FREDERICKSBURG & SPOTSYLVANIA
NATIONAL MILITARY PARK
GEOLOGIC RESOURCE MANAGEMENT ISSUES
SCOPING SUMMARY

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Wartime photograph from Marye's Heights. Photograph is courtesy of the National Park Service.

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Executive Summary

A Geologic Resources Evaluation scoping meeting for Fredericksburg & Spotsylvania National Military Park took place at Petersburg National Battlefield in Petersburg, VA on April 13, 2005. The scoping meeting participants identified the following list of geologic resource management issues. These topics are discussed in detail on pages 13- 19.

1. Characterization, inventory and monitoring of disturbed land sites including trenches, borrow pits, and quarries with a historical perspective

2. Mapping of shoreline changes to understand erosion rates and how better to protect cultural resources

3. Siting of future facilities accounting for geologic parameters such as unstable soils and hydrogeology

4. Hydrogeologic characterization to understand the flow of water beneath the park and be equipped to predict hydrologic response to contaminants

5. Erosion and slope processes

6. Urban encroachment at park boundaries

7. Connections between geology and the Civil War history to appeal to visitors interested in a deeper connection to the landscape

8. Potential fossil resources and unique geologic features

9. Human impacts

10. Surface water and sediment loading including water quality and sediment changes to riparian environments

Introduction

The National Park Service held a Geologic Resource Evaluation scoping meeting for Fredericksburg & Spotsylvania National Military Park in Petersburg National Battlefield in Petersburg, Virginia on Wednesday, April 13, 2005. The purpose of the meeting was to discuss the status of geologic mapping in the park, the associated bibliography, and the geologic issues in the park. The products to be derived from the scoping meeting are: (1) Digitized geologic maps covering the park; (2) An updated and verified bibliography; (3) Scoping summary (this report); and (4) A Geologic Resource Evaluation Report which brings together all of these products.

Fredericksburg & Spotsylvania National Military Park was established during Herbert Hoover's administration on February 14, 1927. The park protects Civil War battlefield sites including the battles of Chancellorsville, Spotsylvania, the Wilderness, and Fredericksburg. These battles occurred on May 2- 4, 1863, May 10- 12, 1864, May 5- 6, 1864, and December 13, 1862, respectively. Fredericksburg & Spotsylvania National Military Park covers 8,374 acres of eastern piedmont near Fredericksburg, VA. It is one of the largest military parks in the eastern United States. It protects some of the intriguing rocks in the Piedmont physiographic province, a variety of threatened habitats, not to mention the historical battlefields.

Fredericksburg & Spotsylvania National Military Park identified 7 quadrangles of interest. All 7 of these quadrangles are contained within the 30'x60' 1:100,000 Fredericksburg sheet. The U.S. Geological Survey mapped this sheet in 2000 (Geologic Investigations Series Map I- 2607).

Many other maps exist for the region that include coverage of the geology, oil and gas features, surficial geology, topography, groundwater features, land use, Landsat imagery, geochemical features, aeromagnetic- gravity, mineral and mineral potential, hazard features, stratigraphy, hydrogeology, structures, glacial features, karst features, etc. The maps are available from agencies such as the U.S. Geological Survey, the Virginia Division of Mineral Resources, the Geological Society of America, the American Geological Institute, the Maryland Geological Survey, the West Virginia Geological and Economic Survey, and the West Virginia Geological Survey. Additional mapping at a smaller scale within park boundaries will be more helpful for park resource management and interpretation.

Physiography

Fredericksburg & Spotsylvania National Military Park lies within the Piedmont Plateau and Atlantic Coastal Plain physiographic provinces. In the area of Fredericksburg & Spotsylvania, the eastern United States is divided into 5 physiographic provinces with associated local subprovinces. These are, from east to west, the Atlantic Coastal Plain, the Piedmont Plateau, the Blue Ridge, the Valley and Ridge, and the Appalachian Plateaus provinces.

The eastward- sloping Piedmont Plateau is located between the Blue Ridge province along the eastern edge of the Appalachian Mountains and the Atlantic Coastal Plain province to the east. It formed through a combination of folds, faults, uplifts, and erosion. The resulting landscape of eastern 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 schists, phyllites, slates, gneisses, and gabbros. Soils in the Piedmont Plateau are highly weathered and generally well drained. The "Fall Line" or "Fall Zone" marks a transitional zone where the softer, less consolidated sedimentary rock of the Coastal Plain to the east intersects the harder, more resilient metamorphic rock to the west to form an area of ridges, waterfalls, and rapids.

The Atlantic Coastal Plain province is primarily flat terrain with elevations ranging from sea level to about 100 m (300 ft) in Maryland. Sediments eroding from the Appalachian Highland areas to the west formed the wedge- shaped sequence of soft sediments that were deposited intermittently during periods of higher sea level over the past 100 million years. These sediments are now more than 2,438 m (8,000 ft) thick at the Atlantic coast and are reworked by fluctuating sea levels and the continual erosive action of waves along the coastline. Large streams and rivers in the Coastal Plain province, including the James, York, Rappahannock, and Potomac, continue to transport sediment and to extend the coastal plain eastward. Beyond the province to the east is the submerged Continental Shelf province for another 121 km (75 miles).

The Blue Ridge contains the highest elevations in the Appalachian Mountain system. These are 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 to form the core of the mountain range. Today this comprises the steep, rugged terrain now exposed after millions of years of erosion. Characteristics of the Blue Ridge province include steep terrain covered by thin, shallow soils, resulting in rapid runoff and low ground water recharge rates.

Geologic History of Central Virginia

Proterozoic Era – In the mid Proterozoic, during the Grenville orogeny, a supercontinent formed which included most of the continental crust in existence at that time. This included the crust of North America and Africa. The sedimentation, deformation, plutonism (the intrusion of igneous rocks), and volcanism associated with this event are manifested in the metamorphic gneisses in the core of the modern Blue Ridge Mountains (Harris et al., 1997). These rocks were deposited over a period of a 100 million years and are more than a billion years old, making them among the oldest rocks known from this region. They form a basement upon which all other rocks of the Appalachians were deposited (Southworth et al., 2001).

The late Proterozoic, roughly 600 million years ago, brought a tensional, rifting tectonic setting to the area. The supercontinent broke up and a sea basin formed that eventually became the Iapetus Ocean. In this tensional environment, flood basalts and other igneous rocks such as diabase and rhyolite added to the North American continent. These igneous rocks were intruded through cracks in the granitic gneisses of the Blue Ridge core and extruded onto the land surface during the break- up of the continental land mass (Southworth et al., 2001). Today these flood basalts comprise the Catoctin Greenstone. The Iapetus basin collected many of the sediments that would eventually form the Appalachian Mountains and Piedmont Plateau.

Early Paleozoic Era –

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 a volcanic arc – continent convergence. Oceanic crust, basin sediments, and the volcanic arc from the Iapetus basin were thrust onto the eastern edge of the North American continent. The Taconic orogeny involved the closing of the ocean, subduction of oceanic crust, the creation of volcanic arcs and the uplift of continental crust (Means, 1995). Initial metamorphism of the Catoctin Formation into metabasalts and metarhyolites, as well as the basin sediments (graywackes) into quartzites and phyllites occurred during this orogenic event.

In response to the overriding plate thrusting westward onto the continental margin of North America, the crust bowed downwards to the west creating a deep basin that filled with mud and sand eroded from the highlands to the east (Harris et al., 1997). This so- called Appalachian basin was centered on what is now West Virginia. These infilling sediments are today represented by the shale of the Ordovician (450 Ma) Martinsburg Formation (Southworth et al., 2001).

During the Late Ordovician, the oceanic sediments of the shrinking Iapetus Ocean were thrust westward onto other deepwater sediments of the western Piedmont. Sandstones, shales, siltstones, quartzites, and limestones were continuously deposited in the shallow marine to deltaic environment of the Appalachian basin. These rocks, now metamorphosed, currently underlie the Valley and Ridge province (Fisher, 1976).

This shallow marine to fluvial sedimentation continued for a period of about 200 My during the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian Periods. This resulted in thick piles of sediments. The source of these sediments was from the highlands that were rising to the east during the Taconian orogeny (Ordovician), and the Acadian orogeny (Devonian).

The Acadian orogeny (~360 Ma) continued the mountain building of the Taconic orogeny as the African continent approached North America (Harris et al., 1997). Similar to the preceding Taconic orogeny, the Acadian event involved land mass collision, mountain building, and regional metamorphism (Means 1995). This event was focused further north than central Virginia.

Late Paleozoic Era – Following the Acadian orogenic event, the proto- Atlantic Iapetus Ocean was completely destroyed during the Late Paleozoic as the North American continent collided with the African continent. This formed the Appalachian mountain belt we see today and a supercontinent named Pangaea. This mountain building episode is called the Alleghanian orogeny (~325 – 265 Ma), the last major orogeny of the Appalachian evolution (Means, 1995). The deformation by folding and faulting produced 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 (Southworth et al., 2001).

During this orogeny, rocks of the Great Valley, Blue Ridge, and Piedmont provinces were transported as a massive block (Blue Ridge – Piedmont thrust sheet) westward onto younger rocks of the Valley and Ridge along the North Mountain fault. The amount of compression was extreme. Estimates are of 20-50 percent shortening which translates into 125–350 km (75- 125 miles) of lateral translation (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 Alleghanian orogenic events (Southworth et al., 2001). Paleoelevations of the Alleghenian Mountains are estimated at approximately 6,096 m (20,000 ft), analogous to the modern day Himalaya Range in Asia.

Mesozoic Era – Following the Alleghenian orogeny, during the late Triassic, a period of rifting began as the deformed rocks of the joined continents began to break apart from about 230- 200 Ma. The supercontinent Pangaea was segmented into roughly the continents that persist today. This episode of rifting or crustal fracturing initiated the formation of the current Atlantic Ocean and caused many block- fault basins to develop with accompanying volcanism (Harris et al., 1997; Southworth et al., 2001). These Mesozoic basins are scattered around the park area.

Thick deposits of unconsolidated gravel, sand, and silt were shed from the eroded mountains. These were deposited at the base of the mountains as alluvial fans and spread eastward to be part of the Atlantic Coastal Plain (Duffy and Whittecar 1991; Whittecar and Duffy, 2000; Southworth et al., 2001). The amount of material inferred from the now- exposed metamorphic rocks is immense. Many of the rocks exposed at the surface must have been at least 20 km (~10 miles) below the surface prior to regional uplift and erosion. The erosion continues today with the Potomac, Rappahannock, Rapidan, James, and Shenandoah Rivers, stripping the Coastal Plain sediments, lowering the mountains, and depositing alluvial terraces of the rivers, creating the present landscape.

Cenozoic Era – Since the breakup of Pangaea and the uplift of the Appalachian Mountains, the North American plate has continued to drift toward the west. The isostatic adjustments that uplifted the continent after the Alleghenian orogeny continued at a subdued rate throughout the Cenozoic Period (Harris et al., 1997). These adjustments may be responsible for occasional seismic events felt throughout the region.

Though glaciers from the Pleistocene Ice Ages never reached the central Virginia area (the southern terminus was in northeastern Pennsylvania), the intermittent colder climates of the ice ages played a role in the formation of the landscape at Fredericksburg & Spotsylvania National Military Park. Freeze and thaw cycles at higher elevations led to increased erosion of large boulders and rocks by ice wedging. Sea level fluctuations during ice ages throughout the Pleistocene caused the baselevel of many of the area's rivers to change. During lowstands (sea level drops), the rivers would erode their channels exposing the deformed bedrock of the Piedmont Plateau. During oceanic highstands, the river basins flooded and deposition resulted in deposits of beach sediments just east of the park.

Stratigraphy

(from Geologic Map of the Fredericksburg 30'x60' Quadrangle, Virginia and Maryland, U.S. Geological Survey, Geologic Investigations Series Map I- 2607, 1:100,000 scale, 2000)

The oldest rocks in the Fredericksburg & Spotsylvania National Military Park area are the Granitic gneiss and Diorite gneiss of the Potomac Creek pluton. These gneissic rocks are Late Proterozoic to Early Paleozoic in age. Underlying most of the park at depth is the Matta Nappe structure (described in following section). This collection of rock units includes the Po River Metamorphic Suite from Late Proterozoic to Early Cambrian age. These rocks are mostly biotite gneiss and schist, with some hornblende- bearing gneiss, and garnetiferous mica schist. Within the Po River Metamorphic Suite are lenticular layers of slightly different compositions that may be the metamorphosed remnants of earlier intrusive plutons.

Within the Salem Church allochthon to the northwest of the park, Holly Corner Gneiss (hornblende- biotite rich gneiss), Quartzite beds of the Quantico Formation (thin impure lenses of quartzite), and Falls Run Granite Gneiss of the Berea Pluton (foliated hornblende and biotite granitic gneiss) are present in a fault- bounded structure. These rocks are Late Proterozoic to Cambrian, Upper Ordovician, and Silurian in age, respectively. South of the Salem Church allochthon is the Ta River Metamorphic Suite of Cambrian age. These are mostly foliated amphibolitic gneisses with some biotite gneiss interspersed. Some felsic granitoid bodies occur in the northeastern portions of the suite.

Surrounding the battlefield units of the park are younger deposits of Atlantic Coastal Plain rocks. The Lower Cretaceous Potomac Formation is exposed by erosion along many of the rivers and streams in the area. This formation is comprised of feldspathic quartz sand and sandstone, silty channel- bar deposits, and lignitic sandy silt and clay layers. Atop the Potomac Formation is the upper Paleocene Aquia Formation of glauconitic sands, silts, clays, and containing some scant fossil layers. Nanjemoy Formation deposits from the lower Eocene overlie the Aquia Formation. These are glauconitic sands, clays, silts, and mixed layers. This unit is as much as 64 m (210 ft) thick. Miocene age sands and gravels as much as 10 m (33 ft) thick overlie the Aquia and Nanjemoy Formations in the park area.

Younger deposits include the Yorktown Formation and Pliocene sands and gravels. The Yorktown Formation is a maximum of 25 m (82 ft) thick and contains quartz and feldspar sands mixed with lesser clays and silts. The upper Pliocene Bacons Castle Formation includes gravelly sand and sandy- silty- clayey upper layers. These are often found in high- level terrace areas. The more recent

deposits at the park include various Quaternary age units. The fine to coarse sand, gravel, silt and clay of the Windsor Formation is of lower Pleistocene to upper Pliocene age. The gravelly Charles City Formation, the sands and silts of the Chuckatuck Formation as well as the Shirley Formation of coarse sands, gravels, pebbles and occasional boulders are of the middle Pleistocene. The upper Pleistocene Tabb Formation contains sands, gravels, silts and clays and underlies low terraces in the area. The Tabb Formation has three members: the Poquoson, the Lynnhaven, and the Sedgefield Members.

The youngest deposits at Fredericksburg & Spotsylvania National Military Park include thick alluvium deposits of sand, gravel, silt and clays as much as 15 m (49 ft) thick, marsh and swamp deposits along larger rivers, shelly sands, and artificial fill from construction of roads, dams, bridges, landfills, and highways.

Structure

The Rappahannock anticlinorium dominates the structural features present around Fredericksburg & Spotsylvania National Military Park. The anticlinorium extends from the Stafford, Virginia area southwards beyond the James River. The anticlinorium trends roughly northeast and plunges to the northeast. The eastern portions of the anticlinorium are comprised of island- arc deposits and some felsic plutons. Associated with the anticlinorium is the parallel trending Quantico synclinorium within the Quantico Formation on the western side of the structure. The feature is bound on the east by the Spotsylvania thrust fault and on the west by the Long Branch fault. The northern end is truncated by the right- lateral Accockeek fault just northwest of Fredericksburg and contains the Salem Church allochthon (meaning, its origin is elsewhere from its surrounding rocks). This is a relatively small fault- bounded area of granitic gneiss. (Mixon et al. 2000). Structures along the limbs of the anticlinorium suggest multiple phases of folding and at least two metamorphic events. (Onasch, 1986; Mixon et al., 2000).

Thrust faults within the Fredericksburg & Spotsylvania National Military Park area have had a pronounced influence on landform development. Most of these are not well exposed. Several large, parallel, low- to high- angle thrust faults dipping to the southeast are present trending northeast- southwest. From east to west, these are the Spotsylvania, Long Branch, Chopawamsic, and Lake of the Woods thrust faults. East of the Lake of the Woods thrust fault lies the Mountain Run fault zone, a 1.6 km (1 mile) wide sheared zone (Mixon et al., 2000). These thrust faults moved large masses of Piedmont rocks and associated plutons atop younger rocks to the west. The Spotsylvania thrust fault separates the Matta nappe, comprised of schist and gneiss of the Po River Metamorphic Suite and accompanying plutons, from the island arc rocks of the eastern limb of the Rappahannock anticlinorium. This feature is northwest verging and recumbent.

Closer to the park are several smaller scale faults including the Dumfries, Hazel Run, Brooke, and Fall Hill faults. These high- angle reverse faults are present along the eastern side of the Piedmont. They are all part of the Stafford fault system within the inner Coastal Plain of Virginia. The Stafford Fault system extends along the Fall Line 68 km (42 miles) from Spotsylvania northeastward to southern Fairfax County. These features are en echelon, or step- like in map trend and all strike northeast. Vertical displacement along these features is minor, only 10 - 60 m (33- 197 ft), but this amount of offset significantly affects the thickness and distribution of Coastal Plain sediments (Mixon et al., 2000). Sediments present on the western, upthrown blocks are thinner than their counterparts on the eastern downthrown blocks across the high- angle reverse faults.

Significant Geologic Resource Management Issues in Fredericksburg & Spotsylvania National Military Park

1. Disturbed land sites

Small- scale abandoned mines, quarries, and assay pits dot the landscape within the units at Fredericksburg & Spotsylvania National Military Park. The state of Virginia has an inventory of mine features such as small open pit mines. Mines are constantly being identified and scanned into their database. Most of these mines were likely iron ore mines, some before the Civil War. However, a gold-pyrite belt occurs in the park area and it is not outside the realm of possibility that many of these small- scale mine features were prospects looking for gold or sulfides. Many circular pits surround Catherine Furnace in Chancellorsville. Mining here started around the Revolutionary War and was started again in Civil War time. There are more than 20 6.1 m (20 ft) wide trenches located within the park. These historical features could be targets for an interpretive program.

These features pose several concerns for resource management. A brush-covered pit on land newly acquired at the Chancellorsville unit is leaching arsenic into the ground and surface water. Visitor safety is a constant concern wherever open pits and loose tailings are associated with a mine feature. Most mine features, accessible to the public have been blocked or filled.

Research and monitoring questions and suggestions include:

- Comprehensively inventory mine- related features at Fredericksburg & Spotsylvania National Military Park, consulting aerial photographs and historic records if necessary.
- Determine extent and nature of acid mine drainage from waste piles within the park. Map and characterize the geology around these areas and the positive and/or negative effects on the biota.
- Are there potential mineral resources that might be subject to theft?
- Research and possibly remediate brush- covered pit in newly acquired Chancellorsville unit that is leaching arsenic.
- Consult the Virginia Department of Mineral Resources database for abandoned mine information.
- Perform a stability survey, focusing on mine tailings within public zones.
- Prepare an interpretive program on the historical search and extraction of useful geologic resources from Fredericksburg & Spotsylvania National Military Park.
- Consult the Virginia Division of Mineral Mining for environmental regulation for current and abandoned mines.

- Possibly establish research opportunities with local universities to monitor local pH, soil contaminants, water quality, etc. near identified mine features within the park units.

2. Shoreline changes

The Rappahannock River is cutting slopes near park headquarters. North of the Chatham Park headquarters, Union forces crossed the river on pontoon bridges. They were subjected to intense sniping by Confederate troops. This historically relevant area (along the eastern shore) is threatened to be washed away by erosion and flooding of the Rappahannock River. The river and other local streams are changing position constantly as part of natural meandering river flow. These shoreline changes threaten existing park facilities and the historical context of the landscape.

Many open fields with streams existed during the time of the battles fought at Fredericksburg & Spotsylvania National Military Park. These areas are now mostly forested and for cultural interpretation needs, plans are being discussed to clear these areas. The resulting increase in soil erosion and subsequent sediment loading into these streams must be taken into account during resource management decision making.

Research and monitoring questions and suggestions include:
- Monitor shoreline change using aerial photographs.
- Research methods to maintain current shoreline positions where the waterway threatens historic features .

3. Siting of future facilities

Plans are being discussed to expand the visitor center, possibly extending it underground beneath the existing parking lot. Many geologic factors must be taken into account during decision making regarding siting future facilities. The presence of high concentrations of shrink and swell clays could undermine any structure. Knowing the locations of springs and understanding the hydrogeologic system helps avoid problems with groundwater flow. Waste facilities should be sited taking hydrogeology into account as well as an understanding of the substrate.

Research and monitoring questions and suggestions include:
- Consult local geologic experts when planning future facilities at the park.
- Locate areas of high swelling clay concentrations, springs, groundwater flow, high slope, unstable substrate, etc. to avoid for future facilities.

4. Hydrogeology

The resource management needs to understand how water is moving through the hydrogeologic system into, under, and from the park. Management also needs to understand how the water table might change over time. Municipal water and wells are the primary drinking water supply sources for the park. There are several wells throughout the park that could be used for monitoring of ground water quality. It would be useful to perform tracer studies in these wells to see how quickly and in what direction water is moving through the system.

Understanding the hydrogeologic system is critical to understand the impacts of human induced contaminants on the ecosystem. The interaction between groundwater flow and the overall water quality should be quantitatively determined at the park. Visitor uses and surrounding development are increasing the levels of certain substances in the water at the park. Nutrients from urban and agricultural waste are causing aquatic disturbances.

There are several somewhat seasonal wetlands within the parklands. These are usually attributed to beaver activity in the area. Though small in scale, wetlands are typically considered indicators of overall ecosystem health and should be researched and monitored periodically.

Research and monitoring questions and suggestions include:

- Inventory groundwater levels at all park units.
- Perform dye tests to look at the hydrogeologic effects of local geologic structures on the watersheds at the park.
- Test for and monitor phosphate and volatile hydrocarbon levels in the groundwater at the park, focusing on areas near facilities.
- Are CFC levels elevated in the groundwater at Fredericksburg & Spotsylvania National Military Park?
- Inventory and map any existing springs in the park, especially with regards to their potential historical importance.
- Test water quality at any existing springs in the park.
- Create hydrogeologic models for the park to better manage the groundwater resource and predict the system's response to contamination.
- Comprehensively map and monitor water and soil quality at all wetlands within the park. This creates a baseline level of ecosystem health to use for understanding future changes.

5. Erosion and slope processes

One of the major goals of the park is to present the historical context of the area; this includes preserving and restoring any old buildings and the landscape

around them. Maintaining this battle landscape often means resisting natural geologic changes, which presents several management challenges. Geologic slope processes such as landsliding, slumping, chemical weathering, and slope creep are constantly changing the landscape at the park. Runoff erodes sediments from any open areas and carries them down streams and gullies. Erosion naturally diminishes higher areas such as ridges and hills, foundations, earthworks, degrades bridge foundations, erodes streams back into restoration areas, and fills in the lower areas such as trenches, railroad cuts and stream ravines distorting the historical context of the landscape. Earthworks at the park are small, ranging in height from 1 to 1.5 m (3- 5 ft). These 140- year- old features are eroding away.

Some slope failure is occurring in the western reaches of the park. However, maximum relief for Fredericksburg & Spotsylvania National Military Park is only 91 m (300 ft) total. These gentle slopes seldom experience catastrophic failure. For park resource management, an awareness of this possibility is necessary in the future siting of park facilities. Areas of higher slope should be monitored for continuous slope creep. Areas likely to fail during intense seasonal storms should be identified.

Swelling soils occur throughout the park area. These are the result of bedrock (amphibolite) weathering. These soils contain clays that swell when water saturated and shrink when dry. In the extreme, this process can destroy roads, trails, visitor facilities, and building foundations.

Research and monitoring questions and suggestions include:

- Map locations of high concentrations of swelling clays.
- Identify areas prone to slope failure during intense storm events.
- Are slope processes destroying the historic features at the park?
- What are the effects of increased erosion on aquatic ecosystems at the park?
- Is runoff in the park increasing due to surrounding development? If so, are there any remedial efforts the park can undertake to reduce this impact?
- How should earthwork erosion be reversed?

6. Urban encroachment

The area surrounding Fredericksburg & Spotsylvania National Military Park is becoming increasingly populated. As development continues, conservation of any existing forest- meadow community types becomes a critical concern. Understanding the geology beneath the biotic communities becomes vital to their management. Park management of the landscape for historic preservation purposes compliments the preservation of these forests.

Research and monitoring questions and suggestions include:

- Cooperate with local developers to minimize impact near park areas.
- Consult conservation groups regarding cooperative efforts to increase the areas of relevant parklands and protect more of the region around the battlefields from development.
- Promote environmentally sound methods of developing land parcels including partial clearing of trees and proper construction of stable slopes.

7. Connections between geology and the Civil War history

Interpreters make the landscape come alive for visitors and give the scenery a deeper meaning. Because geology forms the basis of the entire ecosystem and is directly responsible for the unique history at Fredericksburg & Spotsylvania National Military Park, geologic features and processes should be emphasized to improve the visitor's experience. The website for the park needs to be updated for geologic content and connections with other scientific and cultural disciplines.

In many Civil War battles, it was the advantage that familiarity with terrain, preparation to utilize of the natural features of the area, and the manipulation of the focal points, the gaps, ravines, cuts, hills, and ridges gave to one side or another that was to decide the outcome. At Fredericksburg, the Confederates used the floodplains, river terraces, and north- south trending ridges around the Rappahannock River to their advantage, stalling Union advance on Richmond for several years.

The rolling hills and gentle landscape and topography at Fredericksburg & Spotsylvania National Military Park is defined by the geology. Along the southeastern side of the Rappahannock River valley, along the foot of the bluffs, sits the sunken road. This is where Confederate troops were positioned during the battle in 1862. Marye's Heights and Willis Hill stood behind the road with artillery dug in. This position, defined by geomorphological features, proved insurmountable for Union General Burnside and the Union attach was repulsed (Sherwood and Flora, 2002). In addition to influencing battles, the landscape and topography also affected how troops and supplies were transported during the Civil War.

Research and monitoring questions and suggestions include:

- Create interpretive programs concerning geologic features and processes and their effects on the battleground history of the park.
- Encourage the interaction between geologists and the interpretive staff to come up with a list of features and programs to execute.

- Create a general interest map with simple explanatory text on geologic battle influences for visitors to the park.
- Update the park website relating geology with other resources.
- How can earthworks and other battleground features susceptible to erosion be maintained?
- Where did the stones used in historic wall construction come from?

8. Potential fossil resources and unique geologic features

Within Fredericksburg & Spotsylvania National Military Park are several Triassic age rocks. These rocks have the potential of containing fossils. Fossils would be an important resource at the park as they add to the geologic history of the area. Fossils are also attractive targets for visitors. Fossil theft would be a concern to any paleontologic resources at the park.

More recent fossils such as marine clams, oysters, etc. in the Potomac Formation (?) are present in the park's region. These fossils are not recognized as being particularly important for park management at this time.

Research and monitoring questions and suggestions include:
- Map potential fossil areas, paying particular attention to the Triassic age rocks.
- If fossils are found, perform a comprehensive inventory, possibly curating samples for a park collection.
- If fossil resources are present at Fredericksburg & Spotsylvania National Military Park, consider creating an interpretive exhibit highlighting the geologic story behind them.

9. Human Impacts

Humans began settling the Fredericksburg & Spotsylvania area in the late 1600's to early 1700's. Their farming and homestead activities created an unnatural landscape that persists today at Fredericksburg & Spotsylvania National Military Park. Minor irrigation features, removal of soil and rocks, stone fences, grazed pastures, extensive logging, and other homestead features dot the landscape.

Human impacts continue today as pipelines, power lines, roads, buildings, trails, visitor use areas, imported (invasive species), acid rain, and air and water pollution take their toll on the landscape. Resource management of these impacts is an ongoing process.

Research and monitoring questions and suggestions include:

- Encourage further cooperative efforts with local universities, government agencies, and other groups to study the climate at Fredericksburg & Spotsylvania National Military Park and the effects of change.
- Perform acid rain measurements and correlate with the underlying bedrock to determine if any buffering effects occur. Relate this information to the water quality for the park.
- Perform clay mineralogy and grain size studies on the soils in the park, relating these to pollen studies to determine paleoclimatic patterns.
- Should the unnatural landscapes created by early settlers be remediated?
- Are soils becoming more acidic due to acid rain?
- Monitor chemical alterations in bedrock.

10. Surface water and sediment loading

Fredericksburg & Spotsylvania National Military Park protects reaches of the Rappahannock River and other local streams. As such, the quality of the surface water at the park is very important to surrounding communities. Compaction due to increased visitor use as well as impervious surfaces is increasing seasonal runoff as sheet flow. Many of these areas are managed by engineering solutions such as culverts, bridges, etc.

Flooding and channel erosion are naturally occurring along most of the streams and rivers within the park. This flooding and erosion can threaten wetlands and visitor facilities.

Alterations to park vegetation along the steep, exposed slopes lead to changes in the hydrologic regime at the park. For example, clearing of trees and their stabilizing roots for historical restoration, can lead to increased sediment load in nearby streams and could potentially contribute to slumps and landslides. Hiking trails and other high use areas are also at risk of intense erosion leading to sediment loading.

Research and monitoring questions and suggestions include:
- Research stream sediment loads to determine their effects on aquatic and riparian biota. Is sediment loading in the park streams following a seasonal pattern?
- Accurately map park administrative roads and target streams and areas of erosion for remediation.
- Determine any hotspots for water contamination. Remediate and monitor results.
- Research planting new vegetation along vulnerable reaches of park streams to prevent excess erosion and sediment loading.

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Map of Fredericksburg & Spotsylvania National Military Park

