

PHILADELPHIA'S WISSAHICKON VALLEY: ITS GEOLOGY AND GEOGRAPHY

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ABSTRACT: *The Wissahickon Valley is a spectacular park system located in the city of Philadelphia. The wooded valley is considered by many to be one of the most beautiful urban parks in the world. Its natural beauty is a creation of tectonic forces that occurred during the past 500 million years. Evidence of these forces can be found in the formation of the rocks of the Wissahickon, such as pegmatite, quartzite, schist, and gneiss. Additional evidence is provided by geological features, such as faults, joints, folds, and the rock formations emplaced by the action of water. The unique geology of the Wissahickon Valley has had an impact on geography, history and culture of Philadelphia over the years. The water power provided by the creek brought industrialization to the area, the hills contributed to the loss of the historic Battle of Germantown during the Revolutionary War, and the park provided a place of quiet and beauty for Philadelphia's urban residents. Today, the geology and geography of the Wissahickon is a contributing factor to the park's deterioration through soil erosion. With its urban location, the park suffers from storm water runoff and over-use by a burgeoning population, both problems which are exacerbated by the park's landscape.*

In the northwest section of Philadelphia, bordered by both urban and suburban neighborhoods, there lies a little piece of wilderness called the Wissahickon Valley. City neighborhoods lie on three sides; namely, Chestnut Hill, Mt. Airy, and Germantown to the east, East Falls to the southeast, and Roxborough and Manayunk to the west. On the north side, there is the suburban town of Lafayette Hills in Montgomery County. The Wissahickon Valley and its natural features have been preserved by the Fairmount Park Commission of Philadelphia. Its 1,400 acres were annexed to the park system in 1868, and this land accounts for 1/6 of the land under the auspices of the Fairmount Park Commission. This act made history when the Wissahickon became the first piece of publicly owned land in the United States to be set aside for preservation of its natural beauty (Simon and Jaffe, 1995, summary). In 1964, the Wissahickon Valley received the honor of achieving National Natural Landmark status because, as stated in its nomination, it is considered to be "a symbol of what can be done toward perpetuation of a truly natural area within a vast urban complex" (Simon and Jaffe, 1995, summary). This slice of nature called the Wissahickon Valley has a fascinating geology which has had an impact on the history and culture of Philadelphia.

GEOLOGY OF THE WISSAHICKON VALLEY

Natural Setting

The natural setting of the Wissahickon Valley has been described as "a miniature Alpine gorge" (Daly, 1922). It is a steep-sided valley that is heavily wooded with native trees where lives an abundant animal life, including a diverse bird population and numerous types of mammals. Abundant fish make the Wissahickon Creek section of the park one of the most popular fishing spots in the region. The heart of the Wissahickon Valley, which is called Valley Green and runs from Rex Avenue to Mt. Airy Avenue, is "virtually untouched by the inroads of modern civilization (Simon and Jaffe, 1995, summary). It is truly unbelievable to find such a natural setting in an urban environment where the "beauty of the creek, the grandeur of the trees, and the loveliness of the setting outvie each other" (Brandt, 1927). In this beauty, one is surrounded by the evidence of geological activity, and the Wissahickon Valley has been studied by area geologists for many years.

Geologic Formations

In the science of geology, the term "formation" is used when a particular rock type can be found covering a large area, and this rock is distinctive enough to be recognized apart from the neighboring rocks (Goodwin, 1964). The Wissahickon Valley is such an area, and its formation has been named after the valley itself. The Wissahickon Formation is the most prominent rock unit in Philadelphia and can be found as a broad band of rock across the southeastern portion of Pennsylvania (Goodwin, 1964). It is considered by geologists as part of Appalachia which was the ancient land mass thought to be the foundation of North America (Simon and Jaffe, 1995, features).

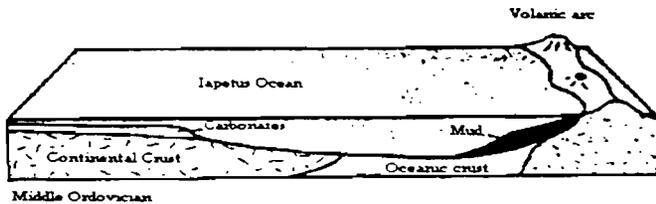


Figure 1. Iapetus Ocean and Volcanic Arc off North American Plate.

The formation of the Wissahickon Valley started 430 million to 500 million years ago during the Taconic Orogeny which was a period of mountain building that occurred during the Ordovician period of the Paleozoic Era (Barnes and Sevon, 1996). At this time, an ancient sea called the Iapetus Ocean and a small mountain range (volcanic arc) could be found off the coast of the North American plate as seen in Figure 1. The Iapetus Ocean began to move towards the North American plate and eventually closed which caused the volcanic arc to be thrust onto the continental crust as shown in Figure 2.

Once on the continent, the volcanic arc formed a larger mountain range called the Taconic Mountains as shown in Figure 3.

During the Silurian Period of the Paleozoic era, which occurred 405 to 430 million years ago, the weight of the Taconic mountains caused the continental crust to subside creating a basin. Sediments washed

down from the mountains, would collect in the basin and eventually formed rocks, such as shale and sandstone. With continued tectonic activity, the shale

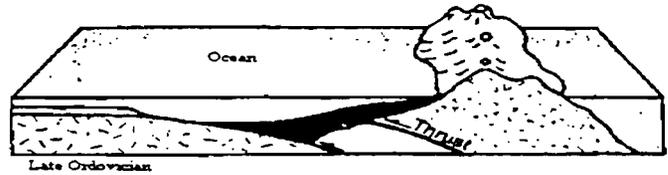


Figure 2. Thrusting of Volcanic Arc onto Continental Crust.

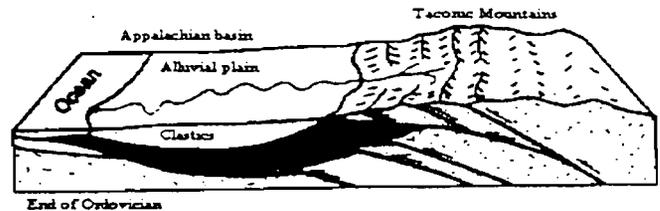


Figure 3. Taconic Mountains.

and sandstone were pushed into the crust. Under the heat and pressure of this action, the rocks were metamorphosed. The shale was converted to slate then schist, and the sandstone was converted into quartzite (Barnes and Sevon, 1996). This first orogeny produced the tight folding that is visible in the rocks of the Wissahickon (West, 1993).

A second period of mountain building called the Alleghenian Orogeny occurred 250 million to 290 million years ago during the Permian period of the Paleozoic Era (West, 1993). A four-way collision between Europe, North Africa, South America, and North America occurred during this period, creating the Appalachian Mountains (Barnes and Sevon, 1996). Geologists state that the evidence of this second period of mountain building can be seen in the geography. The rocks, with the tight folding formed in the first

orogeny, were thrust up by this collision, changing the direction of the folds and creating broad open folds throughout the valley. (West, 1993).

One reason for the uniqueness of the Wissahickon Formation is its preservation through the million of years of geological time. In the distant geological past, there were several areas that underwent the same geological forces as the Wissahickon Valley, including other northeastern states, such as New York (Simon and Jaffe, 1995, features). However, nothing like what is found in the Wissahickon Valley can be seen there. During the three periods of glaciation that occurred in the distant past, these other formations were eroded by the heavy drag of the glaciers (Simon and Jaffe, 1995, features). Because the glaciers did not reach the Wissahickon Valley region of Pennsylvania as shown in Figure 4, the rocks of the Wissahickon Formation were preserved, thereby making it a unique geological feature.

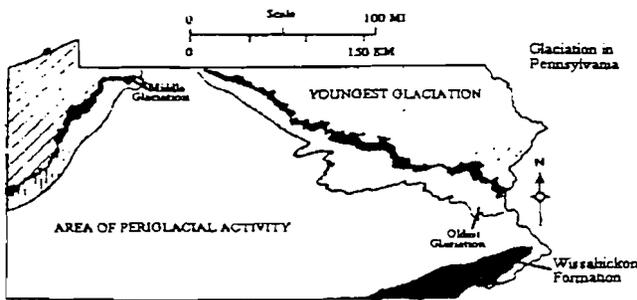


Figure 4. Extent of Glaciation in Pennsylvania.

The Wissahickon Creek also contributed to the formation of the valley. Its origin can be traced to 1 million years ago, and it rises in the sandstone and shale called the Stockton Formation which is found north of the city in Montgomery County (Sollers, 1972). The creek then flows across a limestone formation found in the Whitmarsh Valley, cuts across the hard quartzite rock found in the Wissahickon Formation, and then plunges into a gorge of the metamorphic rock (Simon and Jaffe, 1995, features). As the land rose from the force of tectonic activity, the stream cut through the soft rock while persisting in its ancient bed (West, 1993). This action, which is not unlike the action of the Colorado River in the Grand

Canyon, created the steep hillsides with slopes of over 25% that are found in the Wissahickon Valley (West, 1993; Philadelphia City Planning Commissions, 1976).

Rocks

There are four major types of rocks that can be found in the Wissahickon Valley; they are pegmatite, quartzite, schist, and gneiss (West, 1993). Of these four, only pegmatite is an igneous rock; the other three are metamorphic rocks. Pegmatite was formed during both the Taconic Orogeny and the Alleghanian Orogeny (Goodwin, 1964). It is coarse-grained with large crystals of quartz, feldspar, and mica, and it is a hard rock that is not easily eroded nor broken (Goodwin, 1964).

Quartzite is a metamorphic rock that was formed from sandstone, a sedimentary rock formed during the Paleozoic Era (Goodwin, 1964). Sandstone is mostly comprised of a hard mineral called quartz (Goodwin, 1964). When subjected to heat and pressure, sandstone, with its quartz components, turns into quartzite (Goodwin, 1964). Quartzite is also a very hard rock; therefore, it is not easily eroded nor broken away, and thus is usually found protruding from the rock face.

Schist is a metamorphic rock formed during the Taconic Orogeny, and the most noticeable rock found in the Wissahickon Formation (Goodwin, 1964). This rock has large flaky crystals with a very pronounced cleavage (Goodwin, 1964). Numerous minerals are visible in the Wissahickon schists, including garnet, kyanite, staurolite, tourmaline (West, 1993). Schist is a very soft rock, easily eroded and broken away from the rock face. Because it is easily broken away from the rock face, schist is found scattered on the ground throughout the Wissahickon Valley.

Gneiss is a significant rock in the Valley because the Wissahickon Formation is considered by geologists as a true gneiss formation (Goodwin, 1964). Even though the other three rocks mentioned are significant to the geology of the Valley, gneiss is the base rock of the Wissahickon formation. Gneiss contains large crystals and has a distinctive banded appearance; this was caused by alternating layers of dark schist and light feldspar (Goodwin, 1964). It was formed during both the Taconic Orogeny and the Appalachian Orogeny when molten pegmatite, with its feldspar components, oozed between layers of hot

schist (Goodwin, 1964). Gneiss is very variable in its characteristics depending on the composition of pegmatite and schist; usually, it is not as hard as the pegmatite and quartzite, but not as soft as the schist (Goodwin, 1964).

GEOLOGICAL FEATURES

Faults

In geologic terms, a fault is defined as a fracture in the rockbed where movement has taken place (Goodwin, 1964). Though this section of the country is relatively stable in the geological sense, there are a number of small faults located in the Philadelphia area. In the Wissahickon Valley, there are two known fault lines; they pass through the Wissahickon Valley above Rex Avenue and join together in the area of Chestnut Hill College and the Morris Arboretum (Regional Science Research Institute, 1973). The fault lines called the Rosemont Fault, and the Cream Valley Fault, run in a northeast-southeast direction, and are considered permanently inactive. Evidence of these fault lines can be seen in the geography of the creek. For example, at the location of the fault lines, there is a major bend in both the creek and its tributaries which is a result of the creek shifting from the movement of these fault lines. The fault lines can be seen in Figure 5.

Joints

Unlike faults, joints are fractures in rocks where no movement of one side relative to the other has taken place (Goodwin, 1964). This type of geological feature can also be seen in the Wissahickon Valley near Valley Green Road, on the White Trail. There is a large rock that looks like it is missing a huge wedge (West, 1993). The particular feature was formed because the fractures in the rock intersect at right angles. The rock has many layers or surfaces, and the intersection of each of these surfaces is called a joint. Each set of two joints bound together are called a joint set, and many joint sets, such as seen in this rock, form a joint system (Goodwin, 1964). During creation of the joints, the rocks were brittle; and therefore, they cracked rather than move, when subjected to stress (West, 1993).

Folds

During orogenies, rocks are pushed together, thereby creating a wavy pattern in the rock called folds. Folds are a bending or warping of rocks which is most commonly observed in soft sedimentary rocks or metamorphic rocks formed from sedimentary rocks (Goodwin, 1964). The folds in the Wissahickon Valley are unique because of their layering pattern. In many parts of the Wissahickon, schists and quartzite can be found in alternating layers created when the sedimentary rocks, shale and sandstone, that were the basis of these metamorphic rocks were laid down in this manner (Goodwin, 1964). With heat and pressure from tectonic activity, the shale and sandstone changed to schist and quartzite, but the layers remained to form alternating beds of these rocks. During the orogenies, the land was pushed together creating the folds but leaving the layers in place. Through the years, some of the schist has eroded away leaving a protrusion of quartzite from the rock face. The rock layers as well as the protrusion of the harder rocks are quite evident throughout the Wissahickon Valley. These rock formations are spectacular evidence of the geological history of the Valley.

Water Action

As in the Grand Canyon, the water action of the Wissahickon Creek has created some unique formations in this valley. One can be found on Cresheim Creek where it intersects with the Wissahickon Creek. This is called Devils Pool, and it is considered one of Pennsylvania's outstanding scenic geological features. Devils Pool was formed as water cutting through the zones of weak rock and flowing down over the rocks created a waterfall (Geyer and Bolles, 1987). The force of this water as well as the rock pieces contained in the flowing water have caused the bedrock below the falls to wear down, thus creating a depression that is 9.23 meters (10 yards) deep and 9.23 meters (10 yards) wide (Goodwin, 1964; Geyer and Bolles, 1987). Surrounding the pool, there are outcrops of quartzite and schist containing large crystals of red garnet. Eventually, due to the difference in the hardness between the quartzite and the schist, the schist will erode away leaving protruding veins of the quartzite (West, 1993).

IMPACT OF GEOLOGY ON THE WISSAHICKON VALLEY

History

The Wissahickon Valley was originally occupied by the Lenni Lenape Native Americans. The word "Wissahickon" is a combination of two words from their language; "wisaucksickan" which means

"yellow-colored creek," and "wisamickan" which means "catfish creek" (Simon and Jaffe, 1995, history).

In 1756, while the Germans and other Europeans were developing the region, the Lenni Lenapes held a conference on a rocky outcrop which is now called Indian Rock (Brandt, 1927). At this conference, the Lenni Lenapes decided to leave the area and move on to the Wyoming Valley in Pennsylvania (Brandt, 1927). The legendary spot where this council was held

Points of Interest

1. Cream Valley Fault
2. Rosemont Fault
3. Statue of Tedyuscung
4. Joint System on White Trail
5. Devil's Pool
6. Rittenhouse Paper Mill and Birth
7. Battle of Germantown

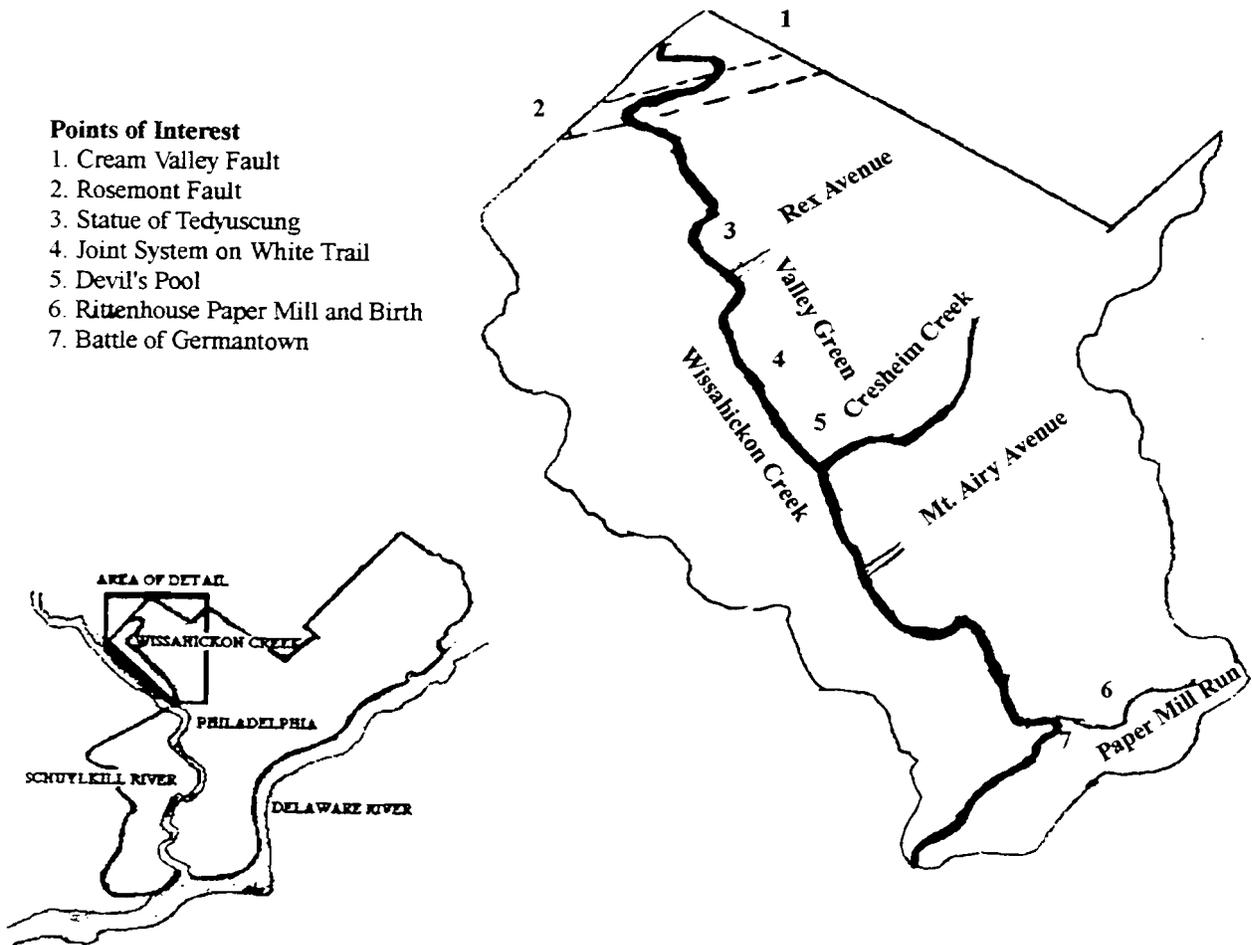


Figure 5. Map of the Wissahickon Valley Including Reference Points.

Philadelphia's Wissahickon Valley

is now marked with a sculpture of Tedyuscung, the last Lenape chief.

The geology of the valley was instrumental in its development and eventual industrialization. As European immigrants came to America, they discovered the Wissahickon Valley and the immense water power provided by the creek. The area changed from one of natural beauty inhabited by the Lenni Lenapes to becoming the first industrial center in Pennsylvania and the colonies. The first mills included a log cutting mill and a grist mill which were erected in 1683 and 1686, respectfully (Simon and Jaffe, 1995, history). Eventually, there were a total of 54 mills along the Wissahickon Creek manufacturing such products as flax, linseed oil, dye and textiles (Simon and Jaffe, 1995, history). In walking through the Wissahickon Valley now, there is little evidence of this industrialism. The area in and around the valley is now considered to be the first reclaimed industrial area in the United States (Simon and Jaffe, 1995, history).

One of these mills was the United States' first paper mill which was built by William Rittenhouse in 1691 on Paper Mill Run, a tributary of the Wissahickon Creek. William Rittenhouse became a prominent citizen of the area, and the emerging community was named Rittenhouse Town after this industrialist (Brandt, 1927). The ancestors of William Rittenhouse continued to live in Rittenhouse Town and contribute to America's early history. His grandson, David Rittenhouse, was born on April 8, 1732 in a stone house located next to the paper mill. He grew up during the tumultuous years leading up to the Revolutionary War and supported America's fight for independence. Though he was trained to be a clockmaker, Rittenhouse was a person who enjoyed the academic life. He studied the sciences and mathematics and became well-known throughout the colonies and Europe for his skills as an astronomer. The contributions of David Rittenhouse to the early years of American history are numerous; he was the director of the Mint, president of the American Philosophical Society, and served as the Pennsylvania State Treasurer from 1777 to 1789. His birthplace in the Wissahickon Valley adds to the historical significance of this area.

The historical significance of the valley can also be seen by the landscape's impact on Revolutionary War history. On October 4, 1777, the Pennsylvania Militia, under the command of General John Armstrong, and the Hessian Jaegers, under the

command of Lt. General Knyphausen, engaged in battle on the hills of the Wissahickon. The Americans occupied the high ground on the west side of the creek while the Germans occupied the hills on the east side (Daly, 1922). This was the beginning of the famous Battle of Germantown. In the end, the American troops were beaten back and retreated to spend the winter at Valley Forge. In his report to General Washington, General Armstrong wrote about the trials of fighting on these "horrendous hills of the Wissahickon" (Daly, 1922).

Culture

The geology of the Wissahickon has created a place so spectacular that it has been valued by residents of the Delaware Valley for many years. Edgar Allen Poe, a one-time resident of Philadelphia, wrote, "now the Wissahickon is of so remarkable a loveliness that, were it flowing in England, it would be the theme of every bard (Philadelphia City Planning Commissions, 1976). In 1920, Christopher Morely, author of the book *Travels in Philadelphia*, wrote:

Perhaps Philadelphians do not quite realize how famous the Wissahickon Valley is. When my mother was a small girl in England, there stood on her father's reading table a silk lampshade on which were painted little scenes of the world's loveliest beauty glimpses. There were vistas of Swiss mountains, Italian lakes, French cathedrals, Dutch canals, English gardens. And then, among these fabled glories, there was a tiny sketch of a scene that chiefly touched my mother's girlish fancy... It was called *Wissahickon Drive, Philadelphia, USA* (Simon and Jaffe, 1995, history).

This is still true today. Many people in Philadelphia and the Delaware Valley visit the Wissahickon Valley to escape to the wilderness, even for just an afternoon. Though studies have never been done, many visitors will attest to the psychological benefits gained by a walk in the valley where it truly feels like another time and place. It is estimated that 717,200 people visit the Wissahickon Valley annually, thus ranking it the fifth among Philadelphia's historic and cultural attractions (Simon and Jaffe, 1995, econ). This rank would put the Wissahickon Valley behind Independence Hall but ahead of the Art Museum, thus making it a major cultural attraction in Philadelphia (Simon and Jaffe, 1995, econ).

THE WISSAHICKON VALLEY TODAY

Today, the beauty of the Wissahickon Valley is deteriorating. The park is suffering from problems that affect many urban parks, such as pollution, deer overpopulation, overuse, introduction of invasive plants, and other difficulties. One of the most severe problems affecting the Wissahickon Valley is soil erosion, and the geology of the park, with its steep hills, is a contributing factor to this condition.

The soil erosion is also exacerbated by the valley's urban location. Being located in a developed area, storm water run-off from paved surfaces and drainage systems from outside of the park have caused major problems within the Wissahickon park area. During heavy rains, enormous amounts of storm water, by following the path of least resistance, will run down the slopes, cutting into the banks, and creating large ravines. This water will erode valley landscapes as well as the park trails which then become unsafe because of the sheer drop into the creek bed (Simon and Jaffe, 1995, recommendations2). Large gullies deface some of the steeper hills, and trees become susceptible to toppling over because of the eroded soil and downward slope of the hillside. Soil creep is evident on paved trails where fencing is leaning downslope towards the creek bed. The storm water run-off is considered to be the "biggest obstacle to the preservation of the park" (Simon and Jaffe, 1995, recommendations2).

Each year, the number of visitors to the Wissahickon Valley increases, and these additional visitors also contribute to the deterioration of the park.

One reason for this increase is the recent popularity of mountain biking, and the hills of the Wissahickon offer one of the best spots in the area for this recreational activity. However, mountain bikes do substantial damage to trails by deeply cutting into them and making them impassable (Simon and Jaffe, 1995, use). Trails users, including bikers, equestrians, and hikers, will then create new trails in order to avoid the ruts; and thus, cutting into forest and the natural beauty of the park. The Fairmount Park Commission and the Friends of the Wissahickon are now working together to develop a solution to the stated erosion problems. A plan has been established that will provide some solutions for the park's many problems, including trail

use and storm water runoff. Some of the new trail regulations include the issuance of permits for trail usage, cyclists limited to certain trails, age and time limitations for cyclists, speed limits on trails, and no motorized vehicles (Palmer,1997). Though these rules seem strict, they are necessary for the preservation of the park.

CONCLUSION

The Wissahickon Valley is an example of the relationship between geology and geography. The features of the land are created by geological forces, and these features are then a determining factor in land use. In the Wissahickon Valley, the collision of land masses led to spectacular rock formations with layers and folds, the creek created the gorge as well as Devil's Pool, and joints created huge rocks with missing wedges. These land features brought changes to the region. The creek brought mills and development, changing it from a natural area to one of industrialization. The geography of the valley also had an impact on history when the Battle of Germantown was started, and lost, on its hills. Even though the Wissahickon Valley was once an industrial area as well as a battleground, the beauty of the land remained, and it became a favorite site for Philadelphians, officially becoming part of the park system in 1868. Today, the valley is still one of Philadelphia's most visited spots. However, geology continues to have its impact. The steep hills make the park susceptible to erosion and is an attraction to mountain biking which cause damage to the trails. Currently, steps are being taken towards protection of the park system. The natural resources of the Wissahickon, created by the forces of geology, preserved through time and history, and appreciated by its visitors, must be protected for years to come.

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