Secrets of Soil Lab

A lab modified From Syracuse University by John Donohue

Objective: Create a soil particle size profile using soil sieves and use it to confirm or exclude possible crime scene locations.

Introduction

Soil means different things to different people. Earth scientists see soil as mineral or organic material that is formed on Earth's surface by dynamic, complex processes. Engineers think of soil as material to build on and are concerned with moisture conditions and the ability of soil to become compacted and hold weight. Agriculturalists think of soil as the top 15-30 cm of Earth's surface to grow crops, while others think of soil as dirt which one plays in or gets "dirty" from.

Soil scientists, or pedologists, are primarily interested in the way the five soil forming factors (parent material, climate, topography, organisms, and time) affect the properties of the soil in its natural, undisturbed state. However, Forensic Geologists study soil that has been disturbed or moved during human activity, to solve crimes. Forensic Geologists obtain soil samples from crime scenes and other sites in question where soil may have been transported, by vehicle or by foot perhaps, and are suspect. Soil characteristics are diverse and this diversity enables Forensic Geologists to use soils as evidence in criminal investigations.

The scenario:

> *The badly beaten body of a freshman has been dumped at Samaritan Center's Emergency Room. An ER staff member found the body while outside on a break. The staff member quickly summons help and the injured teen is treated. Orange County Police have been called to investigate this crime. They have enlisted our help, as the area's forensic science unit, to help solve this mystery. The authorities want to find out who beat this young student; but first we must determine where the crime was committed. The student has dirt ground into his jeans, shirt, and under his nails, all of which has been collected to use during our analysis. We need to collect samples of soil from the Orange County area to use as controls in this experiment. Be sure to follow the correct sampling guidelines, and to properly label and indicate on the map where this sample was taken. Remember, the results of a soil sample test can be no better than the samples we have obtained.*

Background

The Five Soil Forming Factors

Soil formation and the properties of the soil are the result of five key factors:

1. **parent material**: The material from which the soil is formed. Soil parent material could be bedrock, organic material, an old soil surface, or a deposit from water, wind, glaciers, volcanoes, or material moving down a slope.
2. **climate:** Heat, rain, ice, snow, wind, sunshine and other environmental forces break down the parent material and affect how fast or slow soil processes go.
3. **organisms**: All plants and animals living in or on the soil (including micro-organisms and humans!). The amount of water and nutrients ,plants need affects the way soil forms. Animals living in the soil affect decomposition of waste materials and how soil materials will be moved around in the soil profile. The dead remains of plants and animals become organic matter which enriches the soil. The way humans use soils affect soil formation.

4. **topography**: The location of a soil on a landscape can affect how the climatic processes impact it. Soils at the bottom of a hill will get more water than soils on the slopes, and soils on the slopes that directly face the sun will be drier than soils on slopes that do not.
5. **time**: All of the above factors assert themselves over time, often hundreds or thousands of years.

The way the five soil-forming factors interact is always different from one place to another, so soils differ greatly from each other. Each section of soil on a landscape has its own unique characteristics. The face of a soil, or the way it looks if you cut a section of it out of the ground, is called a soil profile, like the profile of a person's face. Every soil profile is made up of layers called soil horizons. Soil horizons can be as thin as a few millimeters or thicker than a meter.

Soil profiles and their horizons change as you move across a landscape, and also change as you move downward deeper into the soil at one location. In fact, soil samples taken at the surface may have entirely different characteristics and appearances from soil dug deeper in the soil profile. One common reason soil horizons are different as you dig deeper is because of mixing of organic material in the upper horizons and weathering and leaching in the lower horizons. Erosion, deposition, and other forms of disturbance might also affect the way a soil profile looks at a particular location.

Now, you may be wondering how many soil types are in existence. The United States Department of Agriculture (USDA) maps and collects soil data at many different scales. According to the USDA, there are over 50,000 different varieties of soil in the United States alone! Since parent material, climate, organisms, and the amount of time it takes for these to all interact varies worldwide, soil combinations also vary worldwide. Forensic Geologists have their work cut out for them. So, how do Forensic Geologists use soil to solve crimes? Read on!

TECHNIQUES USED BY FORENSIC GEOLOGISTS

Soil samples must be carefully collected, handled at the crime scene and then compared by a Soil Scientist to ensure that the soil samples can be useful during an investigation. To compare means to understand that no two objects on Earth are exactly the same; however, two soil samples (or other Earth material) could have originally come from the same place, but a portion of the soil (or other Earth material) could have been removed to another location during human activity. Forensic Geologists look for uncommon and unusual particles, or unusual combinations of particles, in soil samples and compare them with similar soil in a known location. Depending on the type of soil and the minerals present, in addition to grain size, the Forensic Geologist employs intensive observational methods and analyzes crime information to deduce whether a soil sample can be used as evidence.

Often, the forensic geologist must determine the distribution of particle sizes in samples for use during comparison studies, mineral studies, and color studies. To perform these studies, the forensic geologist uses methods that GLOBE students and teachers use to study soil soils. Soil samples are taken from intact soil profiles whenever possible and then characterized for structure and texture. The Forensic Geologist uses sieves, graduated cylinders, and hydrometers to perform soil particle size distribution analyses and also performs bulk density tests to determine soil porosity. If the samples collected are discovered to have cementing agents such as calcium carbonate ($CaCO3$), iron (Fe), or organics which hold the soil particles together, then these cementing agents are removed using special chemicals.

INSTRUMENTS USED TO STUDY EARTH MATERIALS

Approximately fifty common minerals as well as some less common minerals can be seen by the naked eye, but using a lens or low power binocular microscope enables the Forensic Geologist to better detect mineral properties and provide more accurate mineral identification. A common instrument used to study thin sections of rock, mineral, and soil samples is a petrographic microscope. Thin sections of Earth material are mounted on a glass slide and viewed with the petrographic microscope as light filters through its special attachments.

Scanning electron microscopes (SEM) and electron microscopes also can be used to examine particles over 100,000 times their original size making them very useful. Forensic Geologists and lab scientists are able to see, in greater detail, the characteristics and variations of soil samples. Fossils and pollen spores that collect in rocks and soil can also be seen, and are sometimes useful indicators when studying soil samples. In fact, scientists were not able to see the distinct differences in very small fossils, nor scratches on mineral grains, until the SEM was invented. The electron microscope and scanning electron microscope are very useful to the Forensic Geologist who must analyze soil samples with great precision and make important decisions that affect people's lives.

CRIMINAL CASES SOLVED USING EARTH MATERIALS

The Federal Bureau of Investigations (FBI) has collected and studied soil samples, minerals, and other Earth material for criminal investigations since 1935 and thousands of cases involving Earth materials are studied in the United States each year. Throughout the world soil is usually collected at crime scenes, is routinely studied at crime labs, and is often used as physical evidence during crime trials.

Following are some real-life stories of crimes that were solved using Earth materials, thorough investigative work, and dedicated, professional scientists who studied soils and geology to become knowledgeable in their field. So you see, there really is more to soil than what's under foot!

In the case of stolen potatoes on the east coast of the United States, a suspect who possessed the questionable potatoes was convicted of stealing them once analysis of the soil on the potatoes determined that the superphosphate in the soil that was clinging to the potatoes matched the soil from the farm where the potatoes were grown. The farm's soil contained a significant build up of phosphate because the farm was heavily fertilized with nitrogen, potash, and phosphate (phosphate doesn't leach out of the soil as readily as
potash and nitrogen).

In another case, tobacco was reported stolen from a farm. Soil samples were taken from the farm where the tobacco had been stolen, and samples were also taken from the leaves of the stolen tobacco and from the suspect's farm. Soil comparison studies indicated that the soil on the stolen tobacco leaves did not match the soil samples taken from the suspect's farm, but matched soil samples taken from the farm where the tobacco was reported stolen. The suspect was arrested based upon the resulting soil sample comparisons.

Microscopic fossils called diatoms were once very prominent on Earth, and collectively deposited to form a sedimentary rock called diatomaceous earth. Some manufacturers use diatomaceous earth for insulating safes, that are used to store valuables. Burglary crimes have been solved by examining white specks from suspects' hair and clothing to determine that the specks were

actually diatoms that came from broken safes at crime scenes, and not dandruff as the suspects had claimed.

References: http://soil.gsfc.nasa.gov/forengeo/secret.htm
Idea from Mike Revenson, Mahopac High School

Procedure

Part 1: Soil Collection

1) Take the soil sample collector to a site where you want to collect soil from
2) Push the collector into the ground, twisting if needed. Try to get as much of it into the ground as possible while keeping track of which side the viewing window is on
3) Pull the collector out, angeling it so that the viewing window is angled up
4) Take a picture of the soil in the collector so you can view any layering that may be present
5) Push the soil out of the collector into the ziplock bag
6) Rinse off the soil collector so that there isn't any dirt stuck to it and bring the soil sample and the collector back to school

Part 2: Soil preparation

The soil needs to be dry to work effectively with the soil sieves.

1) Get a dish and label it with your name
2) Empty the soil from the ziplock bag onto the provided dish and set aside. They will be placed in a 'drying chamber'

Part 3: Particle separation and profile creation

We are going to use the sieves to separate the different particles based on their sizes and then measure the amount of each size there is to create a soil particle size profile for your sample.

1) Take your dry sample from the drying chamber
2) Break up the clumps of dirt using a bin and a wooden pestle as demonstrated by the instructor.
3) Measure the mass of the dried sample
    a) Recommended: measure the mass of a separate container, add the dried sample to the container and take the difference in mass. This will be the total mass of your dried sample
4) Obtain the soil sieves and make sure they are stacked appropriately. At the top you should have the smallest mesh number and the bottom should be the largest mesh number and then the pan.
5) Place your dried soil sample into the top sieve and place the lid on top of it
6) Vigorously shake the sieves while holding the lid securely on top. Shake it side to side as well as up and down for 4 minutes. Feel free to take turns with this task
7) Carefully place the sieves down on the table and remove the lid
8) Measure the mass of dirt trapped in each sieve separately
    a) Place a clean dish on a scale and measure its mass. Add the dirt from the first sieve to it and measure its new mass. Make sure to brush the inside and backside of it to ensure that all of the soil has left the sieve. The difference between the masses would be the mass from that layer
    b) Place the soil back into the ziplock bag after you have massed it
    c) Repeat this step for the rest of the sieves
9) Calculate the percent composition for each range of particles
10) Graph your results and share your data with the class document

Part 4: Publishing your results

1) Determine the GPS location of where you collected the soil
    a) Go to maps.google.com, find exactly where you took the sample from and single click there.
    b) An address will probably show up, but ignore that and click on the numbers that are there.
    c) This will bring them into the search bar, copy the entire string of numbers here and then paste them into the form.
2) Post your results in the form that has been emailed to you.
3) These results will be added to an interactive google map where you will be able to click on each data point and it will tell you the profile of the soil at that location

Trapped in sieve	**Particle sizes (microns)**	**Mass (g)**	**Percent**
5	>4000		
10	4000-2000		
40	2000-420		
60	420-250		
120	250-125		
250	125-58		
Pan	<58		
		Totale Mass:_____	

4) Create and attach a graph of your data with particle size as the X axis and the percent as the Y axis. Include all required aspects of a graph

Secrets of Soil Lab

Name:_____ Prelab Questions

1) What is soil?

2) What is the composition of soil?

3) How will you be sorting the different sized particles in this lab?

4) Do you expect there to be a wide variety of soil composition in middletown? Why or why not?

Post Lab Questions

1) List any similar features between your soil sample and the evidence soil sample collected off of the victim.

2) Is your soil sample consistent with the evidence soil sample or can you eliminate it as a possible match? Explain

3) Look at your classmates data. Are there any results that indicate where you may want to start looking for the potential crime scene?