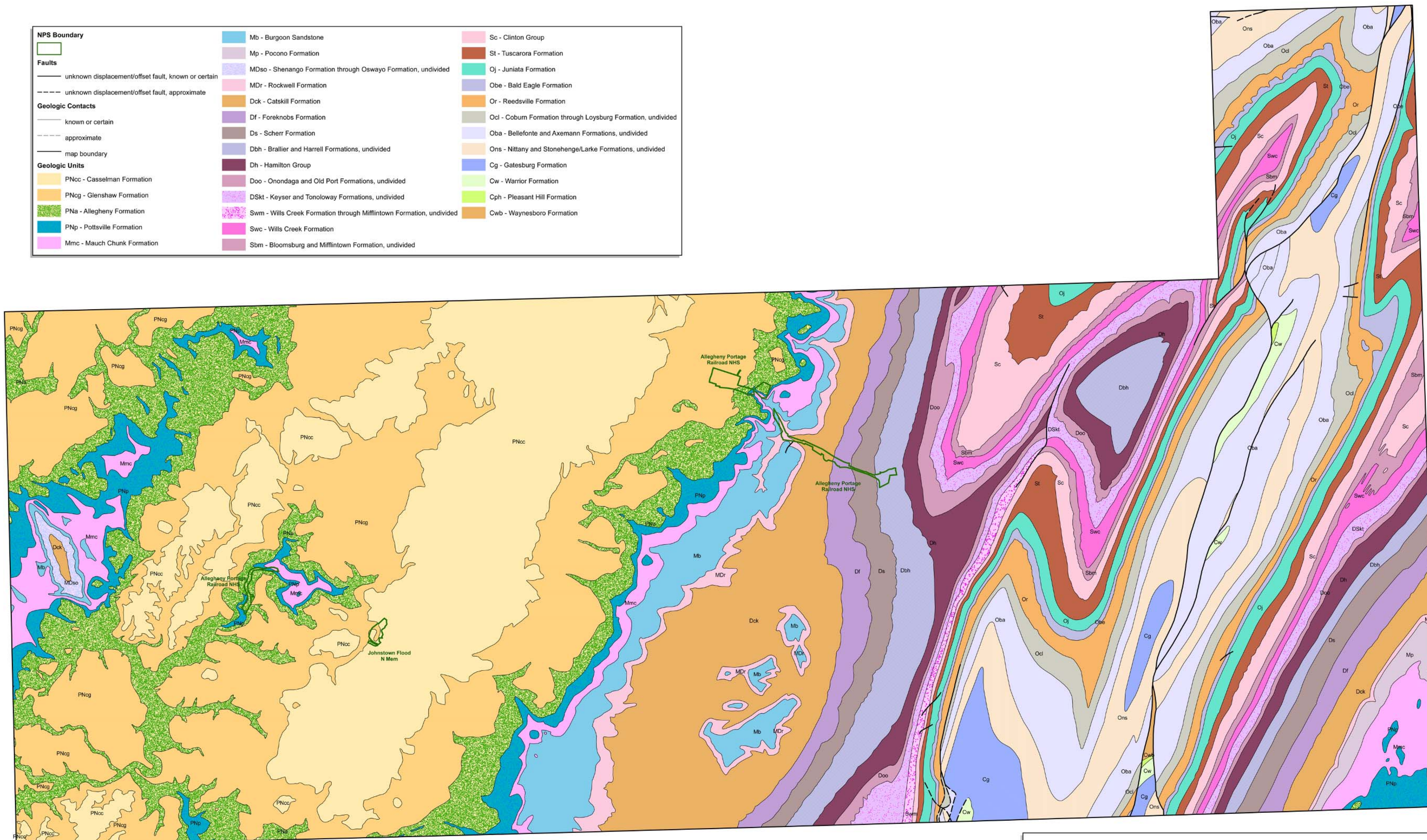
Appendix A: Geologic Map Graphic

The following page is a snapshot of the geologic map for Allegheny Portage Railroad National Historic Site. For a poster-size PDF of this map or for digital geologic map data, please see the included CD or visit the Geologic Resource Evaluation publications Web page (http://www.nature.nps.gov/geology/inventory/gre_publications.cfm).

Geologic Map of Allegheny Portage Railroad NHS



0 4 8 16 Kilometers

0 2.5 5 10 Miles

This map graphically presents digital geologic data prepared as part of the NPS Geologic Resources Division's Geologic Resource Evaluation Program. The source maps used in creation of the digital geologic data product were:

Whitfield, T.G. and others. 2001. *Digital Bedrock Geology of Pennsylvania, Johnstown and Tyrone 30' x 60' quadrangles, Pennsylvania.* Scale 1:250,000. PAGS 30'x60' Digital Quadrangle maps. Pennsylvania Geological Survey.

McElroy, T.A. 1998. *Groundwater resources of Cambria County, Pennsylvania.* Scale 1:50,000. Water Resource Report W 67. Pennsylvania Geological Survey.

Digital geologic data for Allegheny Portage Railroad NHS and all other digital geologic data prepared as part of the Geologic Resource Evaluation Program, are available online at the NPS Data Store: http://science.nature.nps.gov/nrdata/

Produced by Geologic Resources Division

September 2008

Appendix B: Scoping Summary

The following excerpts are from the GRE scoping summary for Allegheny Portage Railroad National Historic Site. The scoping meeting was on June 22, 2004; therefore, the contact information and Web addresses referred to in this appendix may be outdated. Please contact the Geologic Resources Division for current information.

Executive Summary

A geologic resources evaluation workshop was held for Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL) on June 22, 2004, to view and discuss the parks' geologic resources, to address the status of geologic mapping for compiling both paper and digital maps, and to assess resource management issues and needs. Cooperators from the NPS Geologic Resources Division (GRD), NPS ALPO and JOFL units, as well as local geologic experts, were present for the workshop.

Geologic Mapping

Existing Geologic Maps and Publications

After the bibliographies were assembled, a separate search was made for any existing surficial and bedrock geologic maps for ALPO and JOFL.

The bounding coordinates for each map were noted and entered into a GIS to assemble an index geologic map. Separate coverages were developed based on scales (1:24,000, 1:100,000, etc.) available for the specific parks. Numerous geologic maps at varying scales and vintages cover the area. Index maps were distributed to each workshop participant during the scoping session.

It was decided to use Pennsylvania Map 61 for Blair County with focus on the Cresson, Hollidaysburg, and Frankstown quadrangles. Map 61 is presented at 1:62,500 scale but was originally mapped at 1:24,000. This covers the main unit of ALPO.

No water report has ever been done for Blair County since a 1945 folio on Holidaysburg and Huntington.

Use the Pennsylvania map W-67 for Cambria County; this covers Staple Bend Unit and JOFL; some of ALPO main will be included as part of this map at 1:50,000 scale.

Additionally, for coal information discussion focused on map m-96 by the Pennsylvania Geological Survey (PA GS) for only areas containing coal. The GRE would need interpretation from PA GS before digitizing.

A small-scale digital map of Pennsylvania exists and is available from PA GS website.

Other Topics of Discussion

A discussion of geologic resource management issues followed the mapping discussion touching upon the following features and/or processes:

- Aeolian: NA

Fluvial (surface water) Processes: ALPO (Staple Bend Unit) runs down Little Conemaugh River; ALPO main unit is eastern slope of Blair Gap Run; JOFL is South fork of Little Conemaugh; obviously, theme is in park name; foundations in river may be threatened

- Groundwater: NA; but can reference the PA GS water reports as well
- Hazards: Landslides, slumps, rockfalls prevalent in western PA
- Clays that disintegrate when they become water saturated may be underlying JOFL dam abutments; should conduct a site investigation if Ames Limestone is present
- Occasional earthquakes but not of significant magnitude; largest in PA was ≈5M in northwest PA
- Roof fall in Staple Bend tunnel
- Floods
- No CO3 sinkholes
- Paleontology: See Vince Santucci's report on ERMN paleontology.
- Mineral Extraction: See disturbed lands, but coal and Fe known to have been mined
- Caves / karst: Carbonate beds often too thin to form karst, thus a non-issue
- Glacial: NA
- Coastal/Marine: NA
- Geologic interpretation: Allegheny Front was reason for AL Portage and Staple Bend tunnel
- Coal mine remediation
- Mahoning sandstone quarry is big part of park's story
- JOFL topography is essential to park's story
- Unique geologic features: Allegheny Front
- Staple Bend tunnel was first blasted through solid rock in U.S.; took 3 years
- Oxbows at Little Conemaugh viaduct
- Geothermal: NA
- Disturbed Lands–mining subsidence: Coal Mining subsidence at ALPO and JOFL; ALPO Staple Bend Unit and Main unit have acid mine drainage issues; JOFL has acid mine drainage initiating external to the park; PA Department of Environmental Protection has maps showing mined areas and they document mine subsidence events; should be GIS layer.
- The maps are quad-based. They are a regulatory agency; PA GS is a research agency.

- Mine shafts are an issue at ALPO main unit; at Staple Bend unit they appear to be collapsed but haven't been investigated to date; should submit TA request to GRD for Burghardt or Cloues assistance
- Only mined lands need reclaimed in both parks
- Fe-mining of siderite in limestone supplanted local steel industry; effects unknown

Monitoring Issues

Monitor for landslides along steep hillsides of Allegheny Front.

Meeting attendees and contact information

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Allegheny Portage Railroad National Historic Site

Geologic Resource Evaluation Report

Natural Resource Report NPS/NRPC/GRD/NRR—2008/045
NPS D-112, September 2008

National Park Service

Director • Mary A. Bomar

Natural Resource Stewardship and Science

Associate Director • Bert Frost

Natural Resource Program Center

The Natural Resource Program Center (NRPC) is the core of the NPS Natural Resource Stewardship and Science Directorate. The Center Director is located in Fort Collins, with staff located principally in Lakewood and Fort Collins, Colorado and in Washington, D.C. The NRPC has five divisions: Air Resources Division, Biological Resource Management Division, Environmental Quality Division, Geologic Resources Division, and Water Resources Division. NRPC also includes three offices: The Office of Education and Outreach, the Office of Inventory, Monitoring and Evaluation, and the Office of Natural Resource Information Systems. In addition, Natural Resource Web Management and Partnership Coordination are cross-cutting disciplines under the Center Director. The multidisciplinary staff of NRPC is dedicated to resolving park resource management challenges originating in and outside units of the national park system.

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