Mine Over Matter

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## Understanding the Past to Shape the Future of Prince William Forest Park

### *Resource Booklet*

*Bridging the Watershed*

An outreach program of the Alice Ferguson Foundation in partnership with the National Park Service and area schools

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# Understanding Maps



One way to understand the changes that have taken place at Prince William Forest Park, as a result of the pyrite mine, is to actually see the changes. Maps are perfect for this. They are an important source of primary information for historic investigation.[11]

## Just When We've All Agreed That the Earth Is Round ...

Mapmaking, or cartography, blends science, math and art, to create a two-dimensional (flat) representation of a three-dimensional space: the Earth. Simply put, a map tells us where or what something is on the earth.

Now, it sounds easy enough to flatten out the Earth's features and put the shapes on paper. But (surprise) the Earth isn't a perfect round ball shape! [12]

And it isn't easy to make a round shape flat. Think of peeling an orange. You can tear the peel into a strip and squish it on the table. But, it's going to crack into pieces because it can't easily conform to a flat shape.

So, that's the challenge cartographers face when they try to produce a flattened out version of earth, without making it look out of shape, or distorted.

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[11] Rosenberg, Matt. "Map Projections." About.Com Geography. 28 Apr. 2008 http://geography.about.com/library/weekly/aa031599.htm.

[12] Rosenberg, Matt. "Map Projections." About.Com Geography. 21 Aug. 2008 /geography.about.com/library/weekly/aa031599.htm.

## Earth's True Shapes:
### Battle of the Bulge

We call the true shape of the Earth an **Oblate Spheroid**.[13] The term "*Oblate*" refers to its *slightly* oblong appearance. The term "*Spheroid*" means that it is *almost* a sphere, but not quite.

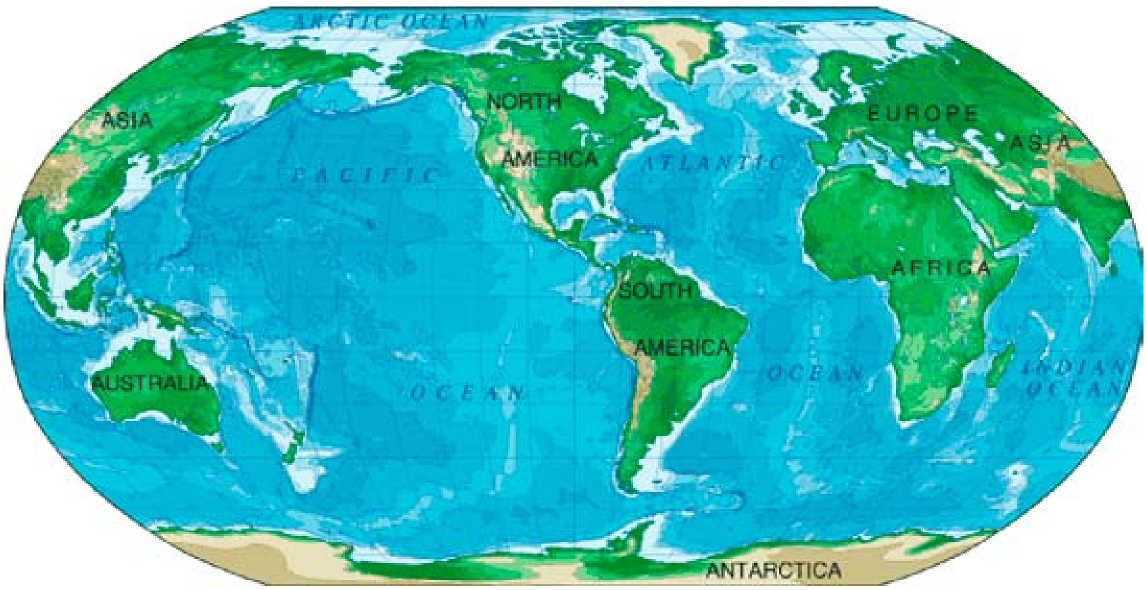
What makes this happen?

We know that the earth rotates. It's this rotational momentum that tends to force the matter to bunch up, or bulge, in the middle. In the case of the Earth, this "middle" is the equator. This "equatorial bulge" causes the earth's radius to be about 21,000m (about 13 miles) greater at the equator than at either of the poles.

### Map Projection

A map projection is a way to represent the curved surface of the Earth on the flat surface of a map. The process of transferring information from the Earth to a map causes every projection to distort at least one aspect of the real world — shape, area, distance, or direction.[14] There are hundreds of different map projections, depending on the purpose of the map.

A map projection is used to portray all or part of the Earth on a flat surface. Because of the earth's shape, this cannot be done without some distortion. Below is an example of a map projection.[15] Notice that all the landforms and oceans are visible on this two dimensional shape:




## Adjusting for Distortion
## or
## Avoiding the Fun House Mirror Look

Of course, while all the landforms are visible, they look a bit distorted. Cartographers can adjust for this distortion by using projections to minimize distortion in certain areas, including area, shape, direction, bearing or relative position, distance and scale. Then the dimensions look pretty much to scale. (We'll talk more about scale later.) While the shape of the Earth is irregular, it is a knowable and calculable shape.

Until recently, maps have been largely drawn by hand. Huge advances in computer technology, and specialized tools including Computer Aided Design (CAD) and Geographic Information Systems (GIS), have made mapmaking considerably more accurate and more accessible.

[13] Elkins, Thomas. "Oblate Spheroid." *Regents Prep: Earth Science: Introduction*. 2003. 28 Apr. 2008 http://regentsprep.org/Regents/earthsci/units/introduction/oblate.cfm.

[14] "Map Projections: From Spherical Earth to Flat Map." National Atlas.Gov. 02 Oct. 2007. 17 Apr. 2008 http://www.nationalatlas.gov/articles/mapping/a_projections.html.

[15] "Map Projections." MapsAndDirections.us. 2008. 5 Aug. 2008 http://www.mapsanddirections.us/projections.htm.

## Parts of a Map

All maps have the same basic features to help you use the map:

### Map Title:

Don't underestimate the title of the map. It gives us important information about the cartographer's intentions and goals. For example, *A Physical Map of Virginia* will show the actual landscape of Virginia, with the mountains, rivers and other geographic features. *A Political Map of Virginia* will show the physical map divided into counties and cities. A map titled *Commonwealth of Virginia Population Changes 1990–2008* will provide information about population changes.

### Compass Rose:

This is the design on a map that shows directions. The most simple is a 4-point rose showing: north, south, east, and west. The compass rose depicts the orientation of the map. Arab navigators developed one of the first 32-point compass roses more than 500 years ago, during the Middle Ages.[16]

- True North (Or True Geographic North): This is the north polar axis of the earth (the North Pole). Some maps, such as topographic maps, point to true north. If you were to poke a stick through the earth, bottom to top, the stick would come out at true north.
- Magnetic North: The arrow on the needle of a compass points toward magnetic north. It is difficult to give an exact location for the magnetic north pole because it moves as the earth's magnetic field shifts. Magnetic north is more than 1,000 miles from the true North Pole. (Near Hudson Bay in northeastern Canada). And, the difference between true north and magnetic north can vary greatly in different parts of the U.S.
- North Arrow: What if my map only shows the North Arrow? Going clockwise, from north, you'll go east, south and west. Just remember:

  **Naughty Elephants Squirt Water Or Nobody Ever Swallows Whales**[17]

### Neatline:

This is an easy one. A neatline is the border of a map. It helps to define the edge of the map and, well, keeps the map looking "neat."

### Legend:

Legend comes from Latin, meaning "things to be read." A map's legend uses symbols to represent natural features (lakes, rivers, and mountains) and manmade objects (hiking trails, restrooms, picnic tables and services like telephones and bathrooms).

### Color:

Colors are almost like a language in cartography. Ask any little kid what the blue lines are on a map, and they will probably be able to tell you that it means water. While that's not always the case (there are the little "blue" highways that crisscross America), it's highly likely. Cartographers utilize color on a map to represent certain features. Many colors used on maps have a relationship to the object or feature on the ground. In general, U.S. road maps will use color in the following way:

- **Blue**: is used for water features, such as lakes, rivers, streams, oceans, reservoirs, highways, local borders;
- **Red**: major highways, roads, urban areas, airports, special interest sites, military sites, place names, buildings, borders;
- Yellow: built-up or urban areas;
- **Green**: parks, golf courses, reservations, forest, orchards, highways;
- **Brown**: deserts, historical sites, national parks, military reservations or bases, con-tour (elevation) lines;
- **Black**: is used for cultural features such as roads, railroads, highways, bridges, place names, buildings, boundaries;
- **Purple**: highways, (also used on U.S.G.S. topographic maps to represent features added to the map since the original survey)

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[16] "Compass Rose." Wikipedia®. 26 Mar. 2008. Wikimedia Foundation, Inc. Accessed 17 Apr. 2008 http://en.wikipedia.org/wiki/Compass_rose.

[17] Giles, Dave. "Professional Skills for Applied Geoscientists." *School of Earth & Environmental Sciences*. 16 Oct. 2006. University of Portsmouth. Accessed 17 Apr. 2008 http://userweb.port.ac.uk/~gilesd/Documents/Tutorial%20Material/BGS238%20Map%20Reading%20Tutorial%20Notes%20Pages.pdf.

## Scale:

The scale of a map shows how much you would have to enlarge your map to get the actual size of the piece of land. Maps are made at different scales for different purposes.

Many, but not all, maps are drawn to a scale expressed as a ratio, such as 1:10,000, meaning that 1 of any unit of measurement on the map corresponds to 10,000 of that same unit in reality. This allows the reader to estimate the sizes of, and distances between, objects.

## Bar:

Distance might also be represented by a bar, which looks much like a ruler.

## Key:

The map's key (or legend) shows the user what the symbols and descriptions mean for interpreting the information on a map. For example, a school is usually a square with a flag on top. However, map symbols used in the U.S. are often used for different things in other countries. So be sure to read the key to understand the symbols!

## Source:

Maps will tell the name of the mapmaker or company and when they were made. This is important since things change over time.

# How Topography Tells The Story

When we followed Thaxton through the story of the mine, he described how water ran off the tailings (or left over waste from the mine) into Quantico Creek. If we're in charge of a reclamation project, one of the first things we want to know is, "Where is the largest concentration of runoff occurring?"

A topographic map would be one tool for determining this. Topography comes from a Greek word combining *topos* (place) and *graphein* (to write).[18]

Topography on a map is represented by brown contour lines in the general shape of the terrain, each line representing elevation by connecting points of equal elevation. For this reason, contours connect in a circle and never cross, although they might nearly touch. On land, they make it possible to measure the height of mountains or hills above sea level, a commonly used reference point. Contours are also used on oceanographic maps showing the topography below sea level.

## Rules of Contour Lines

Some basic rules or facts about contour lines are listed below.[19]

1. Where a contour line crosses a stream or valley, the contour bends to form a "V" that points upstream or valley. In the upstream direction the successive contours represent higher elevations.
2. Contours near the upper parts of hills form closures. The top of a hill is higher than the highest closed contour.
3. Contours are widely spaced on gentle slopes.
4. Contours are closely spaced on steep slopes.
5. Evenly spaced contours indicate a uniform slope.
6. Contours do not cross or intersect each other, except in the rare case of an overhanging cliff.
7. All contours eventually close, either on a map or beyond its margins.
8. A single higher elevation contour never occurs between two lower ones, and vice versa.

On some maps, where there is little elevation change, each contour line might represent a change of 5' in elevation. Where the terrain is considerably steeper, contour lines might indicate a 25' change in elevation. The contour interval (distance between each line) is printed in the margin of most maps. With a little practice, you can learn to visualize the shape of the land and the direction of stream flow.

Topographic maps also provide other information, such as location of mines and quarries, buildings such as schools and forest headquarters, roads, streams, hiking trails and boundaries.

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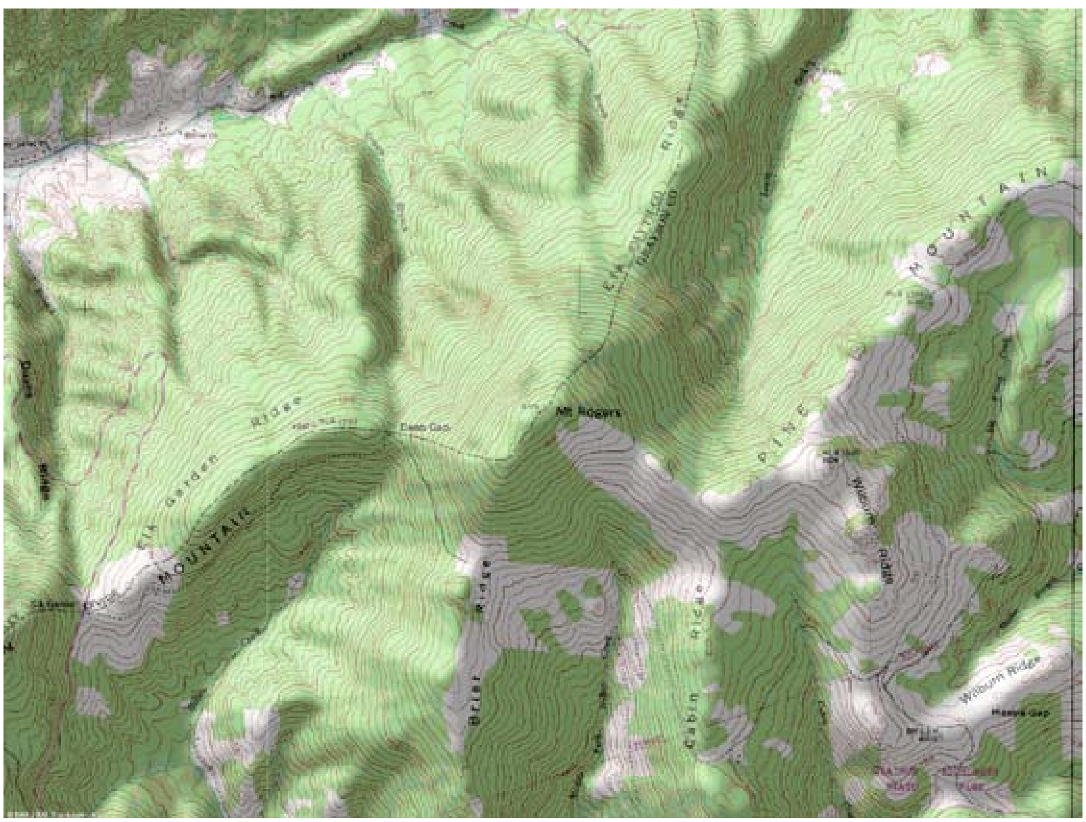
[18] "Topographic Map Symbols." *U.S. Geological Survey*. 28 Apr. 2005. U.S. Department of the Interior. Accessed 17 Apr. 2008 http://mac.usgs.gov/isb/pubs/booklets/symbols/index.html.

[19] Metzger, Ellen P. "Building a Topographic Model." *Learning From the Fossil Record*. Feb. 2002. University of California Museum of Paleontology. Accessed 17 Apr. 2008 http://www.ucmp.berkeley.edu/fosrec/Metzger1.html.

The map below shows the summit of Mt. Rogers, the highest point in Virginia.[20] Use your imagination here to "read" the terrain. The smallest circle shows the summit at 5,729 feet above sea level. Think of that being the top, with the rest of the contours showing the mountain receding or going down. If you can get that perspective, you can actually see the gap, or valley, of Deep Gap.

Looking to the right, the contours are not too tightly spaced together. They are evenly spaced so the incline is pretty consistent. Now, look down the left side of the slope. The contours are incredibly tight, almost touching. Keep in mind that each contour represents a change in elevation of roughly 25 feet — or three flights of stairs. Look where they are nearly touching, and imagine climbing *three flights of stairs nearly straight up*. Of course, that's only one contour. If you were hiking, you'd have a many more to go.

[20] "Map Projections." *MapsAndDirections.us.* 2008. Accessed 5 Aug. 2008 http://www.mapsanddirections.us/projections.htm.



## Interpreting Aerial Imagery

To interpret aerial photos, consider the following:[21]

### Tone (also called Hue or Color):

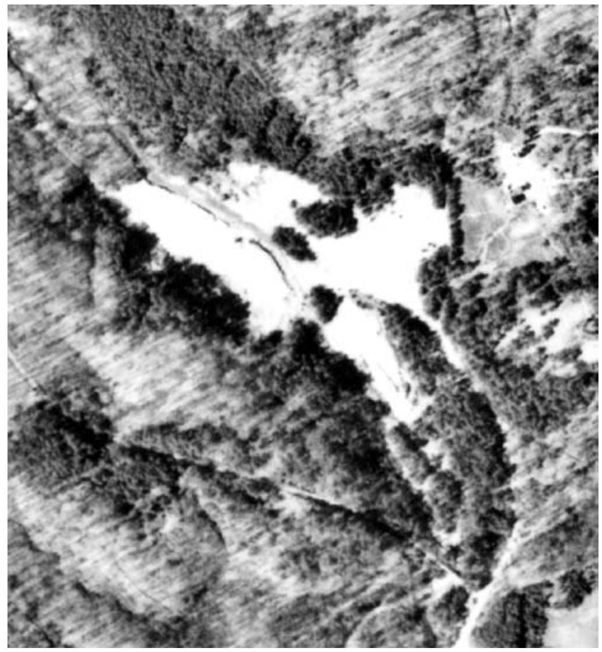
Tone refers to the relative brightness or color of elements on a photograph. It is, perhaps, the most basic of the interpretive elements because without tonal differences none of the other elements could be discerned. The very bright areas of the Cabin Branch Mine show where the land has no vegetation. The darker areas are forested. Can you make a guess as what time of year this photo was taken? (The trees provide a clue.)

### Shape:

Shape refers to the general outline of objects. Regular geometric shapes indicate human use. Some objects can be identified almost solely on the basis of their shapes. The Pentagon is a good example of this. It's not easily mistaken for any other manmade structure or a natural landform.[22]

### Size:

The size of objects are relative to the scale of the photograph. To determine the size of this area, locate the Pyrite Mine Road on the Prince William Forest Park map and compare it to the mine site below.



[21] "Air Photos 101 - Principles of Aerial Photography." *Natural Resources Canada*. 18 Sept. 2007. Accessed 17 Apr. 2008 http://airphotos.nrcan.gc.ca/photos101/photos101_info_e.php.

[22] Janes Information Group. 22 Aug. 2008 <http://images.janes.com/security/international_security/news/misc/pentagon_sat_315_after.jpg.

## Texture:

The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone in photographs. It is produced by a set of features too small to identify individually. Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough". In the picture below, the evergreen tree canopy has that rough appearance, the branches and trunks of the deciduous trees (which lose their leaves in the winter) look stick-like, and the bare area down by the creek looks quite smooth.

## Pattern *(spatial arrangement)*:

The patterns formed by objects in a photo can be diagnostic. The patchwork quilt squares in an agricultural region can easily be identified as farmlands. Large circles in a more residential area might indicate reservoirs.

## Association:

Some objects are always found *in association with* other objects. Where an object is can provide clues into what it is. For instance, knowing where the pyrite mine was located, and knowing that the runoff from the pyrite tailings caused sulfuric acid to flow into the stream (killing vegetation in it's path), will help you identify the location of the mine.

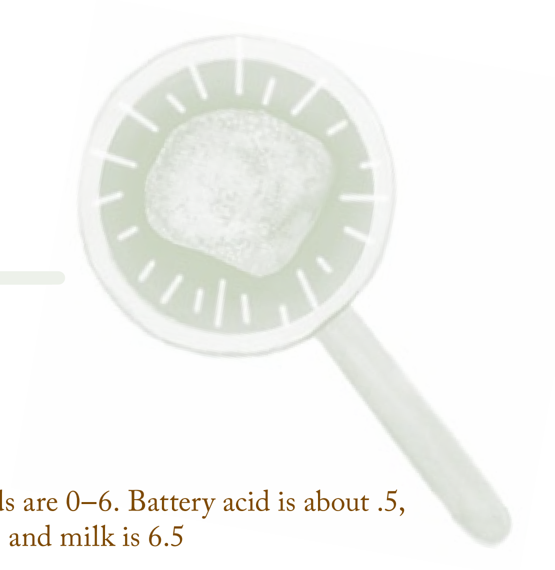
## Shadow:

Shadows aid interpreters in determining the height of objects in aerial photographs. However, they also obscure objects lying within them. If you look at the photo below, you can see that there is a bit of shadowing where the pine trees line the stream bank at the lower center.

## Time:

Time is an important element in interpreting aerial photographs. If you have the benefit of seeing a particular image over a period of years or decades, and know a bit about the way the land has been used (industry, recreation, agriculture or residential/retail) you can determine quite a bit about what may have impacted a piece of land. This is something you'll be able to play around with when you look at the aerial photography of the Cabin Branch Pyrite mine.

# The Basics (and Acids) of Soil and Water Chemistry



Before you head out the door, there is still a little bit you need to know about soil and water chemistry. When we talk about reclaiming, or making usable, the water and soil in and around the pyrite mine, we use the pH scale as one of the measures. But, what exactly is pH? pH stands for the *potential of Hydrogen*. pH tells you how much acid is in the water and soil. It does this by indicating how many hydrogen ions (H+) are in a solution.

Still confused?

First, to understand what different pH measurements mean, you have to know the definitions for acids and bases.

Here goes.

Acids are clusters of ions (atoms or molecules) that are either positively or negatively charged. The more hydrogen ions there are, the more acidic the soil or water is. Acid — think vinegar — is sour. On a pH scale of 1–14, acids are 0–6. Battery acid is about .5, vinegar is about 2 and milk is 6.5

Neutral is 7. What's considered neutral? Pure water. Easy, eh?

Bases, or alkalines, are the chemical opposites of acids. Where acids have a concentration of hydrogen ions, bases reduce hydrogen. On a pH scale of 1–14, bases (like baking soda and ammonia) are between 7–14. Blood has a pH of about 7.3. At the far end of the scale, drain cleaner is 14.

Here's the scale to help you remember. Keep it handy. You might want to use it as a reference tool from time to time.

[23] Willis, Bill. "PH, Acids and Bases." *PH, Acids and Bases.* 1996-2008. Worsley School. Accessed 8 Sept. 2008 http://www.worsleyschool.net/science/files/ph/phscale.gif.

[23]

## Fish Don't Swim In Vinegar (Trees Don't Grow In It, Either)

When the National Park Service first tested Quantico Creek in 1971, the pH was around 2.8.[24] Look at your chart. That's like vinegar! To put this in perspective, most freshwater species — fish, salamanders, snails, dragonfly and mayfly larvae — require the pH to be between 5.5 and 6.5. Frogs can tolerate acidic waters with a pH as low as 4, but eventually die out because all the food they like to eat, dies out at about 5.5.[25] Even frogs can only tolerate so much!

Remember in the story when Thaxton talked about how sulfuric acid forms when the pyrite is exposed to air and water? Well, years of that interaction created acid mine drainage, which ran into Quantico Creek making the water unfit for plants or animals.

If you look at the pictures of Prince William Forest Park, and focus in on the Cabin Branch Pyrite Mine area, you'll see in the earlier photos that there wasn't much plant growth on the hillside below and around the active mine areas. Gradually, following the reclamation efforts, vegetation is returning to the hillside. Still, the pH in the soil was falling in a range between 2.25 and 6.44, depending on the area where the soil was being tested. The goal set by the National Park Service was to get the pH of the soil uniformly up to 6.0 — a comfortable growing condition for most plants. That's roughly the acidity of the saliva in your mouth!

## The Burden of Overburden

There is also one other thing to consider: overburden. Some of the pyrite, sulfur, soil, stone and rocks discarded in the mining process, wound up being used to fill in holes and to level the roads in the park. When the reclamation process started, the researchers measured the depth of the overburden at the site and found some of it ranging from 8 inches to more than 36 inches.[26]

So, instead of just dealing with the acid drainage issues presented at the surface, researchers had to take into consideration the problems of the sulfur being shallowly buried in the soil.

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[24] Harmon, David, ed. 2006 People, Places and Parks: Proceedings of the 2005 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites. Hancock, Michigan: The George Wright Society

[25] "Acid Water and Aquatic Species." *U.S. Office of Surface Mining, Reclamation and Enforcement*. 31 Mar. 2008 http://www.mcrcc.osmre.gov/PDF/Indiana/Old%20Ben/16-17.pdf.

[26] Harmon, David, ed. 2006 People, Places and Parks: Proceedings of the 2005 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites. Hancock, Michigan: The George Wright Society

# An In-Depth Look at Soil Profiles

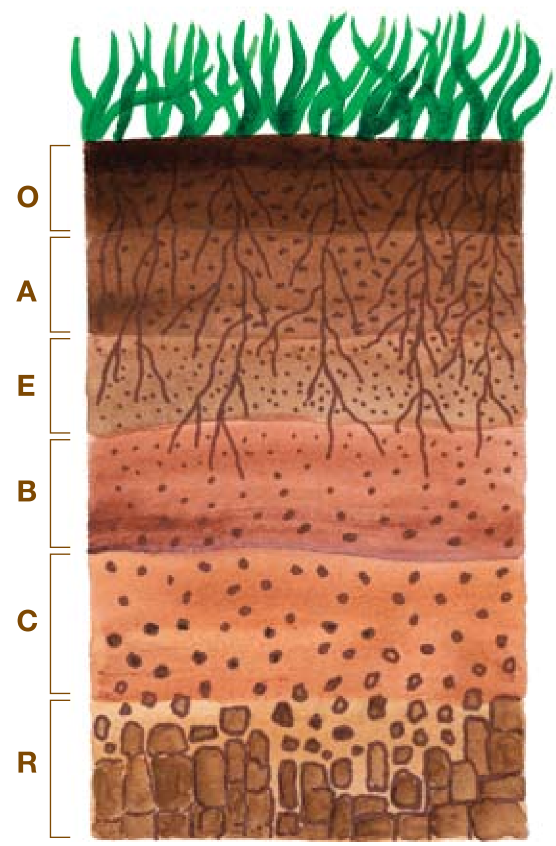
It's likely that you already know a little bit about soil horizons just from taking a drive. Often times, especially out in the country where new roads have been carved out, you'll see various layers in the soil. These layers are called soil horizons. Sometimes you'll see horizons of different colors, or might see some layers that look like crunchy gravel while other layers look more like red clay. The arrangement of these horizons in a soil is known as a soil profile. You can think of soil profiles as being a whole lot like your profile on My Space. You may start out describing very general things about yourself (male, high school student, etc.) and then go a little deeper into your interests. These area like your horizons that make up the profile.

Soil scientists, or pedologists (ped refers to soil), observe and describe soil profiles and soil horizons to classify and interpret the soil for various uses.

Soil horizons differ in a number of easily seen characteristics such as color, texture, structure, and thickness. Other properties are less visible. (Like with your profile, people can tell if you're male or female but wouldn't be able to guess, by looking at you, that you are a musician or an actor.) Properties, such as chemical and mineral content, consistence, and reaction require tests, like the kinds you'll be doing at the Cabin Branch Pyrite Mine. All these properties are used to define types of soil horizons.

Soil scientists use the capital letters **O**, **A**, **B**, **C**, and **E** to identify the master horizons, and lowercase letters for distinctions of these horizons. Most soils have three major horizons — the surface horizon (**A**), the subsoil (**B**), and the substratum (**C**). Some soils have an organic horizon (**O**) on the surface, but this horizon can also be buried. The master horizon (**E**), is used for subsurface horizons that have a significant loss of minerals (eluviation). Hard bedrock, which is not soil, uses the letter **R**.[27]

[27] http://piru.alexandria.ucsb.edu/~geog3/lab_images/soils2.jpg



# Timeline for Site Reclamation[28]



When you head out to Prince William Forest Park to do soil and water testing at the Cabin Branch Pyrite Mine, you'll be asked for ideas for continued reclamation efforts. Of course, you might want to know a bit more about what's been done in the past.

Here is a summary of the actions that have been taken since the reclamation efforts began.

**1980** Superintendent Robert Harney requested:
- soil and water tests
- analysis of plant life
- recommendations for reducing soil and stream bank erosion

27 research plots were installed and nine different techniques used

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**1987** **Pyrite Mine Site 3-Phase Rehabilitation Plan Developed**

Phase 1: Erosion Control
Phase 2: Add filter strip of vegetation
Phase 3: Plant trees, reseed, add fertilizer to reduce acid.

Leave the rest of the site for environmental study.

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**1989** **Four study plots were installed.** Trees planted in these areas showed signs of growth but heavy rains in washed away all the new plants

**1991** **Started taking a closer look at how to clean up the mine and Quantico Creek.**

They found:

- Tailings scattered around;
- Poor water quality resulting in unsuitable conditions for plants or animals;
- Acid leaching into the ground water

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**1993** **Studies resulted in following options:**

- Do nothing
- Construct wetlands to filter contaminants
- Apply lime (to raise the pH) to the creek during heavy rains and to run-off
- Cap, or close off, the tailings piles
- Dig up the tailings.

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**1995** **Reclamation Work Plan**

- **Construct troughs** to divert rain around the worst of the mine site
- **Move tailing piles** away from the stream
- **Add lime** to the tailings to reduce their acid
- **Plant trees**
- **Cap the mine shafts**

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[28] Overview Pyrite Mine ppt

**1995** **Plan in Action**; Work began in the summer of 1995 and completed in October of that year.

- 7 acres (about 6 football fields) of pyrite tailings treated with lime and covered with clean topsoil
- Entire area seeded
- 3500 trees and 500 shrubs were planted
- 8 mineshafts were sealed with cement

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**1998–2000 Post-Reclamation Water Quality Study**

- All study sites have pH sufficient to support biotic life
- Macroinvertebrate counts varied from non-impaired to moderately impaired
- More species of fish in greater numbers
- 10 artificial pools created — sites sampled weekly from March–October for these three years.

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**2004** **Follow-up soil sampling to evaluate:**

- lime cap across hill slope;
- soil conditions in barren area compared to areas where vegetation has taken hold;
- date to determine need for additional soil amendments.

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**2008** **Current Conditions:**

- Site is stable, with lespedeza (a non-native plant) as ground cover;
- Virginia pine is colonizing site from one side;
- Water Quality has improved dramatically; and
- Water and soil monitoring continuing